Complex systems of knowledge integration:

A pragmatic proposal for coordinating and enhancing inter/transdisciplinarity

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Abstract

Humanity's biggest challenges call for organised collective action, informed by the most complex forms of thinking. Different forms of knowledge and practices of knowing operate at different levels of organisation within society. Scientific knowledge is one form of knowing, but the development of science under a culture of disciplinisation and increasing specialisation has led to its fragmentation and blinded it to the possibilities offered by the integration of knowledge. Interdisciplinarity and transdisciplinarity are privileged routes for rich knowledge construction and integration. There is a pressing need for efforts directed toward the intentional construction of a culture where interdisciplinary and transdisciplinary practices may flourish. However, we believe significant change will only occur through the orchestration of a set of activities that attend to the complexity of knowledge construction and integration as emergent outcomes of a complex network of processes and relations that constitute an evolving inter and transdisciplinary ecosystem.

In this paper we present a thought experiment in the form of a proposal for the organisation of an Alliance for Knowledge Integration and of Inter/Transdisciplinary Hubs aimed at coordinating collaborative actions and contributions from a diversity of agents and systems from different levels of organisation of society towards richer and more integrated practices of knowing.

Keywords: Knowledge integration; Interdisciplinarity; Transdisciplinarity; Complex systems

1. Context

Different forms of knowledge and practices of knowing operate within different levels of organisation of society (Bruun, Hukkinen, Huutoniemi & Klein 2005; Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow 1994). Scientific knowledge is but one form of knowing, to which a diversity of social processes contribute (Nowotny, Scott & Gibbons 2001). Nevertheless, at times, science has exceeded its explicit or implicit claims of supremacy (Haack 2011), becoming disconnected from other forms of knowing (Mazzocchi 2006). Additionally, a culture of specialisation and strong disciplinarity within science has led to a state of internal fragmentation (Weingart 2010) that leaves it blind to complexity and prone to accumulate ignorance (Morin 1990). Many voices have called for fundamental revisions in the modes of thinking and practices of science, for example towards increasing complexity (Morin 1990) and for incorporating more integrative, dialogic and collaborative modes of knowledge production and validation (Funtowicz & Ravetz 1994; Nowotny, Scott & Gibbons 2001).

There is a growing need for building new pathways towards a future capable of holding more diverse, albeit coordinated and creative ways of producing, applying, transforming and integrating knowledge. Interdisciplinarity and transdisciplinarity may be privileged routes for the production of knowledge that is congruent with the complexity of the world (Caves & Melo 2018). Such congruence is fundamental for an expansion of our possibilities for action in promoting positive and sustainable change in the complex world (Costanza et al. 2016; Caves

& Melo 2018), and to improve our individual and collective capacity to act upon those possibilities. However, interdisciplinarity and transdisciplinary are also domains that call not just for more coordinated practice but for a deeper understanding of their underlying processes.

In the last decades, there has been a significant growth in the literature on interdisciplinarity. It is not the purpose of this paper to review taxonomies and indicators to support the definition and assessment of different types of interdisciplinary research and we refer the reader to the numerous works in this area (e.g. Bruun et al. 2005; Huutoniemi, Klein, Bruun & Hukkinen 2010; Klein 2010). Some studies have focused on mapping territories and identifying the factors that affect the practice of interdisciplinarity, offering several recommendations (Bammer 2012; British Academy 2016; Bruun et al. 2005; Lyall, Bruce, Marsden & Meagher 2011). Attempts have also been made at defining indicators for interdisciplinary activities (Mansilla, Feller & Gardner 2006). The evaluation of interdisciplinarity at different levels (individual; project/team; institutional; peer scientific community/journals; national/funding strategies) has also received attention, being a critical factor for the dissemination of interdisciplinarity practices (Lyall & King 2013; McLeish & Strang 2016; Strang & McLeish 2015). However, interdisciplinarity per se, as a mode of research activity and knowledge acquisition, still calls for attention. As Lyall and collaborators have stated, “much of the knowledge regarding interdisciplinary research capacity-building is tacit, with practitioners often ‘learning by doing’ through a process of apprenticeship” (Lyall, Bruce, Tait & Meagher 2011, p. 10).

At a time when different research councils and funding agencies are calling for more interdisciplinarity, the lack of standard and generally accepted guidelines on what constitutes high quality interdisciplinary research, risks a deterioration of its value (Mansilla, Feller & Gardner 2006). This may be particularly true in face of the usage of ‘interdisciplinarity’ as a buzz word, increasingly applied to any activity or collaboration involving more than one discipline, without clear reference to the particular sets of processes and diverse modes of working it encompasses (Bruun et al. 2005). There is a diversity of practices that, although often labelled as interdisciplinary, in reality involve minimal interaction between different domains of knowledge, and would be better classified, at best, as multidisciplinary (Bruun et al. 2005; Boden 1999; Klein 2010), or “patchwork interdisciplinarity” (Hardon 2008). As Huutoniemi and collaborators have stated “in multidisciplinary research, the ingredients of new knowledge are imported, exported, or pooled across boundaries without being substantially adapted in the course of interaction. This kind of research is cumulative or additive rather than integrative by nature.” (Huutoniemi, et al. 2010, p. 83). The lack of clarity in the usage of terminology can lead to misunderstandings that undermine the potentialities of interdisciplinarity (Bammer 2012). As other authors have stated, interdisciplinarity is not synonymous with collaboration (Klein 2010) nor does it occur naturally or automatically (Lyll, Bruce, Tait & Meagher 2011).

We adopt the view of inter/transdisciplinarity (ITD) as strong forms of knowledge-based interaction between disciplines (and the individuals representing them), that, from a process perspective, implies some degree of perturbation in

one or all of the interacting elements (individuals, disciplines) (Boden 1999; Klein 2010; Melo 2018). The interdisciplinary interaction may feedback on the disciplines and lead to their transformation (e.g. epistemological, conceptual, methodological). Interdisciplinarity requires an “active interaction across fields” (Huutoniemi, et al. 2010, p. 83) and some form of integration that is “more than the sum of its parts”.

