

3rd INTREPID Report

Interdisciplinary and transdisciplinary research: Finding the common ground of multi-faceted concepts

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Abstract

Inter- and transdisciplinarity are increasingly relevant concepts and practices within academia. While various definitions exist, a clear distinction between inter- and trans-disciplinarity remains difficult. Although there is a wide consensus about the need to define and apply these approaches, there is no agreement over definitions. Building on data collected during the first year of the COST Action TD1408 “*Interdisciplinarity in research programming and funding cycles*” (INTREPID), this paper describes both tensions and common ground about the characteristics and building blocks of inter- and trans-disciplinarity. Drawing on empirical data from participatory workshops involving INTREPID network members coming from 27 different countries, the paper shows that diverse definitions of inter and trans-disciplinarity coexist within scientific literature and in the mind of researchers and practitioners. The understanding about the involvement of actors outside of academia also differs widely across scientific communities irrespective of disciplinary training or the research subjects. The focus should be on the knowledge that is required to deal with a specific problem, rather than discussing “if” and “how” to integrate actors outside the academia, and collaboration should start with joint problem framing. This diversity is, however, not an absolute obstacle to practice, since the latter is made possible through building blocks such as knowledge domains, problem- and solution- oriented approaches, common goals, as well as target knowledge. In order to move towards more effective inter- and transdisciplinary research, we identify the need for trained interdisciplinarity facilitators and ‘accompanying research’ (derived from the Danish term ‘følgeforskning’). These two roles can be essential to inter- and transdisciplinarity practices including the promotion of reflexivity.

Keywords: Interdisciplinarity, Transdisciplinarity, research-practice, collaboration, INTREPID

1. Introduction

The struggle of interdisciplinary research began with the increasing specialization of science into different branches and disciplines during the 19th century (Pombo 2004). While the quest for increasing knowledge about complex subjects led to the continuous establishment of different disciplinary methods, language and traditions in the social sciences, the humanities and the natural sciences, it also created frictions for the collaboration between different disciplines (Klein 1990). Multidisciplinary science evolved with several different disciplines operating side by side, and little or no exchange occurred within different multidisciplinary research projects (Lawrence & Despres 2004). In order to enable and foster collaboration between different scientific disciplines, several proposals were made in the past (Cummings and Kiesler 2005; Porter and Rafols 2009; Wagner et al. 2011, Holm et al. 2013). Nonetheless, interdisciplinary collaboration is still rare (Stokols 2011). While some mechanisms and proposals highlighting the need for interdisciplinarity have focused on creating linkages

by overcoming language barriers, differences between and difficulties across scientific cultures (Fischer et al. 2012; van Rijnsoever and Hessels 2011), other proposals have called for a new culture of science (e.g. mode 2 knowledge production; Gibbons et al. 1994). More cautionary proposals discussed the danger that a strong emphasis on interdisciplinarity could undermine disciplinary scientific expertise and the integrity of research. While these discussions about interdisciplinarity have been ongoing for a long period (Klein 1990, 2008), no agreement has been reached about how to define interdisciplinarity.

The difficulty of arriving at a generalized definition of interdisciplinarity increases with the inclusion of actors outside academia in the research process (Jahn 2008; Lang et al. 2012). Actors outside academia - are often vital within research projects, and as research policies shift towards societal challenges and impact, this trend is further strengthened (for example: EUCO 2013). In recent decades these actors have been increasingly integrated into research projects, thereby creating ties between knowledge domains inside and outside of academia (Stauffacher et al. 2008). This practice is often labelled as transdisciplinarity (Brandt et al. 2013; Lang et al. 2012). While this collaboration is considered helpful, even essential, for addressing many problems and challenges, the same concerns expressed in regards to interdisciplinarity are referred when discussing transdisciplinarity. Debates around inter- and transdisciplinarity are frequent and closely linked to the impact of these approaches on scientific integrity (Jahn et al. 2012, Pohl 2011; Porter and Rafols 2009). The inclusion of actors outside the academia in research may result in scientists compromising their procedures and rigorous standards. Notwithstanding, methods to put inter- and transdisciplinarity in practice are increasing (Brandt et al. 2013) independently of the continuous discussion around the definition of concepts and, how to differentiate transdisciplinarity from interdisciplinarity (Lang et al. 2012).

Well known examples of interdisciplinary or even transdisciplinary frameworks are systems thinking approaches (Meadows and Wright 2008), the ecosystem service concept (Abson et al. 2014), urban design approaches (Broto et al. 2012), and contributions within the field of sustainability science (Kajikawa et al. 2014; Kates et al. 2001). Recent science agendas, have shifted the focus away from research that is built on different disciplines, towards developing and adopting approaches that focus on joint framing of the problem and on solution-oriented approaches (EC 2013; Robinson 2008). While few would question the necessity of disciplinary expertise in education and research, a solution-oriented agenda might reduce the rigidity, and sometimes the desirability of "disciplinary silos". Many of these research processes are output oriented, often seeking broad social and economic impacts. Within research processes, resources can be allocated according to the need to approach specific wicked problems (e.g. climate change), and ultimately create solutions (Brown et al. 2010). These solution-oriented approaches can be interpreted as using interdisciplinarity and transdisciplinarity as a specific lens through which the world is seen, or as a mode in which science can operate. Therefore, in solution-oriented agendas inter- and

transdisciplinarity are a mean rather than an end and, the overall goal is to propose solutions to specific wicked problems.

Interdisciplinary research and collaboration (including transdisciplinarity as discussed above) are increasingly recognized as a precondition to solve the problems and Grand Societal Challenges confronting societies and the planet today. However, although interdisciplinarity is increasingly central to science and research agendas, and is recognized as a precondition for sustainability, its effective implementation in research projects remains an exception to the rule. To better understand how to achieve more efficient and effective interdisciplinary research, a COST Action proposal on *“Interdisciplinarity in research programming and funding cycles”* (INTREPID) was designed in 2014. It was successful, and began its network activities in May 2015 (as TD1408).

