



CASE 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 research practices within academia. Although there is a consensus about the need to apply these practices, there is no agreement over definitions. Building on the outcomes of the first year of the COST Action TD1408 “Interdisciplinarity in research programming and funding cycles” (INTREPID), this paper describes the similarities and differences between interpretations of inter- and transdisciplinarity. Drawing on literature review and empirical results from participatory workshops involving INTREPID Network members from 27 different countries, the paper shows that diverse definitions of inter- and transdisciplinarity coexist within scientific literature and are reproduced by researchers and practitioners within the network. The recognition of this diversity did not hinder the definition of basic requirements for inter- and transdisciplinarity. We present five basic units considered as building blocks for this type of research. These building blocks are: (1) creation of collective glossaries, (2) definition of boundary objects, (3) use of combined problem- and solution-oriented approaches, (4) inclusion of a facilitator of inter- and transdisciplinary research within the team and (5) promotion of reflexivity by accompanying research. These were considered five basic units for effective inter- and transdisciplinary research although the 4th building block was also considered as “matrix” that holds all the others together.

Keywords Interdisciplinarity · Transdisciplinarity · Research-practice · Collaboration · INTREPID

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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 specialized knowledge about complex subjects led to the continuous establishment of different

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disciplinary methods, languages and traditions in the social sciences, the humanities and the natural sciences, it also created frictions for the collaboration between different disciplines (Klein 1990; Lawrence 2015). From this evolved multidisciplinary science which we define as science in which several disciplines operate side by side, and there is little or no exchange occurring within different multidisciplinary research projects (Lawrence and Despres 2004). To enable and foster collaborative exchange between different scientific disciplines, several proposals have been made (Cummings and Kiesler 2005; Porter and Rafols 2009; Wagner et al. 2011). Nonetheless, interdisciplinary collaboration with a continuous exchange and active collaboration between different disciplines is still rare (Stokols 2011). While some of these proposals are focused on creating linkages by overcoming language barriers and differences between scientific cultures (Fischer et al. 2012; van Rijnsvoever and Hessels 2011), other proposals called for a new culture of science founded on convergence between disciplines (e.g. mode 2 knowledge production; Gibbons 2011). Although these discussions about interdisciplinarity have occurred for a long period (Klein 1990, 2008), surprisingly there is no consensus on the definition of ‘interdisciplinarity’.

Actors outside academia are often vital within research projects. Given that research policies shifted towards societal challenges and impact, this trend is ongoing (for example: EU CO 2013). In recent decades non-academic 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 “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 mentioned 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 academia in research has been questioned owing to the possible compromise of scientists’ procedures and rigorous standards (Lang et al. 2012).

Notwithstanding, methods to apply inter- and transdisciplinarity in practice are increasing independently of the ongoing discussion around the definition of concepts and how to differentiate transdisciplinarity from interdisciplinarity (Klein 1990, 2008; Brandt et al. 2013). Well known examples of conceptual frameworks building on inter- and transdisciplinary approaches include 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 problem framing and solution-oriented approaches (EC 2013; Lawrence 2015; Robinson 2008).

At least in the previous couple of centuries, science historically evolved in disciplines, yet a solution-oriented agenda might question the rigidity and sometimes the desirability of “disciplinary silos”. Solution-oriented research processes are concerned with outputs, 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. These solution-oriented approaches can be interpreted as using inter- and transdisciplinarity as modes in which science can operate. Therefore, in solution-oriented agendas inter- and transdisciplinarity are means rather than ends, and the overall goal is to propose solutions to specific wicked problems (Harris et al. 2010).

Inter- and transdisciplinary research and collaboration are increasingly seen as preconditions to solve grand societal challenges confronting societies and the planet today (De Grandis and Efstathiou 2016; Lang et al. 2012). However, although inter- and transdisciplinarity are increasingly central to science and research agendas, and are also recognized as a precondition for sustainability, their effective implementation in research projects is surprisingly rare, as already noted above. To enable a better understanding of how to achieve more efficient and effective inter- and transdisciplinary research, this COST Action focusing on “Interdisciplinarity in research programming and funding cycles” (INTREPID) was designed in 2014, and it began its network activities in May 2015: <http://www.intrepid-cost.eu/>. COST Actions are EU funding schemes that enable cooperation among different scientists from both technology and science domains.

INTREPID’s overall aim is to create a platform for reflection on the role and opportunities of inter- and transdisciplinarity 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. 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. 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 disciplinary combinations, including transdisciplinarity.