Transdisciplinarity has often been defined as a type of interaction that engages science and other social agents and systems in generating knowledge in contexts of application (Brunn et al. 2005; Nowotny et al. 2001). This notion often implies a clear focus on a particular real-world phenomenon, challenge or problem around or about which knowledge is constructed. Transdisciplinarity occurs through the integration of the synergetic, dynamic, processual and relational nature of the contributions, lenses and practices that are deemed necessary to embrace real-world complexity (Brunn et al. 2005). It may also imply the creation of conceptual or pragmatic frameworks that not only integrate, but truly transcend, disciplines (Brunn et al. 2005; Klein 2010; Stokols; Hall, Moser, Feng, Misra, & Taylor 2010). In this sense, transdisciplinarity can also be defined as a type of outcome, emerging from interactions (often interdisciplinary, but also involving diverse social agents) that exhibit an integrative nature, as a coherent ‘wholesome’ body of knowledge, eventually, with a corresponding set of practices for action. Additionally, transdisciplinarity should also lead to some degree of perturbation and change, and to transformation in the broader scientific and societal contexts where the practices of knowledge production unfold (Brunn et al. 2005; Nowotny

et al. 2001; Polk 2015). Through their capacity for the emergence of more complex knowledge and practices for coupling with the complex world, inter and transdisciplinarity constitute key resources for the understanding and management of positive change in human-related systems, increasing both our theoretical and pragmatical capacity (Caves & Melo 2018).

The quality of ITD can also be enhanced if purposively managed. There is a significant amount of accumulated experience and practice that needs to be considered (Lyall et al. 2011b). Nevertheless, we believe that the practice of inter/transdisciplinary needs to be linked, by a self-referential recursive loop, to the scientific (interdisciplinary) investigation of inter/transdisciplinarity (Müller & Riegler 2014).

Even though we are increasing our knowledge and understanding of the factors at multiple levels constraining or facilitating interdisciplinary collaborations, the processes that underlie the interaction of different types of factors, and how these lead to particular types of outcomes is still largely unknown (Stokols, Misra, Moser, Hall and Taylor 2008; Börner, Contractor, Falk-Krzeskinski, Fiore, Hall, Keyton, Spring, Stokols, Trochim and Uzzi 2010). It is necessary to invest in more process-focused research (Stokols et al. 2010) aimed at identifying how different factors and components of an inter/transdisciplinary system couple and transform, through time, and in relation to each other (Mansilla 2010; Stokols et al. 2008).

Inter/transdisciplinary interactions may lead to the type of abductive (Fann 1970; Melo 2018) and imaginative (Whitehead 1978) leaps that have been the key

drivers of the development of science, technology and society (Rozenboom 1997), albeit sometimes serendipitously (Darbellay, Moody, Sedooka & Steffen 2013). On this basis, we believe that the investigation of the processes of ITD may benefit from complex systems-inspired perspectives and models. In this paper we approach interdisciplinarity and transdisciplinarity together (ITD) as we believe they both imply the emergence of some degree of novelty and hence require additional attention to the processes sustaining this complexity.

2. The complexity of inter/transdisciplinarity: a complex systems-informed relational worldview

Interdisciplinary systems exhibit properties of complex systems e.g. social systems (Nicolis & Nicolis 2007). They are based on a variety of dynamic interactions from which novelty, surprise and creativity emerge, along with knowledge that could not be foreseen from the perspective of any individual or discipline alone, nor from the mere juxtaposition of their skills. This creative potential is likely associated with non-linear interactions between a diversity of components and processes involved in ITD activity.

We assume inter/transdisciplinary knowledge and integration to be emergent products of complex social systems. Therefore, one needs to recognise the multidimensional, relational, coupled and non-linear nature of the dynamics of any knowledge production system. Inter/transdisciplinary interactions can be organised in many ways and, under different conditions, can lead to a variety of (more

or less) positive or negative emergent outcomes. In this paper, ‘positive’ inter/transdisciplinary encompasses the emergence of some form of novelty (theoretical, methodological, pragmatic) and knowledge integration and the enrichment of the interacting elements (e.g. individuals, disciplines). Additionally, it needs to lead to positive outcomes in relation to a framework of the purposes and values that motivate, guide or legitimate its activities, as assessed by a given observer (Lissack 2017). By contrast, ‘negative’ ITD leads to fragmentation, conflict or unproductive/destructive outcomes or the absence of novelty, both in relation to the purpose of the interaction and its interacting elements. Additionally, it represents a negative evaluation of its outcomes, from a given observer, in relation to a purpose or value framework.

Every inter/transdisciplinary system will likely be organised differently, not only as a function of the diversity of its interacting elements (e.g. individuals, disciplines, social systems) and the nature of their interactions, but also of the surrounding environment and, above all, the nature of the couplings within and between its levels of organisation (e.g. individual, team, disciplines, institutional environment, scientific community, society in general) (Börner et al. 2010).

In this section we present a scheme that incorporates multiple levels of organisation of ITD, as in other proposals (e.g. Stokols, et al. 2008), but where we wish to place the emphasises on the coupling processes and their role in the emergent outcomes. Based on a previous proposal of a relational metamodel to conceptualise change in complex systems (Caves & Melo 2018), and a subsequent elaboration for particular types of social systems (Melo & Alarcão, in

preparation), we present, in Figure 1, a possible representation of a complex systems-informed relational worldview for ITD.

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We call attention to the coupling processes within and between levels, and to the fact that different configurations of properties and processes will lead to and sustain different types of positive and negative emergent outcomes. While we anticipate that there will be some content/context-dependent specificity to particular inter/transdisciplinary interactions, it is likely that there are also general underlying processes. Strategically, we take the inter/transdisciplinary team as our starting/target point to understand the broader multi-level inter/transdisciplinary system and to illustrate the variety of dimensions, relations and coupling processes that need to be considered when exploring the complexity of ITD. Understanding the internal organisation of the target system and its sub- and supra- system(s) is of as much importance as understanding the coupling processes within and between them due to their roles in enabling or disabling constraints.

Different configurations of relations of different systems and coupling processes (in this relational world) will likely lead to and sustain different types of emergent outcomes, which cannot be reduced to the level of single component subsystems or processes. This complexity calls for a systematic investigation of the structural/organisational and dynamical complexity of ITD, not only at a theoretical level but also empirically, with a strong action-based, pragmatic orientation. Similarly, the practices to promote positive ITD need to be informed by knowledge of how certain types of outcomes are potentiated or inhibited by

particular configurations of relations. There is a variety of contextual factors that shape the work of inter/transdisciplinary teams (Stokols et al. 2008; 2010). Figure 2 adopts an ecosystemic focus (Bronfenbrenner 1979) to represent how the interactions that occur between individuals are constrained by the characteristics of the larger systems in which they are embedded. On the other hand, it presents a simplified representation of the multiple dimensions at which the individuals interact, both at a personal and at a disciplinary level, under the influence of larger systems in which they are embedded. In an interdisciplinary team this complexity is increased in (non-linear) relation to the number of individuals that are involved in the interactions, and their diversity.