INTREPID’s overall aim is to create a space for reflection on the role and opportunities of interdisciplinarity in research programming and funding cycles, addressing the following stages and dimensions: definition of political agendas; policy statements/priorities; research programs; funding calls for projects; ex ante evaluation; selection and excellence criteria; and ex post assessment of output, outcomes and impact. In order to encompass the entire life cycle of research programming and funding, from the strategic and abstract dimension of policy framing, to the practical dimension of project selection and implementation, the INTREPID COST Action draws on examples and experience related to sustainable urban development and research. This broad area is characterized by multiple, interrelated, and interdependent challenges, which require a collaborative effort between disciplines. INTREPID’s network of researchers, practitioners and policy makers from 27 countries initially focused on a narrow definition of interdisciplinarity, but quickly expanded to embrace multiple understandings of collaboration, including transdisciplinarity.

In this paper, our aim is to describe how INTREPID members are building a common understanding of (and dissent over) meanings of inter-and trans-disciplinarity that is crucial to achieve INTREPID’s goals during the network duration (2015-2019). The highly diverse nature of INTREPID’s network, its geographic spread, professional range and disciplinary composition, offers an opportunity to draw upon various definitions, understandings and practices of inter-multi-trans-disciplinarity. Our initial research questions were: 1) what are the characterizing features included in existing definitions of inter- and transdisciplinarity within INTREPID network? and 2) what can we identify as common ground by analysing the diverse interpretations of these multi-faceted concepts? We have sought to answer these two questions through diverse methods including quantitative literature analysis and qualitative participatory processes (described in the next sections).

2. Methodological approach and results

Figure 1 schematically explains the components of the methodological approach used to arrive at a collective understanding of interdisciplinary in INTREPID Cost Action. The starting point was a literature review and keyword cluster analysis that focuses on inter- and transdisciplinary in urban development and research (INTREPID's focus area). The results of this literature review and analysis served as a starting point of a 3 days' workshop that involved 62 out of the 18 members of INTREPID cost action. The workshop, which took place in Lisbon from the 25 to the 27 of November 2015, included three main activities: a preliminary brainstorm session, a world café and a final survey.

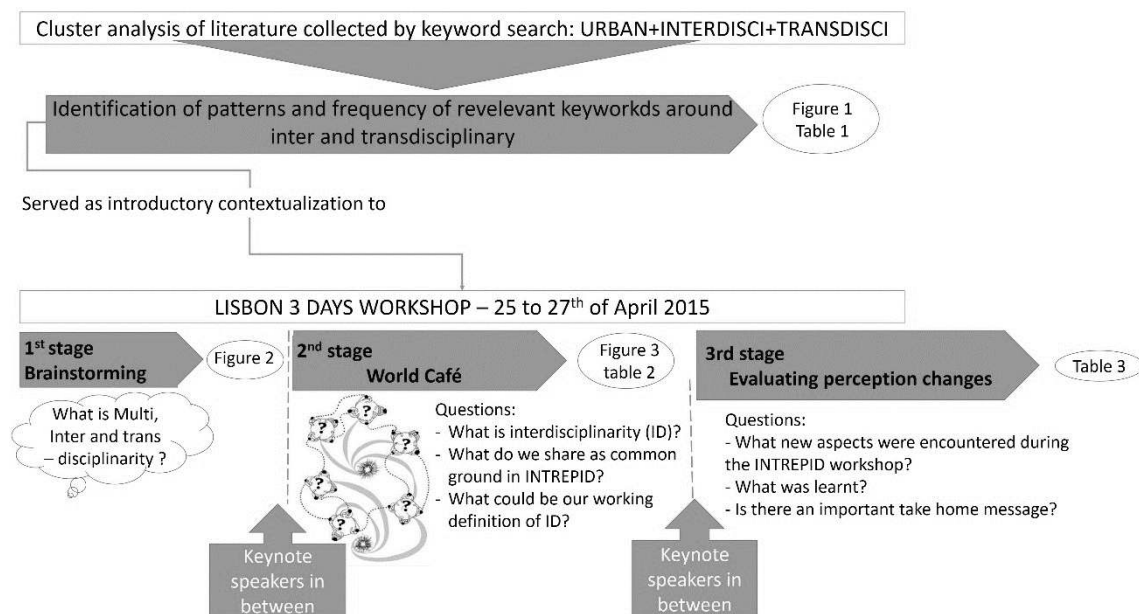


Figure 1: Diagram of the methodological approach used to promote the collective understanding of interdisciplinary within INTREPID cost action.

2.1. The literature review

The literature review started with a search in Scopus database using the keywords: “urban*” and “interdisci*” or “transdisci*”. The same literature search was done in the Web of Science database and results were very similar. From this first query, 2540 scientific articles were retrieved. This initial number was reduced by filtering the scope to “urban areas” (1235 articles) and to articles cited on average at least once a year (755 articles), 189 articles were excluded because of lack of institutional access.

Taking into consideration the full text of the 566 selected articles, a multivariate statistical analysis was developed (for details see Abson et al. 2014) of all relevant words into an ordination. Later a cluster analysis was used to group articles by considering the quantity of common words used. Finally, an analysis with a similar rationale to the “indicator species analysis” (for details see Dufrene and Legendre, 1997) was used to characterize each article cluster by a significant indicator word that was used to label a specific cluster (Figure 2).