In this case report, our aim is to describe how the INTREPID Network is building a common understanding of (and debating dissent over) meanings of inter- and transdisciplinarity that is one of the core goals of INTREPID during the four-year period of the COST Action (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 multi/inter/transdisciplinarity. The research questions addressed are: (1) What are the characterizing features included in existing definitions of inter- and transdisciplinarity within the INTREPID Network? (2) What can be identified as common ground by analyzing the diverse interpretations within the Network of these multifaceted concepts? We have sought to answer these two questions through multiple methods including quantitative literature analysis and qualitative participatory processes, described in the following sections. The interest of this empirical exploratory process, which involved a large and diverse group of researchers and practitioners, is the identification of building blocks for inter- and transdisciplinarity. The identification of these building blocks, contributes to the current literature by demonstrating that within the existing diversity, common conditions exist and need to be understood for the effectiveness of these types of research.

Methodological approach and results

Figure 1 schematically explains the components of the methodological approach used to arrive at a collective understanding of inter- and transdisciplinarity in the INTREPID COST Action. These components include a literature review and a 3-day workshop comprising three sub-components to be explained below.

The starting point was a literature review and keyword cluster analysis that focuses on inter- and transdisciplinarity 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-day workshop that involved 62 of the 78 members of the INTREPID COST Action. Based on the literature review, a set of initial keywords was defined and was then handed out as input information at the workshop. The workshop, which

took place in Lisbon from 25 to 27 of November 2015, included three main components: a preliminary brainstorm session, a world café, and a final survey as shown in Fig. 1.

The literature review

The literature review started with a search in the Scopus database using the keywords: “urban*” and “interdisci*” or “transdisci*” in 2015. 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 at least once a year (755 articles). Note that 189 articles were excluded because of lack of institutional access. We acknowledge that this is not representative for all literature, because it represents a sub-section with an urban focus. However, since this is an arena and topic where many disciplines conduct research and interact, we consider this to be a suitable subset as a focus within INTREPID.

Taking into consideration the full text of the 566 selected articles, a multivariate statistical analysis was conducted of all relevant words that are related to the topic into an ordination (for details see Abson et al. 2014). Then 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” was used to characterize each article cluster by a significant indicator word that was used to label a specific cluster (for details see Dufrene and Legendre 1997). The analyses were conducted to find groups that are supported by the significant indicator words within the literature we examined, and to find overlaps and linkages within the literature.

Figure 2 shows clear and distinguishable thematic groups in the urban-related literature focusing on inter- and transdisciplinarity. 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.

Further in-depth analysis of how inter- and transdisciplinarity are used within this literature sample was completed by an automatic word count using keywords related to both concepts. Twenty-seven keywords were extracted from Lang et al. (2012) that describe design principles for transdisciplinary research that indicate twelve steps to develop transdisciplinary research. Lang et al. (2012) served as a baseline study because it suggests principles, integrates different strands of the literature, and accounts for experiences from transdisciplinary projects over

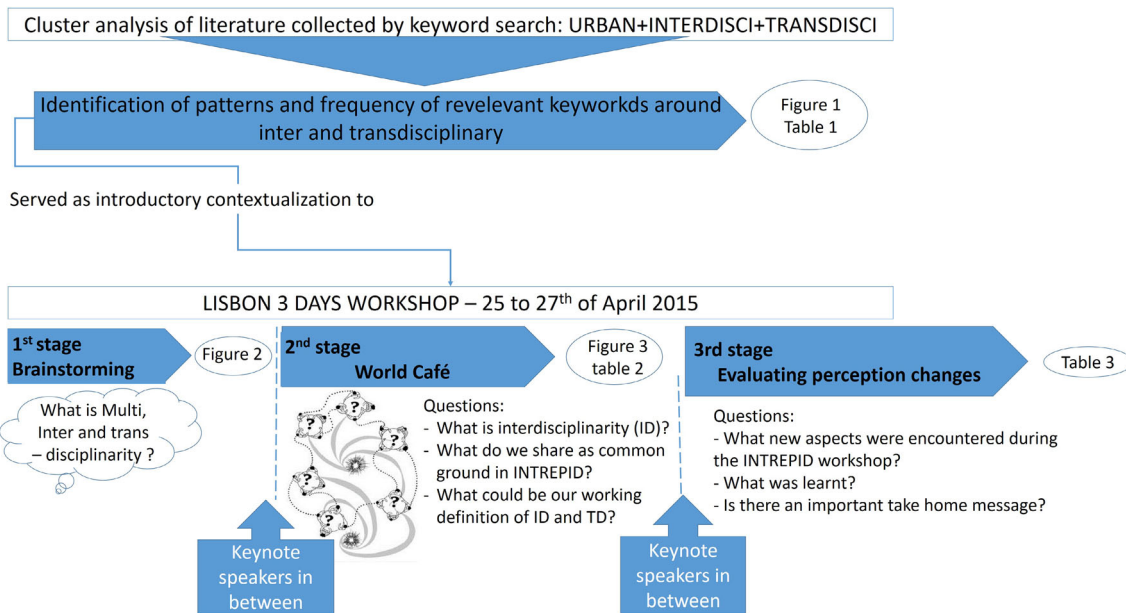
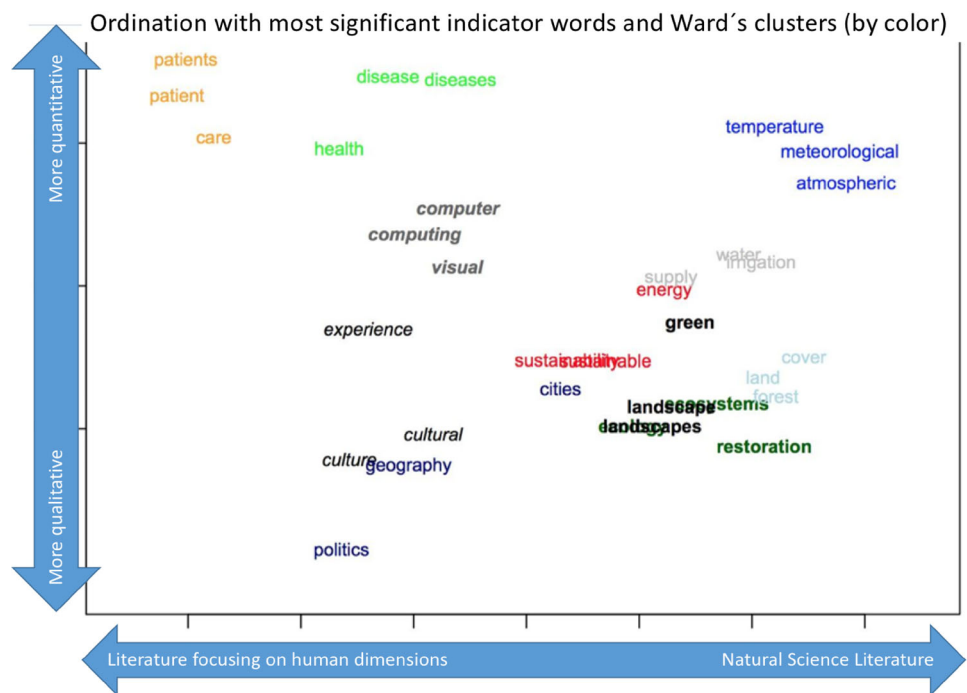