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In inter/transdisciplinary interactions it is not only the individuals, with all their assets, capacities, personalities, cultures and preferred patterns of interaction that are coordinated. There are processes that relate to higher-order levels, such as the extent to which the individuals act under the influence of their disciplinary modes, practices (e.g. modes of thinking/worldviews, theories/concepts, methods/technology) and cultures, within particular frameworks of values and assumptions that are taken for granted (Stokols et al. 2008). The individuals' interaction also occurs under the top-down influence of the constraints imposed by their representations of the disciplines (e.g. they may have been brought into a team to bring a particular set of methods/approaches), their immediate research environments as well as their larger research organisations. Additionally, the interactions between the modes of thinking, the concepts, methods, and general research

practices of each discipline are shaped by the individuals' personalities, their eco-systemic environments and their own susceptibilities. There are different tasks and stages at the level of the interpersonal interaction and the negotiation of intercultural protocols that may need to be successfully addressed before deeper work can be performed (Lyall et al. 2011a) at the level of the interaction between concepts and methods (Melo 2018).

To reiterate, although there has been some work on the development of conceptual frameworks for ITD, particularly at the level of teamwork (Stokols et al. 2010), it is necessary to continue to develop and expand them, with a focus on processes, in order to capture their full complexity and potential. As Stokols and collaborators affirm "(...) the outcomes of TS [team science] initiatives are highly influenced by social and interpersonal processes (...) Yet, the precise way in which these social processes (...) influence scientific productivity and TD [transdisciplinary] integration are not known. The empirical links between interpersonal and intellectual dimensions of scientific collaborations remain unclear" (Stokols et al. 2010, p. 477). More research is needed that is capable of addressing the questions of the when, where, what, with whom, how and why of the inter/transdisciplinary research processes (Börner et al. 2010). It is, therefore, necessary to invest in research programmes targeting process-focused questions related to what works, under which conditions, through which type of processes/interactions, that lead to which type of outcomes. A similar task was initiated some decades ago in the process-focused and common factors approaches to psychotherapies (Duncan, Miller, Wampold & Hubble 2010; Elliot 2010). The thinking in this field moved

from a restricted concern about the absolute efficacy of treatments, as evaluated by randomised control trials, to an exploration of the processes of change that would afford an understanding of how, for whom and under what circumstances treatments work and the prescription for individually-tailored interventions (Beutler & Clarkin 2014) as well as family approaches (Sprenkle, Davis & Lebow 2009). A new wave of process-focused research needs to be capable of focus the complexity of the interactions and the nature of the coupling processes that sustain the inter/transdisciplinary system. It needs to adopt a broad multi-level and multi-method approach capable of a deep investigation of the different processes of ITD, at its different levels of organisation, under an overarching (complex) systems framework (Börner et al. 2010).

There need to be activities that not only strengthen each level of the ITD system, but that above all strengthen the coupling between different levels of organisation. We believe that a focus on the coordination of activities is at least as important, if not more important, than the individual activities per se. We also believe that ITD and knowledge integration activities requires active facilitation, but that individuals involved in the ITD activities, or the organisations in which they are embedded, are not necessarily willing or prepared to do it.

3. Coordinating and enhancing knowledge integration: A proposal

We present a proposal for the organisation of two large and distinct, but highly coupled sets of activities aimed at promoting, supporting, disseminating and evaluating ITD and knowledge integration. Our proposal encompasses the creation of an Alliance for Knowledge Integration and the development of Inter/Transdisciplinary Hubs. We believe that the relevance of our proposal lies not in the individual activities that we suggest in themselves (as we know that many of them are already being conducted on different types of contexts), but in the coordination of these activities, under the scope of two organisational structures designed to attend to the different levels of ITD systems and their coupling processes. We believe that such orchestration of activities will lead to a more coherent and self-organising ITD culture that will result in enhanced impact.

We are aware that many of the individual activities that we suggest have been already been reported based on experiences of different groups and researchers, in different contexts. While acknowledging some of these contributions, for the purpose of this paper, we have not considered them comprehensively. Thus, we assume that the paper falls short in giving full credit to a diversity of contributions from researchers and centres that, in different contexts, have planted and nurtured the seeds of ITD, preparing the ground in which it may flourish.

We believe that the full development of ITD will require orchestration of efforts and resources from individuals and systems stemming from communities

both within science and other social systems. As Hall et al. (2008b, p248) state “A new era of creativity and innovation in transdisciplinary science can be achieved through simultaneous and coordinated efforts that remove collaborative barriers and build new linkages across multiple sectors of society and across spheres of research”. We hope this paper contributes to a vision of an ecosystem for the evolution and flourishing of ITD. Hence while the novelty of the isolated components of our proposal may be limited, we hope that the whole of the proposal brings more than the sum of its parts, suggesting ways for the coordination of actions within and between individuals, programmes and institutions at different levels of organisation of science and society at large.

The overall goal of the proposal is to (i) create a broad cultural and social context that supports positive ITD; (ii) support the development of theoretical and pragmatical frameworks for ITD that support the orchestration of their processes, interactions and practices, at multiple levels of its organisation, towards positive outcomes; (iii) promote a culture of extensive collaborative engagement and participation for knowledge creation and integration; (iv) promote local and global positive practices of knowledge integration along with critical and reflexive societal debates on the nature of knowledge creation and application.

The Alliance for Knowledge Integration and the assemblage of Inter/Transdisciplinary Hubs are structures that both emerge from and organise the activities in our proposal. By being organised as effectively stable, albeit dynamic and evolving, social structures, they may serve to support longstanding positive changes. We envisage these structures as operating in close collaborative

partnerships with other social systems with which they interact, both to influence and to be influenced in a sense that allows their dynamic adjustment for fitness in terms of the relevance of their outputs for society. In figure 3 we present a simplified general scheme of the ecosystemic view underlying our proposal.