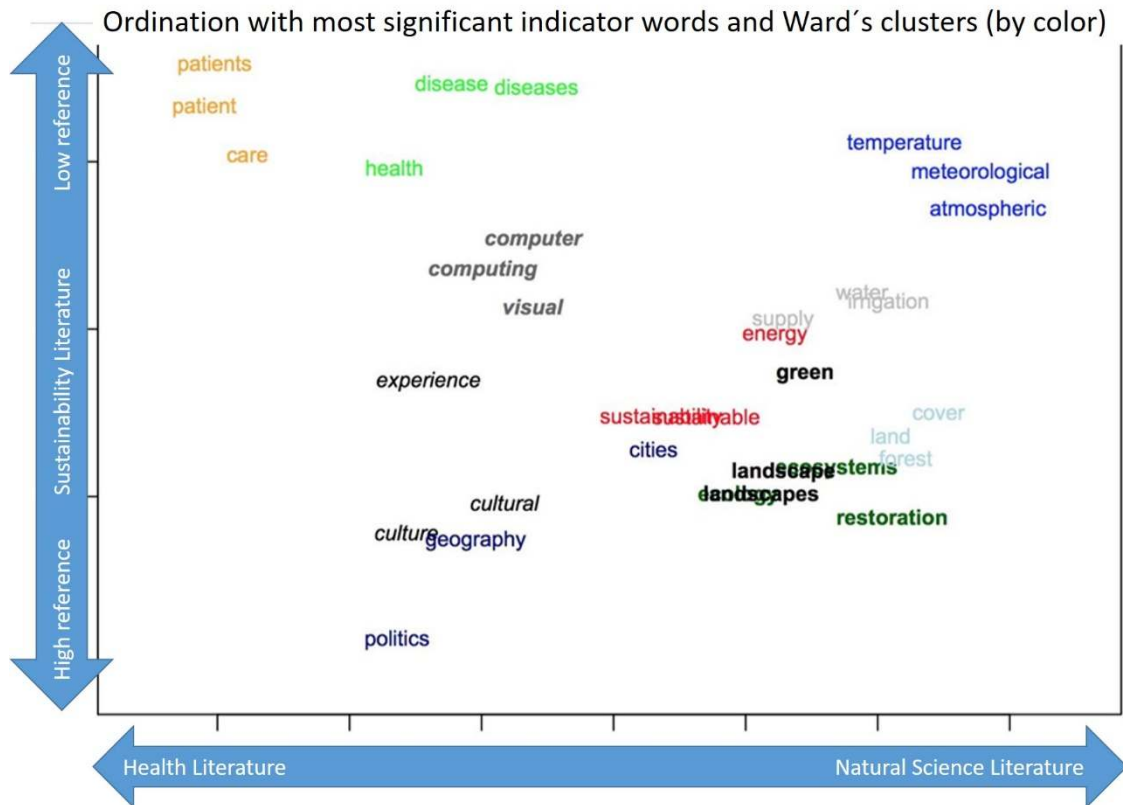


Figure 2: Full text analysis of well-cited publications in urban areas referring to inter and transdisciplinarity (N= 566).

Figure 2 shows clear and distinguishable thematic groups in the urban-related literature focusing on inter- and trans- disciplinarity. In general, words that are distant from each other are from papers that use very different words. On the X- axis, there is a clear difference between the literature characterized by its focus on health issues and the literature more geared towards natural science issues; the y-axis, reveals a sustainability-focused gradient, where the most relevant literature falls along the middle of the axis and at the center of the figure.

Going deeper into understanding how inter- and transdisciplinarity is used within this literature sample an automatic word count was carried out using keywords around both concepts. The keywords were extracted from Lang et al. 2012 that describes design principals for transdisciplinary research. Lang et al. 2012 served as a baseline since it is one of the first articles that suggests such principals and integrates different strands of the literature as well as from experiences in transdisciplinary projects over 10 years. Table 1 summarizes the results of this analysis. From Lang et al. 2012, twenty-seven words were extracted and all have been used in the articles sampled. Yet, the quantity of articles that referred to a specific keyword varies from 87% for the word “system” to “negotiation” that was mentioned in 12% of the full articles sample. Further, Table 1 shows the amount of articles that refer each word more than 3 times. The word “system” is the most referred word while “cooperative” and “negotiation” are the words less referred, with two articles referring them more than three times.

Table 1: Percentage of articles that mention once each keyword extracted from Land et al., 2012. The right column indicates the number of articles which mention each keyword more than three times.

| Words extracted from Lang et al., 2012 | Mentioned (%) | More than 3 times (number of articles) |
|--|---------------|--|
| System | 87 | 55 |
| Knowledge | 80 | 45 |
| Society | 78 | 39 |
| Value | 78 | 37 |
| Complex | 79 | 34 |
| Framework | 72 | 34 |
| Problems | 73 | 29 |
| Perspective | 77 | 28 |
| Method | 62 | 23 |
| Conceptual | 54 | 21 |
| Participants | 45 | 20 |
| Sources | 62 | 18 |
| Real | 61 | 17 |
| Disciplines | 51 | 17 |
| Learning | 42 | 14 |
| Participatory | 30 | 13 |
| Disciplinary | 36 | 9 |
| Transformation | 37 | 7 |
| Aim | 42 | 6 |
| Language | 30 | 5 |
| Solution | 29 | 5 |
| Target | 29 | 3 |
| Domain | 25 | 3 |
| Teaching | 19 | 3 |
| Cooperative | 21 | 2 |
| Negotiation | 12 | 2 |

2.2. The workshop participants – the INTREPID network members

INTREPID cost action network includes 78 members of 27 countries (figure 3). In Lisbon workshop, 62 of these members were present. From these participants 48% were women and 21% were non-academic members of the network.