Fig. 1 Diagram of the methodological approach used to promote the collective understanding of inter- and transdisciplinarity within INTREPID COST Action. Keyword search on top indicates a

combination of the three words. The detailed search string is (Urban + Interdisci) OR (Urban + Transdisci)

Fig. 2 Full text analysis of well-cited publications in urban areas referring to inter- and transdisciplinarity ($N = 566$). Overlapping words are “sustainability” and “sustainable” (center in red), “landscape” and “ecosystems” and “landscapes” and “ecology” at the below right position. Labeling of the axis is our interpretation of the results. The Y-axis indicated how high or low the reference to sustainability science is made in the given publications



10 years. We are aware that this reference does not focus on interdisciplinary. However, Table 1 shows that important words from this branch of science are also included in Lang et al. (2012). Table 1 summarizes the results of this analysis. The quantity of articles that used a specific keyword varies from 87% for the word “system” to 12% for “negotiation”. Further, Table 1 shows the number of

articles that use each word more than 3 times. The word “system” is the most used word while “cooperative” and “negotiation” are the words least used, with only two articles using them more than three times.

Words related to system thinking are most abundant in the publications analyzed, highlighting the relevance of this concept within this branch of the literature. In addition,

Table 1 Percentage of articles that use at least once each keyword extracted from Lang et al. (2012)

Words extracted from Lang et al. (2012)	Mentioned (%)	More than 3 times (%)
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

The right column indicates the percentage of articles which use each keyword more than three times. This analysis highlights how abundant the different concepts and lines of thinking are in the literature. This allows insight into which of these are more important to the authors. We acknowledge that this is only a crude proxy, yet it provides some insight into the importance of the different words

the focus on knowledge underlines the importance of types and exchange of knowledge; in addition, terms related to stakeholders are abundantly explored, such as values and participants. Words indicating more scientific frameworks, conceptual thinking and methods are found in more or less half of the papers. The majority of words are used in half or less of the papers and only half or even a third of the papers use these words more than three times. Although the lack of abundance is no evidence or proxy it can be mentioned that although many papers mention certain keywords, the concepts might not be discussed in-depth.

The workshop

The workshop participants: the INTREPID network members

INTREPID COST Action includes 78 members of 27 countries (Fig. 3). In the Lisbon workshop, 62 of these members were present. Of these participants, 48% were

women and 21% were non-academic members of the network.

At the beginning of INTREPID COST Action participants were asked to provide a description of their research trajectory and research interest. Figure S1 contains a word cloud of the descriptions provided by the 62 participants in the Lisbon workshop, illustrating the focus on inter- and transdisciplinary approaches and urban issues shared by the INTREPID members. We started the workshop with a presentation and discussion of the results obtained from literature analysis. In addition, presentations from invited speakers served as an input to spark discussions and foster a reflexive setting within the workshop.

