DEVELOPING COMPETENCE FOR INNOVATION IN KNOWLEDGE PRACTICE

An exploration of the sustainability science-policy interface

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This thesis is submitted in partial fulfilment of the requirements of the University of Westminster for the degree of Doctor of Philosophy

February 2024

ABSTRACT

This thesis is motivated by institutional claims for a “new type of knowledge” in the sustainability science-policy interface. It thus explores the thinking and practice of experts in the field about professional competencies necessary to induce required innovations in their knowledge practice.

The thesis proposes a novel conceptual framework, synthesising (1) five key features informing claimed innovations in knowledge practice of science-policy sustainability ‘boundary organisations’, (2) a set of ten differentiating individual competencies deemed critical to induce such type of innovations and (3) required approaches to effective development of such competencies. In doing so, this thesis suggests an operative framework to engage with a competence-based approach in response to the need for innovations in knowledge practice within boundary organisations.

Under the conceptual framework above, the thesis engages in an empirical work exploring the thinking and praxis of experts in the field, around three key questions: (1) How do practitioners in the field perceive the need for and the pertinence of such type of innovations, (2) How do they relate to the notion of individual competence and the need for different types of competencies to induce innovations in their own knowledge practice and (3) How can professionals working in the science-policy interface most effectively learn and develop such new set of competences, given their specific organisational / institutional contexts?

Methodologically, this thesis engaged a combined set of empirical research instruments, mostly including *semi-structured interviews* with professionals operating in the sustainability science-policy interface, three *focus-groups* in The Netherlands, Portugal and the UK, with actors operating within the remit of sustainability boundary organizations, and *participatory observation* within the *European Environment Agency*.

Outcomes of this research indicate that, while the need for a new type of knowledge is clearly acknowledged by practitioners in ‘boundary organisations’, notions associated with required innovations in knowledge practice – such as co-creation, systems thinking, transdisciplinarity,

reflexivity and action-orientated knowledge – are still subject to ambiguity and controversy within the institutional context they operate. As practitioners struggle to engage the notion of individual competence in this debate, the type of competencies deemed critical to induce required innovations in their knowledge practice resonates with their own experience. Experts in boundary organisations identify though a lack of institutional frameworks to support their efforts to generate innovations in knowledge practice. While this research synthetises and presents existing examples of learning programmes and approaches to help develop such type of competencies, practitioners in the field manifest scepticism on the extent to which such learning approaches are feasible in their given institutional settings.

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Acknowledgements

Special thanks to:

- My supervisors, Fred Steward, Ben Shawn and Tom Cohen, for their invaluable guidance and support throughout this journey. Profoundly grateful.
- Colleagues and management at the European Environment Agency (EEA), for their availability, openness and encouragement.
- All those participating *in* and contributing *to* interviews and focus-groups, for their active and enthusiastic engagement in this research.
- My wife and my children – my true nest – for all their unconditional support, resilience and love, especially when my absence was most noted.

Dedicated to *Clara, Julia and Vasco.*

Declaration of originality

I declare that this thesis is my own work. When building on the work of others, this is appropriately referenced.

List of acronyms and abbreviations

APA	Portuguese Environment Agency
CECAN	Centre for the Evaluation of Complexity Across the Nexus
CEDEFOP	European Centre for the Development of Vocational Training
CIRET	International Centre for Transdisciplinary Research
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DRIFT	Dutch Research Institute For Transitions
DSRP	Distinction, Systems, Relationships and Perspectives
Eionet	European Environment Information and Observation Network
EEA	European Environment Agency
EEAcademy	European Environment Academy
EPSO	European Personnel Selection Office
ETC	European Topic Centres
EU	European Union
GRSD	Global Sustainable Development Report
JRC	Joint Research Centre
MASOS	Making Sense of Science (report)
OECD	Organisation for Economic Cooperation and Development
PBL	Dutch Environment Agency
PSN	Post-Normal Science
RESCUE	Responses to Environmental and Societal Challenges for our Unstable Earth
RQ	Research Questions
RTD	European Commission Research Unit
SAPEA	Science Advice for Policies by European Academies
SSM	Soft Systems Methodology
SST	Soft System Thinking
STOA	Science and Technical Options Assessment of the European Parliament
UNESCO	United Nations Educational, Scientific and Cultural Organisation