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The development of the Alliance for Knowledge Integration (AKI) will rely on critical partnerships between existing and prospective inter/transdisciplinary centres. These centres may or may not be operating as Inter/Transdisciplinary Hubs (ITH), in the sense developed in this paper. However, the development of an AKI would build upon their accumulated experience. The AKI and ITH are designed to transact knowledge and resources and interact in complementary ways. Both of these systemic entities should develop different ways of effectively coupling with the multiple levels of organisation of society and of supporting each other's activities. In doing so, each may have preferential relations with other types of social systems, acting as mediators for the other. For example, while the relation of the AKI with teaching and research organisations is likely to be mostly mediated by the ITH, the ITH may connect with larger audiences and different types of social systems under the influence of AKI's guidelines and activities. On the other hand, both of these structures, but especially the ITH, can interact with society at large through the wider organisations that host them. In turn, the AKI will not just support the ITH (and, as appropriate, their host organisations), but will also develop strategies and processes that allow for collaborations regarding the creation and integration of knowledge, in general, across the different levels of

organisation of society and, for given challenges, between critical stakeholders.

The AKI may act to support ITH by offering overarching perspectives on the state of inter/transdisciplinarity, building general knowledge and guidelines, while also promoting synergetic encounters of different, formal and informal communities of knowing; the ITH directly promote and support practices of ITD that lead to positive outcomes.

3.1 The organisation of Inter/Transdisciplinary Hubs (ITH)

The role of Universities, as research and teaching organisations, is increasingly under discussion (e.g. Collini 2017; Santos 2018). Nevertheless, they are still institutions where most inter/transdisciplinary activities take. However if, on the one hand, these modes of knowledge production and dissemination are increasingly being advocated, on the other, there is an increasing recognition of the obstacles and pitfalls involved. These challenges include the evaluation of career management issues, funding, publication and the management of research processes (British Academy 2017), amongst others.

Theory, research and practice on ITD need to be more tightly coupled. There is a significant amount of practice experience that deserves investigation and there is a need for a type of process-focused research that could benefit from a strong coupling with the practice of interdisciplinarity. At the same time both the research and practice are best embedded in favourable and supportive contexts. Therefore, promoting positive ITD requires an investment in nurturing a

supporting culture and positive coupling processes within and between the different levels of organisation of an inter/transdisciplinary system (Börner et al. 2008; Stokols et al. 2008).

In the absence of a favourable organisational culture, ITD research will either not flourish or remained restricted to ‘weak’ modes of disciplinary interaction, with limited outcomes (Klein, 2010). Positive ITD does not come for free and demands active facilitation (Lyall et al. 2011a,b); there are both micro and macro cultural and socio-environmental aspects that, being critical to the formation of conditions for creative and productive interactions, require intentional nurturing. It is the dynamic processes implicated in inter/transdisciplinary interactions that, as in most complex systems, makes it difficult to manage; however, it is in this very complexity that its greatest strength and potential to address complex issues lies.

To establish an ecology to support and nurture ITD will require special investment and intentional planning. Universities and other research environments don’t just need to promote inter/transdisciplinary or develop inter/transdisciplinary centres; they need to have their inter/transdisciplinary aspirations and practices supported by structures dedicated to promoting processes that lead to positive outcomes. This can occur under the scope of the activities of Inter/Transdisciplinary Hubs (ITH). ITH will most likely be located within Universities or other research organisations, but they may also arise in other contexts such as companies or NGOs, or from grass-roots organisations. Whatever their context, ITH should be strongly coupled to their local environments and research organisations in order to

support and facilitate positive ITD. We highlight that ITH differ from other types of interdisciplinary centres to the extent that, although they may be places to conduct ITD research, their main purpose is to promote, coordinate, facilitate, expand and integrate ITD research within their host organisations and with key partners.

Additionally, we conceive of ITH as key research sites for the development and evaluation of knowledge and technology on ITD research processes. They will, therefore, constitute “second-order” research centres (Müller & Riegler 2014), using internal inter/transdisciplinary research projects as a source of data to support studies on the influence of processes, practices and other dimensions on ITD. But they also go beyond these activities to develop, deliver and evaluate theory and technology to promote positive ITD to a broader audience. They are designed to create the time and space to intentionally facilitate and build positive inter/transdisciplinary interactions.

When integrated within Universities, ITH may take advantage of the disciplinary-based organisation, while attempting to overcome their limitations and explore the potential of science beyond the disciplinary boundaries. They may operate as (semi-)independent entities with their own appointments and staff and/or draw on the human and other resources available in their hosts’ departments, across faculties. Additionally, they may include academic/professionals who specialise in the processes of managing and promoting positive inter/transdisciplinary. We envisage that staff with a background in the social sciences may play a special role in the management of the activities of ITH: we see scope for the development of a new research field of the Social Sciences of ITD and for a

Psychology of Interdisciplinary Relations. Nevertheless, as new training programmes and specialisations are advanced, other researchers may acquire the necessary skills to facilitate and investigate the processes of positive ITD, beyond the stricter scope of their other research activities.

We envisage the organisation of the ITH around three, closely interrelated, lines of activities, namely: research, facilitation and teaching, as illustrated in Figure 4.

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These activities are aimed to serve the community of researchers of the organisations where these Hubs are embedded or with key partners. They are also oriented to support the activities of the Alliance for Knowledge Integration through partnerships with similar Hubs. We next present a brief description of the proposed activities, highlighting the fact that it is their co-existence and coordination that may lead to the coherence and culture to support critical positive outcomes.

3.1.1 Research

ITH could host a variety of research projects, in different forms (resident researchers/teams; academic visitors/fellowships; hosted research projects), however what is distinctive is that the projects must be strategically integrated in order to contribute to ITH activities through a variety of means (human resources/time dedicated to facilitate activities; disciplinary skills, conceptual, methodological

and technical skills; provision of open data on the processes of inter/transdisciplinary research). Hence, research with ITH has a double complementary function. On the one hand, these hubs may operate as research centres, building on the synergies of the ‘resident’ academics and research projects. On the other hand, they are research centres of/for ITD. Through this line of activity, they pursue the development, evaluation and dissemination of theory and technology (strategies, tools, heuristics) to promote positive inter/transdisciplinary interactions. To support this, alongside the internal research projects, ITH integrate Laboratories of ITD, drawing data from the internal research projects, but also reaching to other contexts and sources to develop theoretical frameworks and pragmatic applications (e.g. tools, strategies, resources) aimed at promoting positive ITD. These Laboratories should have a strong translational focus and develop action-based research in contexts of application, bridging theory and practice, and in close collaboration with the other activities of the ITH.