First stage of the workshop: the brainstorming activity

On the first day of the workshop, we presented the results of the literature review (“[The literature review](#)”) The results presented in “[The literature review](#)” served as a

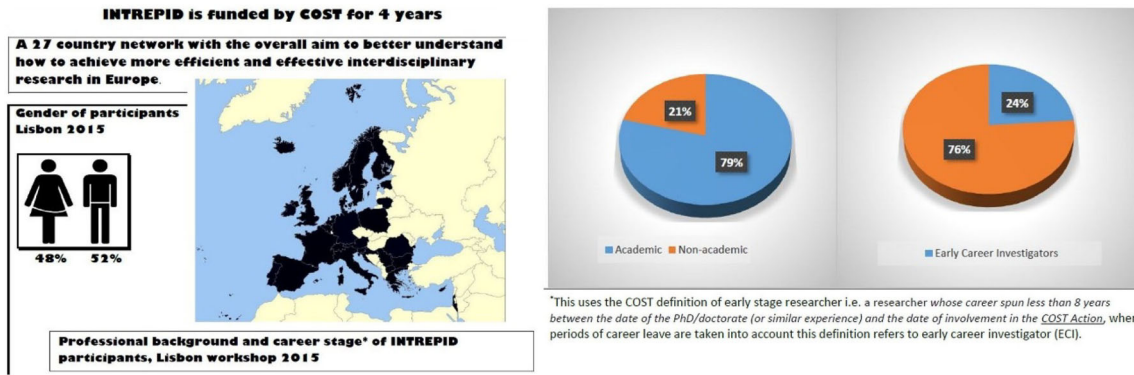


Fig. 3 Characterization of INTREPID COST Action and of the participants in Lisbon workshop

springboard to engage participants into an exchange with each other about inter- and transdisciplinary research in the urban context. After the presentation of the results described in “The literature review”, participants were asked to write on a post-stick one word that denoted each of the following concepts: “Multidisciplinarity”, “Interdisciplinarity” and “Transdisciplinarity”. This was an individual exercise and results were placed on a wall that everyone could revisit during the course of the workshop. Following this self-reflective exercise (Fig. 4), lectures by keynote speakers were given to provide participants with an overview of existing definitions and practical experiences with

inter- and transdisciplinary research processes. Each presentation was followed by plenary discussions.

The brainstorming activity results (Fig. 4) show that multidisciplinary was associated with the widest range and diversity of terms (i.e. 21 different words), which indicated less coherence in interpreting the term among participants. However, the mere number of different terms does not entail either that the terms represent a wider range or more diversity. Multidisciplinarity is linked to words to hint at connecting disciplines and integrating diverse perspectives; interdisciplinarity is associated with similar concepts, but also with words that indicate the idea of a joined