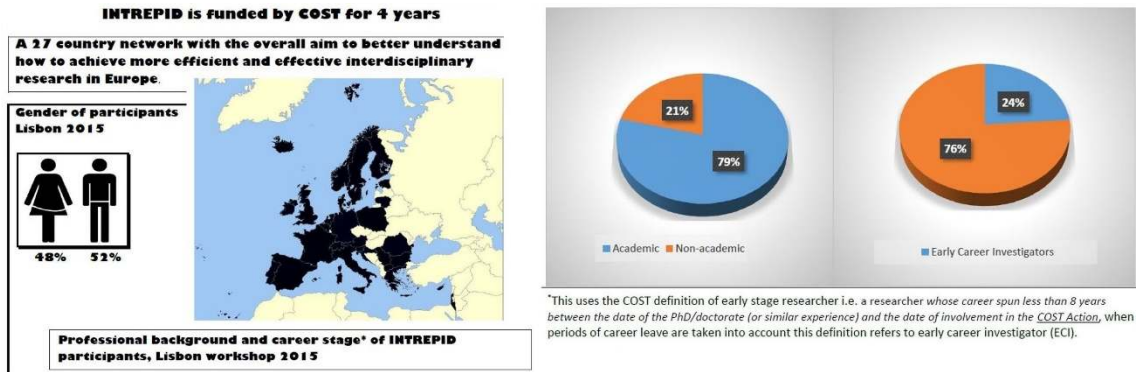


Figure 3: Characterization of INTREPID Cost action and of the participants in Lisbon workshop.

At the beginning of INTREPID cost action participants were asked to provide a description of their research trajectory and research interest. Figure 4 contains a word cloud of the descriptions provided by the 62 participants in the Lisbon workshop, illustrating the focus on interdisciplinary approaches and urban issues that the INTERPID members share.

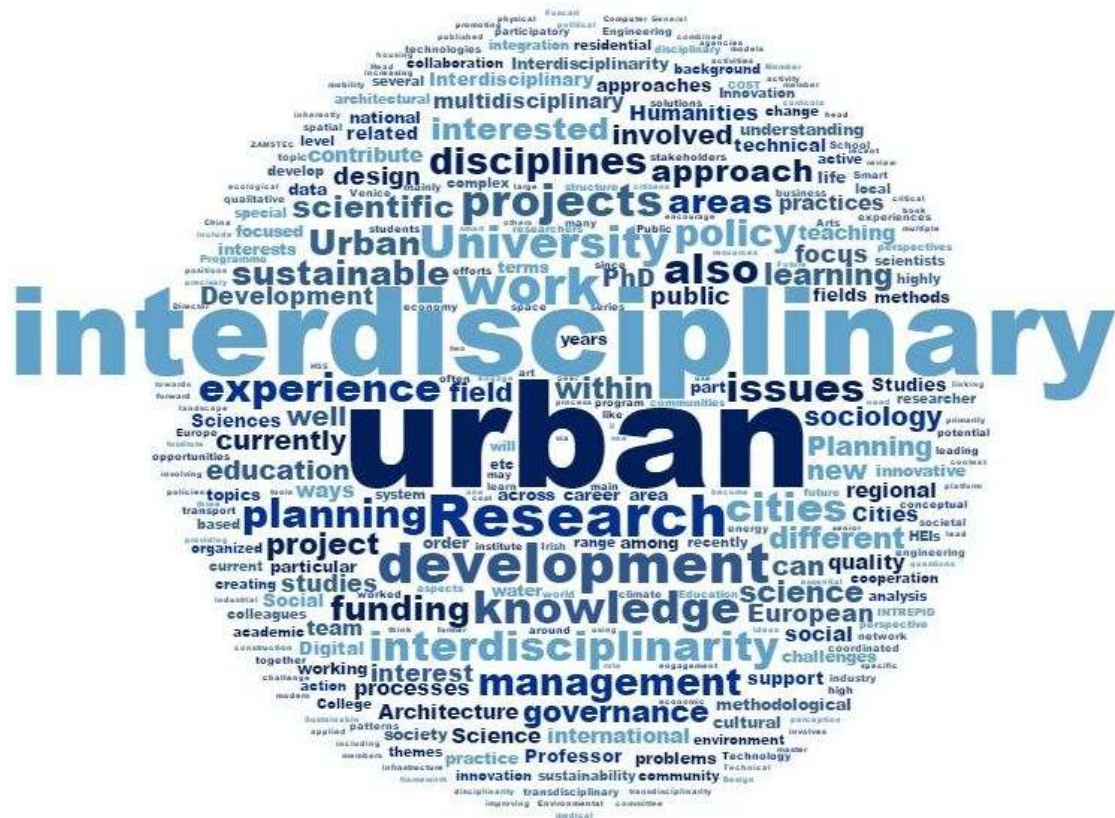


Figure 4: Word cloud using the description of INTREPID members that participated in the Lisbon workshop. This description was retrieved from INTREPID website.

2.3. First stage of the workshop – the brainstorming activity

On the first day of the workshop, after the presentation of the results described in section 2.1, participants were asked to write down one word that they related with each of these concepts: “Multi”, “Inter” and “Transdisciplinarity”. This was an individual exercise and results were placed on a wall that everyone could revisit during the entire workshop. The analysis of the results was done in the final day of the workshop. Following this self-reflective exercise (Figure 5), lectures by keynote speakers were given to let participants have an overview of existing definitions and practical experiences with inter and transdisciplinary research processes. Each communication was followed by plenary discussions.