3.1.2 Facilitation

ITD requires a supporting culture that favours creative interactions and conditions for researchers to meet within and beyond the scope of their disciplines (Lyll et al. 2011a). There is a need for environments that stimulate and support formal and informal encounters for researchers where intellectual playfulness, engagement and curiosity are stimulated as key ingredients for the fostering of creative leaps and innovation. There are many reports, both documented and

anecdotal, of inter/transdisciplinary experiences where informal and free interactions have played key roles in building positive inter/transdisciplinary relations. It is necessary to dedicate time and effort into building a favourable working environment, addressing key preparatory tasks for interdisciplinary work (e.g. building a common language, goals, values, expectations, a climate of openness and trust and ways of coordinating practices). Not all individuals and teams present the same level of readiness and skill for inter/transdisciplinary collaborations (Stokols et al. 2006). Nor are they all necessarily aware of the full complexity of those interactions or present the knowledge, skills or profile to be facilitators in inter/transdisciplinary teams (Hall et al. 2008a, 2012). There is a diversity of processes and contributions to ITD that needs to be managed. Facilitation can be performed internally, or by external facilitators, however, in any event, it should be guided by the available evidence collected from a variety of contexts and by empirically-grounded theoretical frameworks, as much as by the team members' previous experiences. Although interdisciplinarity may be practiced by individual researchers, the challenges at the team level are likely to be greater and call for specialised support (Stokols et al. 2006). Facilitation of inter/transdisciplinary work may occur at different stages of a project, depending on its specific features and the conditions of the team (e.g. goals, resources, history of working together). Many organisations have group facilitators, most commonly with a training in psychology or other social sciences, working to promote team building or foster particular types of creative or collaborative processes (e.g. Schwartz 2016). While there are generic team processes to be considered, there are also unique aspects of

the inter/transdisciplinary interactions that need special attention and that ITH should be equipped to address. In the context of ITH, facilitation activities should be tightly coupled with, or occur under the scope of Laboratories for ITD.

Facilitation in ITH can target audiences both internal and external to the organisations that host them or key partners (e.g. Universities) in two ways: (i) by facilitating a suite of on-going activities aimed at creating an environment and culture favourable to positive and creative interdisciplinary interactions and (ii) by providing on-demand tailored services. The aim is to create playful, creative, informal contexts (i.e. environments/processes) for different types of interactions between individuals, ideas, disciplinary cultural practices, concepts, modes of thinking, methods and tools in order to meet the needs of researchers with different degrees of inter/transdisciplinary engagement.

3.1.2.1 On-going facilitation

ITH may offer a suite of activities including:

(i) *Facilitated open workspaces*

These are spaces that during designated periods of time can serve as hot desk environments. The distinctive feature is that they are organised and supported by a facilitator so as to provide opportunities for the engagement between individuals from different disciplines or areas of study, both

directly and indirectly. The minimal requirement for a researcher to spend time in these spaces is that they be willing to discuss their work with others, to disclose the ideas, concepts and methods they are currently working on and to engage in group activities managed by a facilitator in order to promote dialogue. Activities may be as simple as asking the participants to visually represent the essence of the concepts, ideas, or methods they are working on, have these exposed to others, and then be available to be approached or engage in conversations. Additionally, during coffee or lunch breaks, facilitators may propose interactive exercises to stimulate a particular type of creative interaction or to engage the participants in ‘end of day’ discussions focused on a creative and free exploration of possible interactions between the different facets of the participants’ work. Activities would be designed to overcome obstacles of language and expertise and facilitate positive communication and interaction between different worldviews, concepts and methods.

(ii) Interdisciplinary seminars and workshops

The ITH should follow the traditions of many research centres in promoting open seminars on cross-disciplinary topics to a broad range of audiences, to the extent that they serve to promote and disseminate inter/transdisciplinary experiences.

(iii) Reverse inter/transdisciplinary seminars

One of the main strengths of inter/transdisciplinary work is the exposure to and interaction with different perspectives and views on a given subject/phenomena. These views derive from different lenses, modes of thinking and concepts, ideas and methods used as exploratory tools. However, established habits, or internal and external disciplinary and contextual constraints may limit the extent to which interactions are able to occur in a sustained context of respect, curiosity, openness and exploration, where individuals allow themselves to engage in true reflections and to be perturbed by the views of others.

In some ways, interdisciplinary interactions can be explored like interpersonal relations, namely family relations. Not only is it necessary to keep a focus on the processes of coupling supporting these relationships as it is possible to create opportunities for these relations to rehearse new modes of organisation. In (psycho-)therapeutic contexts some approaches have been developed to allow a collaborative and reflexive, but also respectful exposure of families to multiple views on their lives (and realities), and through that, to create opportunities for the emergence of new possibilities for thinking, feeling and action. Techniques that have been developed to facilitate change in family relations could be productively adapted to facilitate positive inter/transdisciplinary interactions (e.g. reflecting teams, Andersen 1990).

We have experimented with this kind of approach in the facilitation of interdisciplinary dialogues and meetings and believe that these and other forms of collaborative and reflexive dialogue strategies (e.g. World Café, Brown, Isaacs, &

The World Café 2005) can successfully be imported into ITD contexts, but adaptation and application deserves more attention and should be evaluated in relation to different types of outcomes and experiences.

(iv) Cross-fertilization events

Creativity benefits from the exploration and enlargement of a space of possibilities. To some degree, this may occur through the reconfiguration and recombination of the existing building blocks and contents of our thinking but also by engaging in exploratory movements towards new modes of thinking or pushing their boundaries to the point where new possibilities emerge and the landscape is transformed (Boden 2004).

ITD activities constitute powerful instruments of scientific creativity (Darbellay et al. 2014). However, it is well known that there are many barriers to positive inter/transdisciplinary interactions, particularly those associated with differences of language or worldviews (ontologies and epistemologies).

Inter/transdisciplinary communities need to invest time in building common ground and finding ways of communicating, outside of the linguistic frames and inevitable jargon of their disciplines. In coordination with the AKI, the ITH may work towards developing a necessary language and supporting metaphors that serve as a lingua franca to support interdisciplinary exchanges; ideally, this would evolve (through a variety of processes) to support a wide range of inter/transdisciplinary activities, but we anticipate domain-specific branches (as dialects).