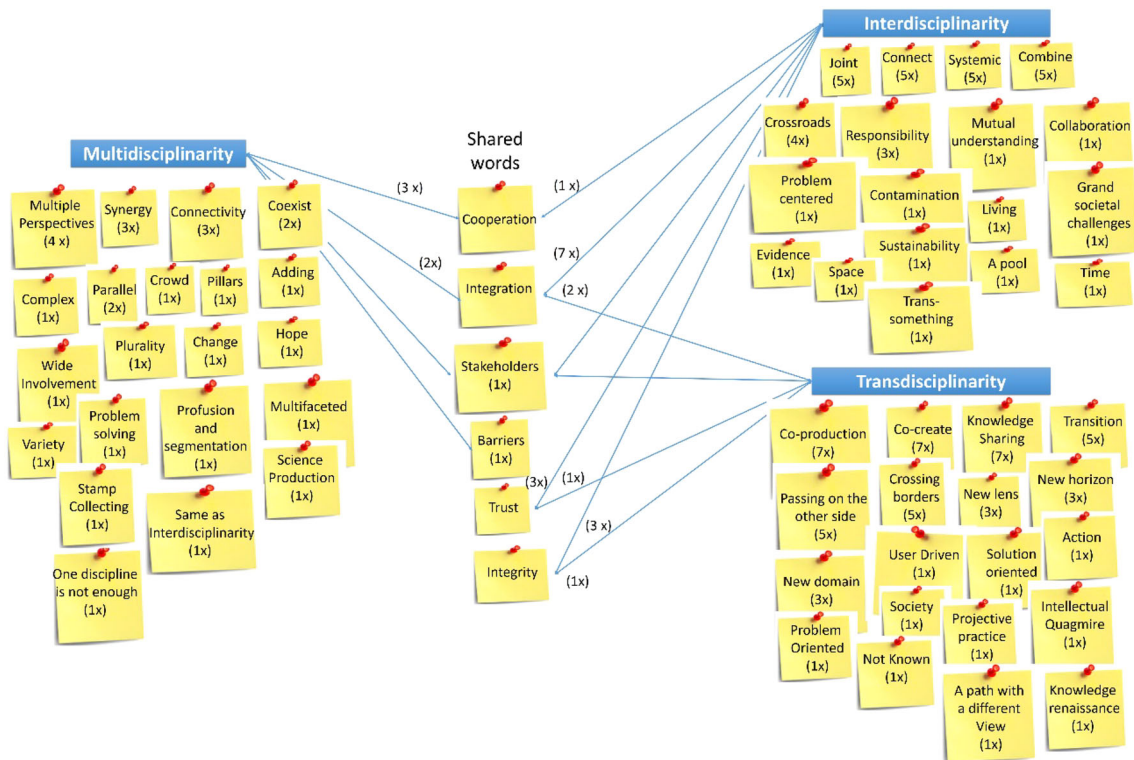


Fig. 4 Results of the brainstorming activity at the beginning of the Lisbon workshop. The numbers in brackets refer to the number of times the word was mentioned

perspective as well as some words that have a more normative dimension. Transdisciplinarity is most commonly associated with words that indicate normative dimensions, as well as change and dimensions of knowledge. Overall, the strong overlap of certain words that are shared among multi-, inter- and transdisciplinarity (e.g. cooperation, trust and integration) are recognized across all three domains.

Comparing the words that occurred several times, the maximum number of times a word repeated in the case of multidisciplinary was four (i.e. “multiple perspectives”). Five words used to describe multidisciplinary were also used while thinking about interdisciplinarity (i.e. “cooperation”, “integration”, “trust”, “integrity” and “stakeholders”) while four 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 most repetition was observed (Fig. 4). Words such as “co-production”, “co-create” and “knowledge sharing” were mentioned seven times in association with transdisciplinarity. Interdisciplinarity and transdisciplinarity were linked to 18 + 19 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).

Second stage of the workshop: the world café

The world café activity was scheduled in two different rooms due to the high number of participants. In each room, there were four working groups. After 40 min participants changed tables while one person per table, designated as rapporteur, stayed and recorded the main conclusions. The number of participants per table was 5–6, which then rotated 3 times. There was no pre-arranged distribution of participants. Over a period of 120 min (3 × 40), participants discussed the following pre-arranged questions, discussing all questions on all tables all three 40 min time slots:

1. What is interdisciplinarity?
2. What do the INTREPID Network participants share as common ground?
3. What could be shared working definitions of interdisciplinarity and transdisciplinarity?

Each table discussed all the three questions and rotation was used to increase interaction between the participants.

By the end of the discussion, eight summaries were collected, representing each of the groups’ discussions.

Several overlapping ideas emerged when comparing the summaries of the groups’ discussions. The content analysis of all summaries revealed a common ground whereby interdisciplinarity implies exchange, sharing and integration for mutual understanding. However, the boundary of interdisciplinarity and its differentiation from 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 can also involve non-academic partners in different ways. For example, architects, were involved in many interdisciplinary studies of urban development. During these discussions, definitions of academia and research were questioned since research practices occur outside of academia. Hence talking about researchers and non-researchers does not distinguish between those that are within academia from those outside. Actors outside academia can be expert on a specific field and undertake research activities (Lawrence 2017). Therefore, one group proposed to use the term extra-academic for those actors that develop activities (including research) outside academia.

A general conclusion from the group and plenary discussions was the difficulty in achieving a unique definition for interdisciplinarity within INTREPID COST Action. This is not surprising because it reflects the findings of the literature review.

During the world café, and while replying to question 2 and 3 the groups continued discussing what is needed to allow interdisciplinarity to work effectively, and what is essential to foster exchange, sharing and integration for mutual understanding between disciplines as well as actors 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 to work within collaborative settings that enable information, integration and collaboration.

Focusing on the participatory setting, two crucial aids for interdisciplinarity were identified:

- inter- and transdisciplinary facilitators (i.e. individuals who focus on the management of the interaction between inter- and transdisciplinary teams and on the ordering of the achievements of these collective processes);

- accompanying research, which we define as research done by individuals not engaged in the research activities, but who are capable of interacting with it, observing it, and documenting it, so that a constant and cumulative reflection process occurs and contributes to the progression of the research agenda.

Although there was not sufficient time to clearly define these two roles, they were linked to the need to create an environment of trust, the capacity and space to negotiate research processes, and agreement about codes of conduct (Lawrence 2017). Finally, reflexivity was considered of great importance for inter- and transdisciplinarity, and the role of a facilitator was linked to the promotion of such activity. We acknowledge that reflexivity can be both the reflexivity of individuals as well as an overall team. In addition, with an accompanying researcher, an external (e.g. outside the research process) reflecting perspective could be promoted, and reflexivity could be increased. The accompanying researcher could provide an external perspective to the internal reflexivity process by the identification of possible biases or blind spots.