1. INTRODUCTION

1.1 Overview

This thesis explores the role of individual competence in delivering innovative knowledge practices required to support sustainability transitions. Its focus is on the individuals and organisations operating at the interface between science and policy for sustainability. It departs from questions such as ‘the competencies required to innovate knowledge practice at this interface’ or ‘how are such competencies different from those currently at stake to address other pressing policy challenges’ and ‘how are they developed individually and institutionally’.

The motivating trigger behind this research work is the argument by the European Environment Agency (EEA) that governance endeavours for systemic transitions in the sustainability arena require a ‘new type of knowledge’.

Following preliminary literature reviews and the work experience at the EEA, it became apparent that the concept of ‘new type of knowledge’ is better expressed through the notion of ’innovative knowledge practices’. This requires attention to the concept of ‘competence’ – how are practitioners in the field capable of inducing such innovations – rather than to traditional expertise. These innovative knowledge practices are, for the sake of this thesis ‘situated’ in a particular domain – that of the ‘boundary organisations’, operating at the intersection between science and policy. The definition and development of new competences for boundary practitioners to induce innovations in knowledge is therefore a central focus of the thesis.

This research work – including its empirical investigation – seeks therefore to explore the relevance of addressing innovative approaches to knowledge practice, and the need to question and understand the type of individual competence required to induce such innovations – and how to develop such competence within organisations at the science policy-interface.

1.1.1 From ‘a new type of knowledge’ to ‘innovations in knowledge practice’

In the sustainability science-policy arena, knowledge produced in the past decades has been recognised by international organisations and governments alike to have been of great value for policy-making. However, the growing complexity of sustainability challenges – as perceived by actors in this field – and their interdependence with economic and social systems in a globalised world “has brought with it increasing recognition that existing knowledge and governance approaches are inadequate to deal with them.” (EEA, 2015)

It is important to acknowledge the EEA is not alone in the claim above. On the contrary; such a claim is situated within a wider debate on the role of knowledge – including scientific knowledge – in supporting policy and governance.

This brief introduction to the subject, does not intend to open room for a broader epistemological debate around the type of knowledge informing sustainability policy per se. In that regard, more will be explored at chapter 2 below. It is nevertheless relevant to frame and illustrate some of claims, tensions and approaches impacting the work and thinking of organisations (and respective actors) such as the EEA.

The quest for a ‘new type of knowledge’ to better inform policy making is neither new nor exclusive to the sustainability arena. For some decades now, scholars and researchers have been claiming that the nature of policy challenges calling for science contributions do require a different approach to how science is produced, and knowledge is generated.

The perceived *nature* of challenges[1] and the *persistence* of associated problems leads actors in this field to questioning whether they have the adequate understanding of phenomena and the right type of knowledge to deal with them. Many argue they don’t, claiming the community of knowledge brokers, scientists and political agents alike are failing to adjust responses to increasingly complex and systemic challenges.

[1] Be such challenges in the sustainability arena or in the wider context of social issues, including striking contemporary challenges with global security, terrorism and migrations.

From the failure to adjust mental models (Cabrera & Cabrera, 2015)) to the problem of induction (Kuhn, 1970); from the role of science towards intentional change and behavioural science (Cabrera & Cabrera, 2015; Wilson et al., 2014)) to the lack of transdisciplinarity (Dieleman, 2013), a large number of scholars and researchers indicate the need to question how science can best support policy decision in dealing with highly complex and systemic problems. Work done through natural science disciplines, based on empirical measurable evidence, seems – although invaluable – insufficient. Knowledge based on testable predictions, systematic observations and principles of indisputable objectivity and certainty is claimed to be incapable of responding by its own to the interdependent, wicked, complex, and systemic nature of the problems it tries to address.