A series of activities can be designed to reduce obstacles to communication whilst also promoting cross-fertilization across domains by facilitating the circulation of ideas and concepts, methods and tools. ITH may organise activities that afford researchers the chance to encounter, embrace and engender novelty and engage in free explorations of other domains. This may occur in contexts that are free from the everyday pressures of having to deliver outcomes for a particular project or grant proposal. ITH can organise seasonal activities like ‘interdisciplinary markets’ where researchers may explore each other’s work and showcase their preferred concepts, ideas or tools. For example, researchers may be invited to enter an auction, where others may “buy” or exchange the ideas, resulting in a commitment from both seller and buyer of later engaging in a deeper interdisciplinary engagement.

Researchers may also be required to make short talks in competitions where they have to communicate without using ‘forbidden’ jargon words.

Activities should be organised so as to promote rich dialogues, between scientists from different disciplines and with other stakeholders, based on exercises that foster the importation, circulation, adaptation or filtering and exploration of a field through the lenses of another one. This could involve the use of alternative modes of communication based on artistic expression or the crafts. ITH should provide a mixed portfolio of activities, balancing (all too common) goal-directed events with (rarer) open-ended opportunities, that promote a free exchanges of ideas and the strengthening of relations with the aim of building interdisciplinary capacity to meet future challenges.

(v) Interdisciplinary reading and discussion groups

The definition of standards for the evaluation of inter/transdisciplinary research is still a work in progress (McLeish & Strang 2016). The ITH may contribute to these efforts through promoting opportunities for the development of specific skills to assess and understand interdisciplinary research processes and outcomes.

ITH can organise different types of reading groups, focused on the exploration of ITD publications (papers; reports; themed discussions). Existing guidelines (e.g. Lyall et al. 2011a,b; McLeish & Strang 2016) can be taken as a starting point for the reflection and discussion around the papers. These groups can work towards the development of progressively more complex inter/transdisciplinary modes of thinking and tools to manage the research process from planning to publication. Through the discussion of papers, with a focus on how interdisciplinary processes and outcomes were conducted and reported, they may contribute to promote the sensitivity and capacity of the participants to analyse inter/transdisciplinary research. If these activities are coordinated, across ITH, under the scope of guidelines provided by AKI (see below), they may also play a critical role in developing and refining agreed processes and methods for exploring and evaluating inter/transdisciplinary that may be widely adopted (Bruun et al. 2006).

(vi) Databases of Inter/Transdisciplinary skills and networks.

The ITH can play a role in mapping the networks (and types) of interdisciplinary collaborations within their host or partner organisations by developing and managing databases that capture existing interdisciplinary projects, partnerships and collaborations. However, we believe that it is necessary to move beyond information on interdisciplinary projects and collaborations, to building platforms that provide information on specific profiles of ITD skills, that may lie at the level of the individuals or in the collaborative team/network. Thus, researchers registered on such a platform, should be invited to provide information not just on their individual work, but also encouraged to build a profile of interests, skills, capacities and experiences in relation to different types of ITD interactions and collaborations aiming at particular types of goals (Bruun et al. 2005; Huutoniemi, et al. 2010). The information could include both disciplinary-based skills and skills that are specific to ITD contexts (e.g. individual's capacity to facilitate meetings; building communication bridges within a team; capacity to be challenged and take risks; writing skills, etc). Researchers could optionally indicate their stance/orientation in relation to particular kinds of work (e.g. readiness and capacity to pursue a particular type of project, or play a particular kind of role in a team). These skills databases will grow naturally if researchers invite their collaborators to participate. In this way, the interdisciplinary potential and capability contained in dynamic collaborative networks may be captured.

We envisage that such databases will be of great value to a variety of agents. They could be used by the researcher community themselves to search for

potential collaborators. This may be especially important for younger researchers, who are seeking to engage in inter/transdisciplinary collaborations and who are still building their professional networks. An obvious beneficiary are agents, particularly for the civil society, seeking to form interdisciplinary teams for strategic purposes and/or in response to a particular challenge and/or funding call. The databases may serve the development of an ITD culture, by supporting the planning and management of both the human resources and the contextual conditions influencing interactions between individual researchers and disciplines; they could also support needs-assessment in requests for facilitation services, e.g. in considering the degree of “collaborative readiness” (Hall et al. 2008a) of an ITD team; hence, they should allow for an exploration of an individual’s general and specific competencies for ITD (Hall et al. 2008a). They should also include information on teams, such as their stage of development (e.g. degree and quality of previous engagement; levels of trust; type of shared experience in relation to the nature of the interactions) in relation to the nature and stage of development of the project (e.g. scope of ITD; clarity of common goals and desired outcomes; definition of processes for ITD interaction) as well as contextual conditions (e.g. expectations of funders; availability of equipment, capacities/constraints of the physical environment) (Hall et al. 2008a).

We note that such databases are a valuable resource and there should be a strong emphasis on developing appropriate ethical frameworks and security protocols to safeguard individuals’ information and privacy.

3.1.2.2 On-demand facilitation

With properly trained teams, the ITH can also deliver on-demand facilitation services, informed by the latest theoretical and methodological developments in the field and under the scope of an action-research (Reason & Bradbury 2013) applied, collaborative approach. These services should include an assessment of the needs of each client so that the facilitation can be tailored to the degree of experience, maturity and current needs of a particular group. These services may include the provision of (i) spaces providing a neutral context for teams to meet. The spaces should be adaptive and reconfigurable to create a physical environment that can be tailored to the needs of a group at the particular stage of development of their work and their current state as an inter/transdisciplinary team; (ii) facilitators; (iii) facilitation toolkits with sets of activities and strategies that the teams may use to facilitate their own internal processes. These services can be provided in isolation or in combination.

3.1.3 Teaching

There is an increasing number of offers of (mostly) graduate and undergraduate interdisciplinary teaching/learning programmes. However, this type of course is not always delivered in a truly interdisciplinary fashion, nor do they necessarily include specific training in interdisciplinary skills. Such interdisciplinary programmes don't necessarily expose students to the dynamics of inter/transdisciplinary team interactions or provide opportunities to conduct their own research

projects in a proper interdisciplinary fashion. Therefore, they don't necessarily prepare students to be able to engage in positive inter/transdisciplinary team projects. Future inter/transdisciplinary researchers or practitioners need to have specific training in key skills, engage in live interactions and have opportunities to observe the work of inter/transdisciplinary teams or to be mentored in their own projects by experienced inter/transdisciplinary researchers. Many of the obstacles and difficulties present in ITD can be avoided or effectively managed if one is aware of them and has the skills to address them. Some lessons are difficult and often painstaking to learn without guidance or awareness of the bumps and turns likely to be found along the roads of ITD.