Last stage of the workshop: evaluating perception changes

During the last day of the workshop, we reviewed of the outcomes produced previously. Most participants reported

changes in their viewpoints about inter- and transdisciplinarity 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. However, some participants involved in applied work and non-academic professions expressed their frustration about the amount of time spent in discussing and clarifying concepts.

Regarding planned tasks of the INTREPID Network, one decision was to develop a first draft of a glossary based on the outcomes of the workshop. Today this glossary is available on INTREPID website. Its current format and content was based not only on the Lisbon workshop but also on other interaction moments between INTREPID members.

The glossary includes five sections (Table 2). The first section comprises a working definition of multi-, inter- and transdisciplinarity. The second section is designated “Working and integration towards a common goal, aim, problem or solution. The third section is titled “Links to extra-academics”; the fourth section of the glossary is titled “Boundary objects”. Boundary objects are analytical concepts that have a shared interest by researchers in different disciplines. Given that they are interpreted differently by scholars, collaboration across disciplinary boundaries can enable an enriched understanding (Star and Griesemer 1989). This is precisely what the INTREPID

Table 2 Terms defined in the glossary developed by INTREPID COST Network

Glossary at http://www.intrepid-cost.eu/	
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 research	
Trust	Negotiation
Reflexivity	

Workshop achieved. The fifth and final section is entitled “Accompanying research”, which includes definitions of trust, negotiation, reflexivity. This glossary reflects all words that seemed valuable to the research community, given our analyses and all the steps of the workshop. While naturally more words could be defined, these words were most abundantly used and often also most controversial. The glossary was compiled after a lengthy exchange within the group via an online editing process, where all members could contribute to reaching a joined definition.

The glossary is proposed as a constantly evolving tool, accessible for comments. Today, the suggested definitions have been agreed by all INTREPID members. They have also agreed on the possibility of the revision of the online glossary due to the constant evolution of our collective work in inter- and transdisciplinarity during INTREPID COST Action.

Interpretation and discussion

Can we collectively define inter- and transdisciplinarity?

The overall results of the exercise presented here provide evidence of diversity as well as common ground when trying to reach a definition for inter- and transdisciplinarity. In the context of urban development, Fig. 2 shows that while developing inter- and transdisciplinary projects different communities use different languages, and within a community some consistency of terminology exists. Figure S1 shows that “interdisciplinary” and “urban” are two keywords used by participants at the INTREPID workshop. 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. However, the results presented in Fig. 4 suggest that even when interdisciplinarity is a common interest, the diverse experience and range of worldviews of participants can produce significant diversity. Such diversity has been pointed out before due to the array of concepts used to define of multi-, inter- and transdisciplinarity and the changes of understandings over time (Repko and Szostak’s 2017; Lang et al. 2012; Jahn 2008; Klein 1990, 2008; Kueffer et al. 2007; Bruce et al. 2004; Lawrence and Despres 2004). The resourceful website of Td-Net in Switzerland also addresses definitional issues and concludes that “if the different definitions of inter- and transdisciplinarity serve different purposes, then the paradox—how can different definitions be true at the same time?—dissolves. This is only a paradox as long as we seek a general definition that is valid in all contexts. However, if definitions single out specific aspects of inter- and

transdisciplinarity—if they narrow the complex, all-embracing idea to serve a given purpose—then the paradox is replaced by the question of how well a definition suits a given challenge. The plurality of definitions becomes an opportunity for finding the most useful and appropriate definition in a particular project context.”

Therefore, diversity should not be interpreted as disagreement. The outcomes of the Lisbon workshop confirm this; although a common definition was not achieved (nor considered achievable, in reply to our first research question), this lack of a joint definition did not hinder the capacity to collectively discuss how to operationalize and promote inter- and transdisciplinarity in urban research. For INTREPID participants, and many other research networks, definitions of inter- and transdisciplinarity are variable. Nonetheless, inter- and transdisciplinarity can have common goals and aims, or be collaborative efforts for the creation of joint solutions (Christensen et al. 2016; Abson et al. 2014; Lang et al. 2012; Harris et al. 2010; Pohl and Hirsch Hadorn 2008). While some INTREPID members recognize the relevance of extra-academic knowledge, we conclude that this may not be essential for interdisciplinarity; however it is a commonly understood ingredient of transdisciplinarity (Lang et al. 2012; Lawrence 2015).

By embracing the diversity of understandings of inter- and transdisciplinarity, the INTREPID Network was able to collectively identify a common ground and initiate a discussion on what tools, methods and practices can promote inter- and transdisciplinarity. This common ground is characterized by building blocks that are presented and discussed in the following section. We use the idea of building blocks since the features presented are considered basic units from which inter- and transdisciplinarity can be constructed.

Common ground for inter- and transdisciplinarity

We propose sets of building blocks to improve shared understanding of collaboration between different participants in inter- and transdisciplinary research. These building blocks have been defined by taking into consideration the outcomes from the literature analysis and the discussion during the Lisbon workshop.