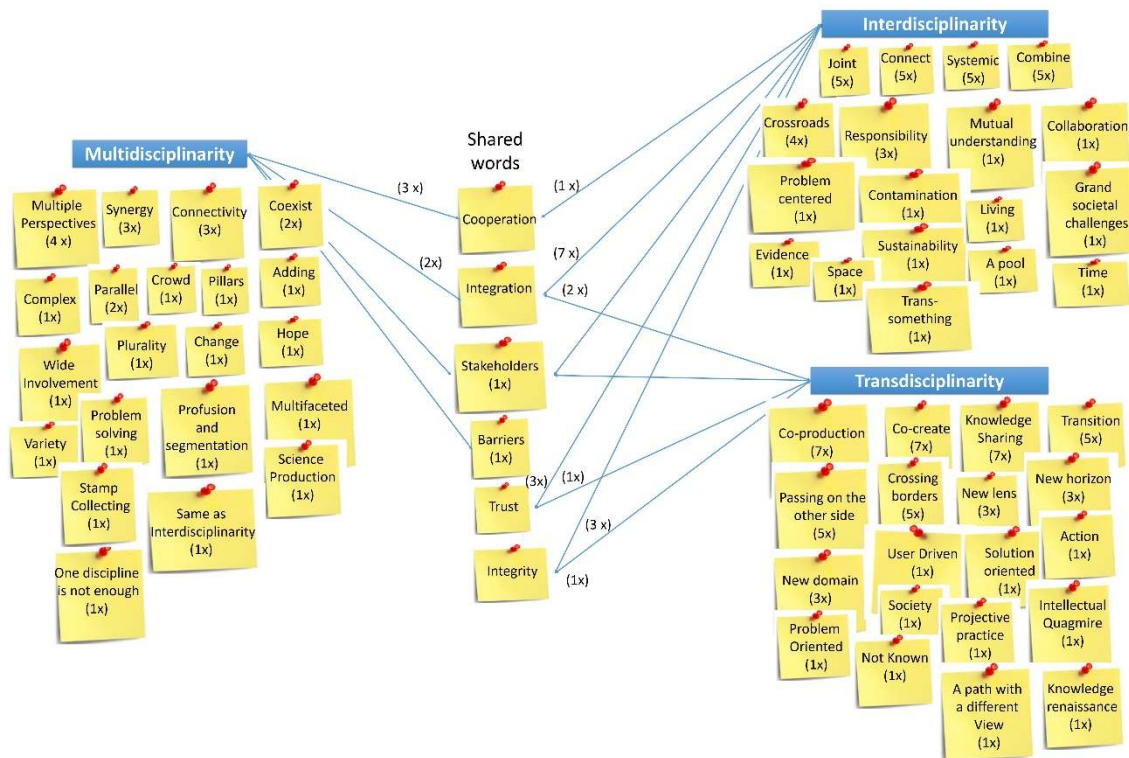


Figure 5: Results of the brainstorming activity undertaken at the beginning of the Lisbon workshop. The number in brackets refer to the number of times the word was referred.

The brainstorming activity results (Figure 5) show that multidisciplinary was attached to the widest range and diversity of terms (i.e. 21 different words), which denotes less coherence about the term among participants. Further, the maximum number of times a word was repeated was four (i.e. “multiple perspectives”). Four words used to describe multidisciplinary were also used while thinking about interdisciplinarity (i.e. “cooperation”, “integration” and “stakeholders”) while five were as well presented to define transdisciplinarity (i.e. “integration”, “stakeholders”, “barriers”, “integrity”).

The number of words being repeated is higher in the case of interdisciplinarity (i.e. “integration” was repeated seven times) but transdisciplinarity was the concept where more repetition was observed (figure 5). Words as “co-production”, “co-create” and

“knowledge sharing” were repeated seven times in association with transdisciplinarity. Interdisciplinarity and transdisciplinarity were linked to 18 distinctive words. Comparing the words used to define inter and transdisciplinarity one can observe a strong reference to co-production, crossing borders, and the ‘new’ or innovative contribution in the case of transdisciplinarity, while interdisciplinarity is primarily attached to notions of connectedness and combination (partly overlapping with multidisciplinary).

2.4. Second stage of the workshop – the world café

The world café activity was scheduled into two different rooms due to the high number of participants. In each room, there were four working groups and after 40 minutes participants would change table while one person per table, designated as rapporteur, stayed and recorded the main conclusions. The number of participants per table was 5 to 6. There was no pre-arranged distribution of participants i.e. participants were free to choose to sit where they wished. Over 120 minutes, participants discussed the following pre-arranged questions:

- 1- What is interdisciplinarity (ID)?
- 2- What do we share as common ground in INTREPID?
- 3- What could be our working definition of ID?

By the end of the discussion, eight summaries were collected, representing the groups’ discussions. Figure 6 provides an example of one of the summaries done by the rapporteur during this world café activity.

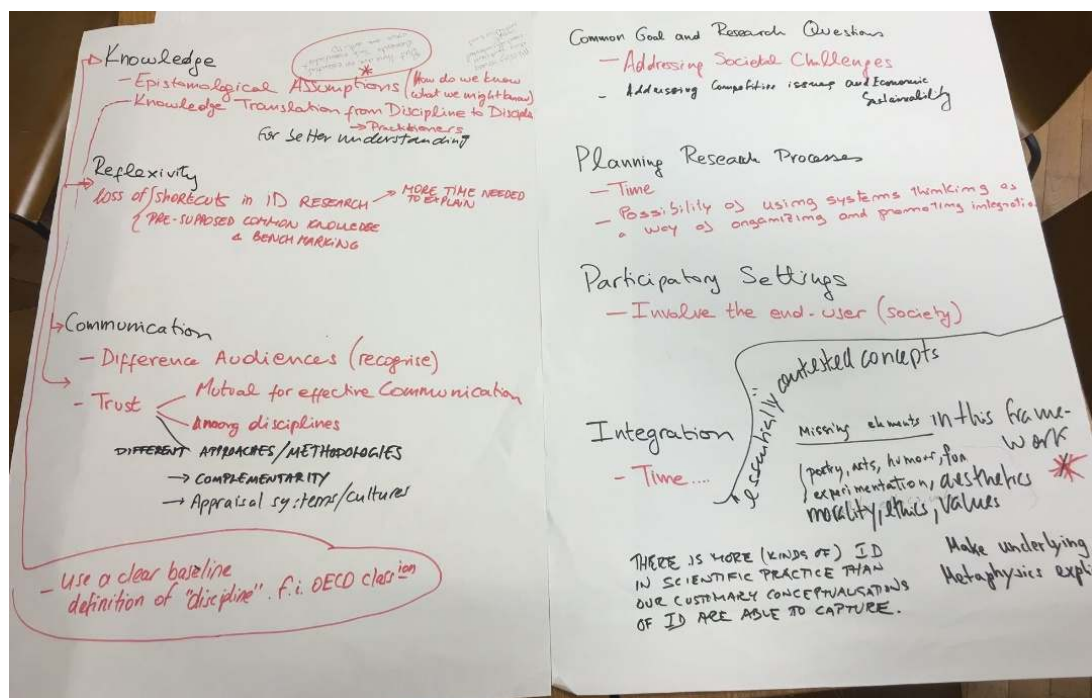


Figure 6: Example of the summary report of one discussion table during the world café activity.