A good synthesis of such a perspective is provided by Otto Scharmer, below:

> "Across the board, we collectively create outcomes (and side effects) that nobody wants. Yet the key decision makers do not feel capable of redirecting this course of events in any significant way. They feel just as trapped as the rest of us in what often seems to be a race to the bottom. The same problem affects our massive institutional failure: we haven't learned to mould, bend, and transform our centuries-old collective patterns of thinking, conversing, and institutionalizing to fit the realities of today." (Scharmer, 2009)

Innovative approaches to knowledge practice are required. Yet, as limitations of traditional approaches to knowledge systems are acknowledged, a new paradigm to inform current knowledge practices appears to be yet hard to define. In recent years, Edgar Morin, Maturana (& Varela), Peter Senge, Frank Capra, Jake Chapman, Hans Dieleman, Michael Gibbons, Basarab Nicolescu, Otto Scharmer, have been offering some possible pointers into this.

As an example, a popular approach (amongst many of the boundary organisations investigated) to such a generic knowledge generation challenge came up with the expressions "Science Mode 1" and "Science Mode 2". The term was coined by Gibbons, Limoges and colleagues in the book

"The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies" (Gibbons et al., 1994). As the authors more recently synthetized it:

> "The old paradigm of scientific discovery ('Mode 1') – characterized by the hegemony of theoretical or, at any rate, experimental science; by an internally-driven taxonomy of disciplines; and by the autonomy of scientists and their host institutions, the universities – was being superseded by a new paradigm of knowledge production ('Mode 2'), which was socially distributed, application-oriented, transdisciplinary, and subject to multiple accountabilities." (Nowotny et al., 2003)

The two modes are usefully summarised in the table below, by Ana Jakil (Jakil, 2011):

Table 1 – Mode Science 1 and Mode Science 2

Mode 1 Science	**Mode 2 Science**
'Either/Or' thinking.	'Both/And' thinking.
Based on old physics (Newton).	Based on new physics (Einstein).
Reality made up of separate parts.	Reality made up of interdependent parts.
Whole is a sum of separate parts.	Parts are not separate, but understood only in their relationship to the whole.
Reductionist worldview.	Holistic worldview.
Materialistic worldview.	Recognition of the invisible/unseen behind the material.
Mechanistic worldview.	Organic worldview.
World as a linear machine.	World as a non-linear complex machine.
Focus on the structure.	Focus on the process.
Science can arrive at total truth about social reality.	Science can give only interpretations of the social reality.
Absolute relationships and predictions possible.	Statistical probabilities only; cannot predict the change in nature / society.

Controversy around the theoretical frameworks supporting the above distinctions between these two 'Science Modes' is also present. More so, however, are the challenges of attempted alternative scientific praxis, with stakeholders questioning the validity, credibility, and saliency of science outputs. (Benessia et al., 2016; Saltelli et al., 2016)

On the other hand, the growing complexity, ambiguity, and uncertainty surrounding *evidence-for-policy* confronts traditional scientific approaches sitting on rigorous propositions of analytical certainty, objectivity, and predictability. Research and academic institutions are encouraged to question their own praxis of knowledge production, methods, organisational governance, and, ultimately as such, the scientific paradigms they are sitting on.

An example of this, often referred to by actors within the science-policy interface, is the growing role advocates of 'post-normal science' are playing within the sustainability science-policy arena. The questions raised within this paradigm in relation to evidence-based policy (O'Connor, 1999), feed straight into the attempts described above to question current scientific praxis and generate alternative *knowledge-for-policy* (Ravetz, 1999). This will be later presented in section 2.3.5 of this thesis.

In the midst of such controversy, scientific and policy communities alike endeavour substantive efforts to understand these seemingly changing realities, seeking to re-position and reinforce the role of science in informing policy-making. There is an active movement to question existing knowledge systems and the need for innovative approaches to knowledge practice.

The literature is relatively abundant in this regard, also within the sustainability knowledge arena as such. Much of the debate emerges expectedly at the core of scientific and academic territories, and the effervescence of such debate may suggest an underlying argument for a foundational change (or revolution) in the whole system of scientific knowledge production, transfer and application.