From the literature analysis, we were able to obtain 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 research communities. The question that can now

be posed is: Does the lack of use of these keywords reflect the lack of importance of these concepts, or insufficient recognition of their actual importance, or that they are implicitly recognized as important? The results from this workshop suggest that the last two possibilities might explain Table 1. The same words found to be less frequent in the literature (Table 1) were present either explicitly or implicitly during the Lisbon workshop. From this analysis, we conclude that the first building block answers to the need of dealing with key concepts. Within an inter- and transdisciplinary setting, there is a need to make explicit the understanding of all key concepts. Abson et al. (2014) provide a concrete example of how a taken for granted concept, such as ecosystem services, is multifaceted and its definition needs to be revisited to improve its utility for sustainability in precise situations.

Building block 1: dealing with language diversity and communication: Creating a glossary to promote understanding and future interaction

Although “language” was not formally referred to during the brainstorming (Fig. 4), the lack of a coherent language and a communication protocol were often mentioned during the world café. INTREPID members agreed that communication fosters inter- and transdisciplinary collaboration, and can be considered a precondition to create bridges. The development of a glossary highlights its importance for the INTREPID Network. Creating a joint understanding and definition of the problem to be dealt with by inter- and transdisciplinarity has been previously described as a required step for inter- and transdisciplinarity (Scholz and Steiner 2015; Lawrence 2015; Lang et al. 2012). However, there are also arguments against the use of a strict linguistic coordination (Choi and Richards 2017), and what can be helpful in one context can be a barrier in another context, e.g., in terms of the hierarchy of actors (Jakobsen et al. 2004). However, in this specific concept we have created a common glossary to fulfill the needs expressed by the participants of the INTREPID Network. We left the glossary open to change and discussion; therefore, it is not a strict linguistic coordination effort but a springboard for joint definitions, integration of language diversity and communication. Our results highlight that joint understanding needs to make explicit what we mean when using certain concepts. This can be a time-consuming process, but it can also be understood as an ice-breaking requirement that prepares the grounds for effective inter- and transdisciplinarity. After or in parallel with this process, the definition of boundary objects can also contribute to advancing inter- and transdisciplinary dialogue.

Building block 2: boundary objects as structuring elements of interdisciplinarity

The word ‘target’ listed in Table 1, was not one of the words used by INTREPID participants during the workshop, yet it can be linked to the need to work towards a common goal. A common goal can serve as a boundary object for inter- and transdisciplinarity and it can be an important catalyst to make inter- and transdisciplinarity more concrete, and ultimately more solution oriented. A boundary object was first defined by Star and Griesemer (1989; 389) as “objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites”. 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 to approximate a solution. The need to arrive at common goals has been defined as a baseline for inter- and transdisciplinary research by several other authors, because it enables researchers to achieve multiple perspectives while focusing on goals and outcomes (Vilsmair et al. 2015; Wiek 2007; Scholz and Tietje 2002).

INTREPID members have also defined the production of transformation knowledge as a boundary object. A prominent classification of knowledge includes 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). Transformation knowledge refers to the practical implications that can be derived from target knowledge to change existing habits, practices and institutional objectives. Transformation knowledge enables practitioners to evaluate different problem solving strategies and to achieve the competence to foster, implement, and monitor progress, and to adapt and change behavioral attitudes (Hirsch Hadorn et al. 2008).

In relation to this manner of classifying knowledge, INTREPID members considered that to achieve transformation knowledge there is need to combine efforts developed within problem- and solution- oriented approaches. Consequently, we propose that inter- and transdisciplinary efforts can evolve faster if participants share a joint problem or strive towards joint solutions collectively.

Building block 3: combining problem- and solution-oriented approaches to drive inter- and transdisciplinarity

In Fig. 4, the word ‘solution’ is explicitly mentioned when defining transdisciplinarity. It is implicitly linked with multi-, inter- and transdisciplinarity when words such as ‘problem solving’ and ‘problem centered’ are used. INTREPID members considered that a combination of problem- and solution- oriented approaches are needed, as frameworks when different actors work together towards understanding problems and finding solutions. Problem-oriented approaches are prevalent in the literature, spanning across different disciplinary settings (de Vos et al. 2013; Kueffer et al. 2012; Roman et al. 2011; Scholz and Steiner 2015). Solution-oriented approaches go one step further by focusing on solutions, instead of focusing only on problems (Wiek and Kay 2015; Hart et al. 2015; Childers et al. 2014; DeFries et al. 2012; Matson 2009)). Using this approach, the vision that is co-produced by all participants in the research process includes integration, reflection and communication (Lawrence 2017; Miller et al. 2014). The combination of problem- and solution-oriented approaches is a change in mindset, and in the overall way that conventional research is organized. By identifying problems and visioning solutions those approaches that allow for scenarios and back casting, can aid crossing disciplinary boundaries.