Several overlapping ideas emerged when comparing the summaries of the groups' discussions; however, no common definition of interdisciplinarity arose from the discussions. The content analysis of all summaries revealed a certain common ground whereby interdisciplinarity implies exchange, sharing and integration for mutual understanding. However, the boundary of interdisciplinarity and its differentiation with transdisciplinarity was not well defined. In most of the groups, the level of participation of non-academics in research was a key issue of disagreement for some participants interdisciplinary research took place between academics whilst others argued that interdisciplinary research involved non-academic partners in different ways. For example, architects, considered by some participants as non-academics, were involved in many interdisciplinary studies of urban development. During these discussions, definitions of academia and research were questioned since research practices take place outside of academia, hence talking about researchers and non-researchers does not distinguish between those that are within academia from those outside academia. Actors outside academia can be expert on a specific field and undertake research activities. Therefore, one group proposed to use the term extra-academic for those actors that develop activities (including research) carried out outside academia.

An overall conclusion from the discussion groups was the difficulty in achieving a unique definition for interdisciplinarity within INTREPID Cost Action. In this subject one of the groups concluded that interdisciplinarity is "a means, but not a goal".

The groups moved on to discussing what is needed to allow interdisciplinarity to work effectively; what is essential to foster exchange, sharing and integration for mutual understanding between disciplines as well as outside of academia. During these discussions, participants agreed on:

- the need to have common goals between those involved in an interdisciplinary process,
- the need for a holistic understanding of the problem that is being examined or discussed,
- the need for integration of different knowledge domains,
- the need to work within participatory settings that enable information, integration and collaboration.

Focusing on the participatory setting, two roles within interdisciplinary were identified:

- interdisciplinary facilitators,
- accompanying side research.

Although there was no sufficient time to define clearly these two roles, they were linked to the need to create an environment of trust, the capacity and space to negotiate research processes and codes of conduct. Finally, reflexivity was considered of great importance for interdisciplinarity and the role of a facilitator was linked to the

promotion of such activity while with accompanying research an external (e.g. outside the research process) reflecting perspective could be achieved.

2.5. Last stage of the workshop – evaluating perception changes

In the last day of the workshop, we reviewed of the outcomes produced previously, and discussed future tasks of INTREPID.

Most participants reported changes in their viewpoints about Interdisciplinarity driven by the exchange, joint learning, and identification of shared goals during the workshop. The fact that the workshop was planned and included skilled facilitation was considered beneficial. Yet, some participants mostly involved in applied work and non-academic professions raised frustration by the amount of time spent in discussing and clarifying concepts.

In regards to the planned tasks of INTREPID, one of the decisions was to develop a first draft of a collective dictionary based on the outcomes of the workshop. Today this dictionary is available on the on-line [INTREPID website](#). Its current format and content was based not only in Lisbon workshop but also in other interaction moments between INTREPID members. Nonetheless, the starting point was the Lisbon workshop.

The dictionary is entitled: “Collective dictionary & beyond interdisciplinarity” which highlights the collective understanding that in order to promote interdisciplinarity we need to do more than trying to define it . For now, the dictionary includes five sections (table 2). The first section comprises a working definition of multi-, inter and transdisciplinary. The second section ism designated “Working and integration towards a common goal, aim, problem or solution”, and includes a definition for: common goal, understanding the problems, integration, interface between academic and practice, collaborative problem framing, contracting disciplines, perspectives, target knowledge, solution orientated. The third section entitled “Links to extra-academics”, includes definitions of: Intensity of involvement of extra-academics, extra-academic knowledge, mutual learning, implementation-partners, practitioners, participatory settings, real world problems, stakeholder. The fourth section of the dictionary is titled “Boundary objects” and contains definitions for: wicked problems, transformation knowledge, societal problems, system knowledge, system, knowledge domains, transgression. The fifth and final session entitled “Accompanying side research” includes definitions of: trust, negotiation, reflexivity.

Table 2: Terms defined in the dictionary developed by INTREPID cost network.

| Collective dictionary & beyond interdisciplinarity | |
|--|---|
| Working definition | |
| Multidisciplinarity | Interdisciplinarity |
| Transdisciplinarity | |
| Working and integration towards a common goal, aim, problem or solution | |
| Common goal | Understanding the problems |
| Integration | Interface between academic and practice |
| Collaborative problem framing | Contracting disciplines |
| Perspectives | Target Knowledge |
| Solution orientated | |
| Links to extra-academics | |
| Intensity of involvement of extra-academics | Extra-academic knowledge |
| Mutual Learning | Implementation-Partners |
| Practitioners | Participatory settings |
| Real world problems | Stakeholder |
| Boundary objects | |
| Wicked problems | Transformation knowledge |
| Societal problems | System knowledge |
| System | Knowledge domains |
| Transgression | |
| Accompanying side research | |
| Trust | Negotiation |
| Reflexivity | |

The dictionary is defined as a constant involving tool, open for comments. Today, the suggested definitions have been agreed upon by all INTREPID members. Members have also agreed on the possibility of the revision of the online dictionary due to the constant evolution of our collective work in interdisciplinarity during INTREPID cost action.