We believe that ITH can play a unique role in (i) creating a context where collaborators from different disciplines can meet and work together in the conception, planning and delivery of inter/transdisciplinary graduate research programmes; (ii) support inter/transdisciplinary research in the context of undergraduate or graduate programmes; (iii) teaching the skills necessary for a positive engagement in inter/transdisciplinary; (iv) creating opportunities for inter/transdisciplinary skills and knowledge to be applied to real-world contexts in the context of continuous professional development courses.

We envisage the following lines of teaching for the ITH:

i) Skills courses

ITH could be responsible for delivering interdisciplinary skills modules on inter/transdisciplinary undergraduate or graduate courses for their host research organisations and/or partners (Lyall et al 2011b; cf. Interdisciplinary wiki). Advanced skills courses can also be organised targeting established academics and researchers.

ii) Graduate programmes

ITH can promote the organisation and the delivery of (i) inter/transdisciplinary graduate programmes, focused on a variety of themes; (ii) inter/transdisciplinary graduate programmes targeting the investigation of ITD itself (in a recursive fashion), in its different dimensions and its research processes (in close collaboration, when relevant to the Laboratories for ITD and the Facilitation Services) at its different levels of organisation; (iii) practice-oriented graduate courses focusing on interdisciplinarity in terms of its management (e.g. “Masters of Inter/Transdisciplinary Research Administration” targeting research officers) and facilitation (e.g. Masters programmes for inter/transdisciplinary facilitators).

(iii) Postgraduate and continuing professional development courses .

ITH can facilitate inter/transdisciplinary courses focused on real-world challenges and critical social issues, aimed at knowledge construction, integration

and application in real-world contexts. These courses can target (separately or simultaneously) different stakeholders including practitioners, business managers and policy-makers.

(iv) Interdisciplinary summer schools.

Some research centres have a tradition of conducting interdisciplinary summer schools where students have an opportunity to engage in deep interdisciplinary interactions, both directly and indirectly (through exposure to the interactions of supervisors from different disciplines- cf. YCCSA Summer School). ITH are privileged places for hosting a variety of programmes with different levels and types of inter/transdisciplinary engagement and, through the Laboratories of ITD, for the development and evaluation of new interdisciplinary teaching technologies.

(v) Support and integration in an Alliance of Knowledge Integration.

Finally, the ITH should play a critical role in supporting the activities of an AKI through affiliation. The development and administration of the AKI should rely on human resources coming from the ITH and synergies must be established between their respective activities.

3.2 A case for an Alliance for Knowledge Integration (AKI)

This paper is based on the assumption that knowledge should be pursued that promotes sustainable and integrated well-being and human flourishing in all dimensions of human existence. However, it also assumes that there are multiple types of knowledge and multiple ways of knowing, as well as many views about them (Jakubik 2007; Santos 2016). There are forms of local and contextually-bound knowledge that are particularly relevant for a given cultural and social setting with a degree of fitness for (local) problems that may exceed that of traditional scientific knowledge. The complexity of the world calls for an integration of a plurality of ways of knowing and types of knowledge, and an expansion of our horizons (Mazzocchi 2006), as spaces of possibilities for action. But these processes require special attention and purposeful investigation (Raymond, Fazey, Reed, Stringer, Robinson & Evelyn 2010; Sutherland, Gardner, Haider & Dicks 2013).

The rhythms of scientific production are slow compared to the demands of the world and society needs to develop responses based on incomplete knowledge (Funtowicz & Ravetz 1994) that, nevertheless, have pragmatic value. There is a need for development of appropriate frameworks that address aesthetic, ethical and methodological dimensions along with issues of validation and decision-making associated with knowledge development, implementation and integration in the contexts of application (Nowotny, Scott & Gibbons 2001; Ravetz 2006).

On the other hand, knowledge enterprises risk becoming just another commercial activity, evaluated mostly in terms of its economic revenue or impact

according to metrics (e.g. impact factors; league tables, citations) that are blind to their aesthetic, ethical and pragmatic value in relation to a common social good. A culture founded in the pleasure and beauty of learning may need to be reinvented as Universities become more and more focused on their balance sheets than in the celebration and appreciation of knowledge per se, and its relation to positive human development. Additionally, if not reframed towards positive goals, the practices of knowledge production may well be caught up in the same type of problem-focused, negative approaches that have delayed a journey towards human flourishing and general well-being (Seligman & Csikszentmihalyi 2014). There is an aesthetic dimension in the pursuit of knowledge (Borrelli & Grieser 2017) that, having played a fundamental role in the development of human civilizations, risks being lost under the contemporary pressures for problem-solving and (narrowly conceived) economic targets.

3.2.1 Aims of an AKI

We propose the foundation of an Alliance for Knowledge Integration aimed at: (i) promoting and disseminating high quality positive practices of ITD and conditions to promote them, in all of their dimensions and levels of organisation; (ii) promoting and facilitating extended debates about the aesthetics and ethics of knowing; (iii) promoting and facilitating extended debates about the nature and possibilities of knowing (its complementary pairs- the unknown/unknowable) and knowledge integration towards a common social good; (iv) promoting positive

practices for the creation, dissemination and application of scientific knowledge in relation to other socially, culturally or pragmatically relevant ways of knowing ;

(v) promoting positive collaborations within and between the different levels of organisation of society regarding the promotion, integration, application and dissemination of knowledge towards sustainable well-being and positive human flourishing.

3.2.2 Foundation and Core Activities of an AKI

As already stated, the development of an AKI should rely heavily on the human, technological, material and knowledge resources of the ITH and other existing interdisciplinary centres, constituted as critical founding partners for the AKI. Additionally, from its inception, the AKI should involve critical stakeholders and representatives from different levels of organisation of society in the planning, operationalisation and evaluation of its development. The AKI should result from a process of co-construction and coordination between different perspectives and views on knowledge and knowledge integration.

Table 1 summarises our proposal for an AKI regarding its core activities, including those more oriented to the academic community and some more oriented to cooperation among different agents and levels of organisation of society. While the table presents a brief description of each type of activity, we wish to highlight the activities of the Journal for Knowledge Integration (JKI) and the Charter and Awards for ITD and Knowledge Integration.