While that may well be the case, this thesis does not intend to enter such a wide epistemological debate. The introduction above was provided to illustrate some of the broader questions, tensions and approaches impacting the work and thinking of organisations (and respective actors) implied in this thesis.

It indicates how scholars and international organisation in the sustainability arena manifest concern about the modes of producing knowledge and suggest a need to find innovative approaches to knowledge practice in the science-policy interface.

1.1.2 Capacity for innovation in knowledge practice

While present in preliminary literature reviewed, the question of ‘capability’ for knowledge innovation is rather absent in overall discourses in the field. Mentions to the required capability to induce innovations in knowledge practice within the sustainability science-policy interface were rarely found – especially those from the perspective of individual competences.

Within explored institutional contexts, and based on observed discourses, references to the capacity to induce a new type of knowledge in the sustainability science-policy interface appear to privilege the idea of collective, organizational or institutional capability – and to a lesser extent that of professionals / practitioners’ individual competence.

Both angles of *collective capability* and *individual competence* would be relevant in the context of this research project. However, the deliberate option in this thesis was to address primarily the perspective of *individual competence* – focusing on the situation of practitioners and experts on the job – as that was deemed, precisely, to represent the most relevant added-value and novel contribution to knowledge this research could offer.

What does an individual professional operating within the science-policy interface – a researcher, a civil servant, or a sustainability professional – need to be *differently* competent at, and to generate such a *different* type of knowledge? What different type of competencies are required, and how can those be (further) developed?

These questions and challenges informed the essential questions at the basis of this research work: in brief, a growing perception that, with all of the above, while international organisations, researchers and scholars engage in discerning what needs to change in knowledge practice at the sustainability science-policy interface, not much has been researched on how practitioners perceive the needs for such type of innovations and their own capacity (competence) to induce them. Do practitioners feel such changes needed and desirable? Do they perceive such type of innovations feasible in the institutional context they operate within? Do they feel capable, as key actors in the field, to induce such type of innovations?

In addressing these questions, there is a need to integrate and synthesise the literature inputs seeking to describe what innovations in knowledge practices are required. The literature to date is scarce in explaining what exactly this 'new type of knowledge' is about in the particular context of the sustainability science-policy interface. It is not evident what innovative approaches are required to generate a more suitable and usable 'type of knowledge' to inform decision-making.

Being aware of it, actors in the field dedicate significant efforts to explore the question, seeking to induce innovations in knowledge practice at the science-policy arena, to better support policy for sustainability transitions / transformations.

One important illustration of such efforts is expressed in the report "Making sense of science for policy under conditions of complexity and ambiguity" (SAPEA, 2019). This report was commissioned to SAPEA[2] consortium to inform the European Commission Group of Chief Scientific Advisors' Scientific Opinion.

While the report re-states the important role of science in informing policy decisions, it also draws attention to the idea that "science advice must be based on the best available evidence, communicated in a transparent and accountable way that explicitly and honestly assesses uncertainties, ambiguities and tensions". (SAPEA, 2019)

This report is accompanied by other studies, initiatives, programmes, or projects seeking to enhance the capacity of scientific research to support policy work. Relevant to mention would

[2] Scientific Advice for Policy by European Academies

be, for example, the European Commission Joint Research Committee report[3] on "*Understanding our political nature: How to put knowledge and reason at the heart of political decision-making"* (Mair D., 2019), the work of the European Parliament Panel for the Future of Science and Technology (STOA), the work and report of the Organisation for Economic Co-operation and Development (OECD) on "*Standards of evidence for policy design, implementation and evaluation",* the Future Earth consortium Knowledge-to-Action Networks, seeking to bring together innovators from academia, policy, business, and civil society to address pressing sustainability challenges and the NEXUS Network contributions, supporting transdisciplinary research to create links between communities of researchers, policymakers, business leaders, and practitioners.

At the same time, a significant body of research is emerging, accompanying, reviewing, and qualifying these processes. On a gradual, incremental, basis, more inputs are provided on what innovations should be put in place, leading organisations towards this 'new type of knowledge' to inform policies in the sustainability arena.