Although the above building blocks have been considered catalysts of inter and transdisciplinary work, the following one was discussed not just as a basic unit but also as the “cement” that puts them all together.

Building block 4: formalization and adequate recognition of the role of inter- and transdisciplinary facilitators

In the Lisbon workshop, as shown in Figs. 3 and 4, most participants were working at Universities and hence involved in research 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 (Fig. 4). During the world café, participants concluded that many of them have been facilitating inter- and transdisciplinarity within their profession. This was not something someone else or an institutional setting 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). During the workshop, this facilitator role was described to enable collaboration, creation of trust, organization of space and the necessary time to undertake inter- and transdisciplinary work, which also includes several moments of negotiation.

Therefore, trained facilitators can enable the formulation and implementation of diverse and well-defined inter- and transdisciplinary research agendas.

The role of a facilitator in inter- and transdisciplinarity is referred by several authors not in a formalized manner, but rather as a function that needs to be incorporated when developing this type of research. For instance, Lang et al. (2012) argues that the planning, structuring and organization of the research process are among the most important parts of inter- and transdisciplinary research. Institutions such as the Socio-Environmental Synthesis Center (SESYNC) endeavors are early examples of attempts to facilitate such approaches (Palmer et al. 2016). Bergmann et al. (2010, 2012) discusses the need for joint spaces that support the exchange of meta-coordination between disciplines by a facilitator (i.e. a supra-level organization to coordinate or integrate research) as an important foundation for inter- and transdisciplinary research.

The necessity to facilitate collaboration between researcher has long been recognized, (Okhuysen and Eisenhardt 2002), and the USA National Research Council highlighted in 2015 the importance of team science (National Research Council 2015). Other researchers suggest the embeddedness of philosophers into wider research (Tuana 2013), thereby having philosophy serve as a catalyst within inter- and transdisciplinary collaboration. Nonetheless, as several INTREPID members stated, insufficient recognition within academia has been attributed to the role of the facilitator of inter- and transdisciplinarity. Although this role requires specific skills that need to be trained, it also implies the application of methodologies by which outcomes are achieved and can be extrapolated with an added value to the overall community of inter- and transdisciplinary researchers. Such a role was not perceived as a type of technical work but as a scientific field where a lot of experimentation is yet to be done. Recent accounts prove that much ground is still to be covered (Piso et al. 2016), since the combination and sequence of different research steps is not well understood to date.

Therefore, we emphasize the necessity of inter- and transdisciplinary facilitators that allow a sufficient reflexivity about context, dialogue, communication, and building a shared conceptual framework. 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 facilitate collaboration is much lower. Several national funding schemes already recognize the necessary structural changes within the research process. However, such structural changes are slow and demand recognition beyond the national scale. To cross disciplinary borders and harmonize different

approaches, languages and incentives, inter- and transdisciplinary facilitators can make a crucial contribution. Providing adequate resources for facilitators and recognizing inter- and transdisciplinary collaboration in research funding schemes can promote stronger and more efficient, bridges towards integration and creative solutions to real world challenges.

Finally, INTREPID members also recognized a fifth building block linked with this one but that deserved an independent reference. The final building block was discussed as a possible operationalization and organization of the reflexive processes that should occur during inter- and transdisciplinary research processes. The capacity to reflect and to be reflexive during this type of research can make the creation of transformative knowledge an important achievement of these kinds of research. Therefore, INTREPID members argued for the need for accompanying research by an independent observer, also since this will enable an unbiased or at least less biased participation in the whole research process.

Building block 5: the need for accompanying 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 provide an external view-outside of the research team- on what is occurring (Bergmann et al. 2005) that is able to change these activities during the research process (Wagner and Ertner 2016). Although accompanying research is not a generalized custom approach in medical research, there are examples of the effectiveness of embedded accompanying research in clinical practice (Stokols et al. 2008).

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 agenda. However, the idea is to go a step further. By embodying the research process of the different communities working together, a more in-depth reflective process can be induced in participants to increase awareness and promote transformational change. (Christensen et al. 2016). Therefore, reflexivity implies analyzing, discussing, experiencing and thinking creatively ahead. Reflexive perspectives in inter- and transdisciplinarity 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. This type of experience can enable

participants in a reflexive process to apply what has been learned in future processes and actions.

Conclusions

Further establishing inter- and transdisciplinarity will demand a conscious and reflective facilitation and fostering of interactions. We propose that it is time for both researchers and policy makers to recognize this prerequisite, which will support and advance much of the current established research practice. Recognition that inter- and transdisciplinarity needs to move beyond using the terms and trying to define them toward sharing evidence of how they are done is an important advance provided by cases such as the one reported here inter- and transdisciplinary facilitators can play a key role in these processes and their role should be supported by research funding to increase our knowledge about inter- and transdisciplinary collaboration. Integrating frameworks and shared goals about solutions can serve as catalysts to increase the motivation or even effectiveness in fostering inter- and transdisciplinarity. 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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