-Insert Table 1 around here-

3.2.2.1 Open Journal for Knowledge Integration (JKI)

The JKI is conceived as an entity with a dual purpose both for disseminating knowledge, but also for becoming a context and a Laboratory for the production of knowledge regarding ITD and knowledge integration. The journal will be a space for the open publication and dissemination of varied types of inter/transdisciplinary research, without a focus on a particular domain or subject. Associated with its role in publishing research, the journal should organise opportunities for the debate and dialogue of key issues relating to ITD through the discussion of specific papers in multiple formats (e.g. round tables; commentary papers; focused seminars exploring a paper from multiple perspectives; targeted reviews of related publications). These dialogues and debates will also - in turn - be published, opening the way for further discussion and commentaries, in a recursive manner. Published commentaries to the papers can focus both on the processes and outcomes of inter/transdisciplinary as well as on their relevance for society at large or specific groups. The Journal assumes a reflexive and recursive stance to the extent that it will also investigate, critically evaluates and reflects upon its own activities, publishing about its own processes and results. Its editorial board will periodically investigate the journal output in order to produce knowledge on the status of ITD and its key processes. Critical syntheses, reviews and meta-studies, with a

focus on the inter/transdisciplinary research processes, will constitute a major activity. Hence the journal will simultaneously be a first-order, as well as a second-order science journal, operating in recursive loops. Effectively, itself a laboratory and platform for inter/transdisciplinary processes and knowledge integration, the editorial board may constitute, integrate or coordinate working groups focused on the development and refinement of guidelines for inter/transdisciplinary peer review as well as for developing procedures and guidelines for reviews conducted by lay people and representatives of critical stakeholders groups. The reviews themselves will be interdisciplinary, as well as transdisciplinary, engaging a variety of stakeholders and critical voices from different sectors of society. Hence it should be organised in the spirit of an open science, oriented towards public good and engaged in producing knowledge that is recognised, critiqued and validated by representatives of a variety of critical social systems who are either potentially affected by, or involved in, the knowledge production. Developing training programs for non-academic reviewers should be part of the Journal's activities.

Through the Journal and its other key activities, the AKI aims at becoming a dynamic and transformative vehicle for a new type of science where ITD and diverse practices of knowledge integration and evaluation play a critical role.

3.2.2.2 Charter and Awards for Inter/Transdisciplinarity and Knowledge Integration

A key feature of the ITD landscape is the diversity of views concerning definitions, practices and evaluation. There is a need to integrate this knowledge and terminology to develop an agreed set of terms and practices that will serve as benchmarks for inter/transdisciplinary activity. We propose that the AKI will, through consultation with the ITD community, draw up a Charter of ITD that sets out agreed definitions, guidelines for supporting practices, indicators and frameworks for evaluation. Further, in recognition of the different stages of investment/development in ITD of an institution/centre, certain levels of attainment, regarding the extent to which they create conditions for positive ITD at different levels (e.g. individual career support, team level, institutional and evaluation structures) could be defined and recognised through a tiered series of Awards (e.g. Bronze, Silver, Gold etc).

The Charter and Awards will serve multiple roles, including: i) For institutions/centres that seek a recognised framework to guide investment in the development of their inter/transdisciplinary practices and culture, ii) For institutions/centres that seek to communicate their existing inter/transdisciplinary investment and culture, through alignment with the Charter, iii) For funding and regulatory bodies, to have a clear and recognised way of evaluating the commitment/capability of an institution/centre to undertake inter/transdisciplinary research, and iv) For

individual researchers seeking jobs, as a guide in evaluating the receptivity of institutions/centres for undertaking and recognising inter/transdisciplinary research.

The idea of the Charter and Awards is inspired by the Athena Swan awards in the UK-based Athena SWAN Charter (Athena Swan) that seeks to encourage and recognise commitment to gender equality in advancing careers in higher education institutions. Established in 2005, Athena SWAN has been very successful in changing the culture, with over 140 institutions as Charter members to date (2018). Another motivation is the power of standardised protocols. We draw an analogy of the current state of ITD with the days of computer networking, characterised by multiple protocols and limited compatibility, that constrained access and scalability. We seek, through the Charter and Awards, the definition and adoption of agreed standards and protocols (cf. TCP/IP or HTTP) for ITD that allow for widespread adoption and rapid growth, and afford the possibility of stimulating the emergence of vigorous and creative cultures for knowledge integration.

4. Conclusion

In this paper we present a proposal for knowledge production and integration organised around the constitution Inter/Transdisciplinary Hubs and an Alliance for Knowledge Integration, as highly coupled complementary entities. This proposal is grounded in an ecosystemic, complex systems-informed view of ITD. While some of the proposed activities have been carried out before, in different contexts and to various extents, we hope that, from the careful consideration of the

organisation and dynamics of a range of coupled activities, something novel and valuable will emerge and flourish into the future. The implementation of these activities needs to attend to the complexity of the ecosystemic relational processes involved in ITD and knowledge integration to ensure their evolution and a positive adaptive fitness of its outcome, in the face of changing circumstances. The interactions within and between the proposed activities may lead to the emergence of new opportunities for knowledge production and to increase its complexity to a level more congruent with the complexity of the world. This may lead to new or enhanced understanding and afford new possibilities for action. More complex ways of knowing are required for a transformation of the conditions leading to positive human flourishing and future sustainable development. We believe the ideas presented here deserve attention across theoretical, empirical and pragmatic levels and hope that future research and social initiatives will be developed around them.

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Fig. 1. A relational worldview for intra/transdisciplinarity systems

Fig. 2. Multiple levels of inter/transdisciplinary interaction, mediated by interactions between individuals.

Fig. 3. A simplified representation of a proposal for knowledge integration activities. For simplification we have included only a few arrows to represent the interactions and influence between the different levels of systems portrayed. However, these arrows should be viewed as bifurcating into a multiplicity of connections, of differing strengths, between all the systems considered, representing recursive influence between them. The multiple interactions within and between the multiple systems and levels of organisation of knowledge portrayed in Figure 1 may create conditions for the emergence, integration and application of new, expanded and enriched forms of knowledge and ways of knowing.

Fig. 4. A model for the internal organisation of the Inter/Transdisciplinary Hubs (ITH).