3. Results interpretation and discussion

3.1. Can we collectively define Interdisciplinarity?

The literature shows that definitions of multi-, inter and transdisciplinarity are diverse, and they build on a wide array of concepts and understandings (Lang et al. 2012; Lawrence and Despres 2004), and change over time (Bruce 2004; Jahn 2008; Klein 1990, 2008; Kueffer et al. 2007). The overall results of the interdisciplinary exercise presented here provided evidences of such diversity. In the context of urban development, Figure 2 shows that while developing inter and trans-disciplinary work different communities use different languages, within a community some consistency of terminology exist. Figure 4 shows that for the INTREPID members that participated in the Lisbon workshop, “interdisciplinarity” and “urban” are two keywords. Therefore, one might expect that within a group where these two words are so prominent, achieving a common definition for interdisciplinarity would be an easy task. Yet, the results presented in Figure 5 suggest that even when interdisciplinarity is a common interest, the context in which we operate, the diverse experience and range of worldviews produce significant diversity.

However, diversity does not have to be an adversity. The outcomes of the Lisbon workshop show that although a common definition was not achieved (nor considered achievable, in reply to our first research question), that did not hinder the capacity to collectively discuss how to operationalized and promoted interdisciplinarity with quality. For INTREPID members, interdisciplinary definitions vary and its practice spans across different disciplines. Interdisciplinary practice creates interaction between disciplines, such as integration or collaboration. Interdisciplinarity can have common goals and aims, or be a collaborative effort for the creation of joint solutions. While some researchers recognize the relevance of extra-academic knowledge here, we propose that this may not be essential for interdisciplinarity, but mainly for transdisciplinarity.

By embracing the diversity of understandings of interdisciplinarity we were able to collectively identify our common ground and initiate a discussion on what can promote interdisciplinarity and what are the best practices.

3.2. The suggested common ground for interdisciplinarity

Instead of adding to the large and far-reaching set of definitions that exist already, based on our results, we suggest certain building blocks required to make an understanding of collaboration between different knowledge domains transparent. These building blocks have been considered to be INTREPID’s common ground.

From the literature analysis, we were able to have a snapshot of the terminology used by different research communities working in urban areas with inter and transdisciplinary approaches. In Table 1 we observed that keywords such as ‘system’, ‘knowledge’, ‘society’, ‘value’, ‘complex’, ‘problems’, ‘frameworks’, ‘perspectives’ are well established and transversal; however, keywords such as ‘language’, ‘solution’, ‘target’, ‘domain’, ‘teaching’, ‘democracy’, ‘cooperative’ and ‘negotiation’ are

restricted to a few communities and possibly to specific trends of the overall communities identified in Figure 2. The question that can be posed is does the lack of use of these keywords reflects the lack of importance of these concepts, insufficient recognition of their actual importance or that they are implicitly recognized as important. Our results suggest that the last two possibilities might explain Table 1 results. The same words found to be less frequent in the literature (Table 1) were present along the overall work developed during the Lisbon workshop, either explicitly or implicitly.

Dealing with language diversity and communication: Creating a dictionary to promote understanding and future interaction

Although “language” was not formally referred to during the brainstorming (figure 5), the lack of a coherent language and a communication protocol were often mentioned during the world café. INTREPID members agreed that communication fosters interdisciplinary collaboration, and can be considered a precondition to create bridges between different knowledge domains. The development of a dictionary highlights its importance for the INTREPID network.

Combining problem and solution oriented approaches to drive interdisciplinarity

Problem-oriented approaches are prevalent in the literature (Kueffer et al. 2012), spanning across different disciplinary settings (de Vos et al. 2013; Roman et al. 2011; Scholz and Steiner 2015). Solution-orientated approaches go one step further (Childers et al. 2014; DeFries et al. 2012; Hart et al. 2015; Matson 2009) by focusing on solutions, instead of focusing on problems (Wiek and Kay 2015). Using this approach, the vision that is co-produced by all participants in the research process includes integration, reflection and communication (Miller et al. 2014). In Figure 5 it can be observed that the word ‘solution’ is explicitly referred while defining transdisciplinarity and is implicitly linked with multi and transdisciplinarity when words such as ‘problem solving’ and ‘problem centered’ are used. INTREPID members considered that a combination of problem and solution approaches are needed, as frameworks or approaches where different actors- if necessary including intra- and extra-academics- work together towards understanding problems and finding solutions. This is a change in mindset, and in the overall way that research is structured. By identifying problems and visioning solutions these approaches can clearly aid crossing disciplinary boundaries, because they allow for scenarios and back casting.

Boundary objects as structuring elements of interdisciplinarity

The word ‘target’ listed in Table 1, was not part of the words used by INTREPID participants along the workshop, yet it can be linked to the need to work towards a common goal as well as target knowledge.

A common goal can serve as a boundary object towards interdisciplinarity and it can be an important catalyst to make interdisciplinarity more concrete, and ultimately more goal oriented. If we define a concrete goal - such as societal change in a specific system setting - then this joint goal or outcome can serve as a boundary object. The need to

arrive at common goals has been defined as a baseline for interdisciplinary research (Wiek 2007), since it enables researchers to achieve multiple perspectives (Scholz and Tietje 2001) while focusing on goals and aims (Vilsmaier et al. 2015).

A prominent knowledge driven approach is system, target and transformational knowledge types (Change 1997). Target knowledge refers to the scope of action and problem-solving measures given by the natural constraints, social laws, norms and values within the system, and the interests of actors and their individual intentions (Jahn, 2008). A comprehensive evaluation of desired target states, potential risks and benefits under prevailing uncertainties is needed; thereby target knowledge determines the plausible system development (ProClim, 1997).

Another important concept that can serve as a boundary object, and is linked with the word 'domain' presented in Table 1 is knowledge domains. Instead of talking about expert, scientific or lay knowledges, different forms of knowledge can be formalized in order to create typologies understood as knowledge domains. These domains can be used by actors within and outside academia and should be included whenever needed. The use of the term 'knowledge domain' would make the distinction between various concepts unnecessary, including inter- and transdisciplinarity. While there is an established branch of science, that designates collaboration between scientists and stakeholders as transdisciplinary, definitions of this term vary, especially in the United States (Brandt et al. 2013; Robinson 2008). By talking of knowledge domains instead of disciplines, we are able to include knowledge from both inside and outside of academia, which reduces confusion on how to label extra-academic knowledge. Focusing on knowledge domains instead of disciplines can enable solution-oriented agendas.

Formalization of the role of interdisciplinary facilitators

In the Lisbon workshop, as Figures 3 and 4 exemplify, most participants were involved in research, universities and teaching; therefore implicitly, the keyword teaching (Table 1) was well represented, although it was not linked to multi-, inter- or transdisciplinarity during the brainstorming activity (Figure 5). Nonetheless teaching, learning, education is one of the pillars of action of INTREPID.

The planning, structuring and organization of the research process are among the most important parts of interdisciplinary and transdisciplinary research (Lang et al. 2012). Through joined spaces, exchange and by meta-coordination between disciplines (i.e. a supra-level organization to coordinate or integrate research) an important foundation is provided for inter- and trans- disciplinary research (Bergmann et al. 2010). During the world café, participants concluded that many of them have been facilitating interdisciplinarity within their profession. This was not something someone else taught them to do; rather it was something they needed to do, enjoyed doing and had built competence in doing. This facilitator role is linked to other less frequently used words in inter or transdisciplinary urban literature – cooperative and negotiation (Table 1).

In order to allow for a sufficient reflection about context, integration and communication, we emphasize the necessity of interdisciplinary facilitators. While this is recognized within science, it is not prevalent. In addition, funding agencies are slowly recognizing interdisciplinary research as a specific category within their evaluation schemes. Most European Union research projects in the FP7 Framework or Horizon 2020 include researchers from several disciplines. While many resources are invested in supporting different disciplines, the proportion of resources allocated to create collaboration across knowledge domains is much lower. Several national funding schemes are already establishing these knowledge domains and recognize the necessary structural changes within the research process. However, such structural changes are slow and demand recognition beyond the national scale. In order to cross disciplinary borders and harmonize different approaches, languages and incentives, interdisciplinary facilitators can make a crucial contribution. In addition, more knowledge about what is required to cross boundaries between different knowledge domains is required. By providing adequate resources for facilitators and by recognizing interdisciplinary collaboration in research funding schemes, new domains of knowledge can be promoted, building bridges towards stronger integration and creative solutions to real world challenges.

Inter- and transdisciplinary are predominantly conducted with an awareness and recognition of different disciplines, but also often with the aim to challenge this mindset (Wernli and Darbellay, 2016). The recognition of disciplinary research is necessary in order to guarantee scientific excellence and integrity within disciplines (Klein 1990), yet these well-established structures can also create borders. Although by the use of the term knowledge domains we would not necessarily need to refer to disciplines, they are the backbone of academia. Therefore, facilitation of exchanges between existing disciplines is a baseline of interdisciplinary collaboration. During the workshop, this facilitator role was described as the development of competences for promoting collaboration, creation of trust, organization of space and the necessary time to undertake interdisciplinary work, which also includes several moments of negotiation. Therefore, trained facilitators can enable the formulation and implementation of diverse and well-defined interdisciplinary research agendas.

The need for accompanying side research

Another role that participants felt is needed, especially in interdisciplinary processes, is of accompanying side research. The term 'accompanying research' derives from the Danish term 'følgeforskning', which does not have a direct English equivalent (Christensen et al. 2016). The idea is to accompany research activities and by providing an external view on what is occurring being able to change these activities along the research process. This accompanying research is designating a collaborative research process strategy in which extra-academics in a given field and the academic researcher accompany each other both in the practices of a specific project or practice and in reflecting on it and on its investigation (Christensen et al. 2016). Protocols on this branch of science are rare. Approaches in medical research demonstrate the effectiveness of embedded accompanying research in clinical practice. Other branches

of science, such as psychology, have comparable approaches. Accompanying research should be understood as a kind of ‘meta-method’ for how to create and develop research relationships, rather than a specific set of guidelines for how to collect or process data. In that sense, traditional methods like the interview, observation or shadowing can be included as a part of a larger accompanying research design setup (Christensen et al. 2016).

Accompanying side research can promote reflection and reflexivity. Reflection implies analyzing, discussing, experiencing, thinking ahead. Interdisciplinarity needs to be able to gain reflecting perspectives, which can be promoted by an external analysis. Reflecting perspectives in interdisciplinarity can increase learning from experience, promotion of deep learning, acquisition of new knowledge and skills, understanding of own beliefs, attitudes and values and improvements of personal confidence.

Concluding remarks

Interdisciplinarity demands resources. It is clear that the integration of diverse knowledge domains will cost more than the mere continuation of a discipline-based research. However, the complexity of real world problems is increasing, and society today faces wicked problems that demand multiple approaches (Waddock 2013). Being objective and creating reproducible knowledge will demand resources. We propose that it is time for both researchers and policy makers to recognize this. We propose that a conscious reflection about the different forms and approaches required to integrate knowledge domains is necessary. Ultimately, we need the collaboration required to solve specific problems or work towards solutions. Recognition that interdisciplinarity needs to move beyond the use of the term and evidence of how it is being done needs to be shared between communities. Interdisciplinary facilitators can play a key role in these processes, and their role should be supported by research funding in order to increase our knowledge about interdisciplinary collaboration. Integrating frameworks and shared goals about solutions can serve as catalysts to increase the motivation or even effectiveness in fostering interdisciplinarity. This can trigger a transformation of science itself, allowing for those structural changes necessary to jointly collaborate - both inside and outside of academia.

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