Despite all such contributions, the literature reviewed appears nevertheless to lack comprehensiveness and integration. Contributions in this arena come along, at first glance, dispersed and fragmented, as it takes the perspective of existing disciplines of study or get conditioned by the boundaries of existing research programmes.

The absence of clear pointers to approach such a quest rendered the work of those operating in the sustainability science-policy interface more difficult. While working for the European Environment Agency it was of manifested clarity that such ambiguous propositions on the type of knowledge required were making it harder for experts to find out "what is the right thing to do" in such contexts.

[3] This report will be further referred later in this thesis.

Furthermore, existing research efforts around these issues do not integrate the perspectives of practitioners in the field, especially to what extent those in the field perceive their own – and that of others – capability to induce innovative approached in knowledge practice.

On the other hand, targeted and systematic feedback from the field was missing, along with inputs from international reports and academic research. There was a need to go beyond the existing literature, and, consequentially, sound actors engaged in generating such 'new type of knowledge' in the sustainability science-policy arena.

The overall purpose and motivation behind this thesis are connected to the challenges described above, perceived while working at the European Environment Agency over the past years.

1.2 Research questions

From the above, emerged **four** important **propositions** underlying this thesis from the outset which inform the key research questions as defined below. These propositions are based on perspectives largely informed by the initial / preliminary literature review, and by my own personal experience and professional career within the field of knowledge innovation, learning, and competence development.

The **first** one is that, based on initial investigations and literature reviewed, there seemed to be a lack of research work in relation to individual competences required for innovations in knowledge practice were. No evident (institutional) agendas were found on this topic and there appeared to be an important gap in terms of academic research and literature on this specific issue. While there is work done in what the so-called "competencies for sustainability", there is no specific research on individual competencies associated with the capacity to induce innovation in knowledge practice. This makes it difficult to respond to "real world" challenges faced by those working at the science-policy interface. Stabilizing what those required 'innovations in knowledge practice' are, and what competencies are required to induce such type of innovations, appears as a striking need. A newly constructed conceptual framework is required in order to support boundary organizations in their efforts to induce such innovations in knowledge practice. That is a contribution this thesis can undertake. It calls however for a non-traditional research approach, different from a traditional perspective through which there is an existing, specific and selected discipline of knowledge or body of reviewed theoretical literature, based on which the empirical work is developed. In the context of this thesis, under a transdisciplinary approach, the researcher has to go further and "cast the net wide", searching for literature, theoretical frameworks and concepts that could help interpret the reality and challenges at stake. The empirical work – and inherent findings – are therefore mostly based on such a conceptual and theoretical construct, rather than just on a previously existing body of knowledge, specific to this research questions, pre-existent to this thesis.

The **second** proposition is that the quest towards innovative approaches to knowledge practice calls for a set of individual competencies our traditional education and training models are normally not used to address and serve. Innovating to generate, transfer and use a *different* type of knowledge requires thinking *differently*, learning *differently* and building a *different* set of mental models to interpret reality. Classical paradigms of education, learning, and training do not incorporate such a *difference* in knowledge practice. On the contrary, they tend to reproduce existing modes of processing information which, ultimately, generates the same type of knowledge praxis. This suggests, therefore, that individuals operating in the sustainability knowledge arena might be ill-equipped to generate innovations in knowledge practice.

The **third** important proposition is that, among sustainability knowledge-based organisations, there is a gap in relation to their competency frameworks: either they are inexistent, or they lack references to different types of competencies required to bring about innovations in knowledge practice. Under this proposition lies an assumption based on professional experience that, in success cases, most of the individual competencies inducing such type of innovations are mobilised intuitively or instinctively – and not following a deliberate, explicit, and steered application.

Finally, some significant current initiatives around the world indicate it is possible to acquire the different set of competencies required to generate innovation in knowledge practice, provided adequate learning strategies are put in place. Such learning paths may be significantly different than the ones commonly used in formal education contexts or in professional organisations.

Following all of the above, this research project, therefore defines the following key research questions:

1.2.1 Reviewing and structuring claimed innovations in knowledge practice towards a "new type of knowledge" for sustainability transitions / transformations

Which key innovations in knowledge practice are claimed as needed in order to respond to sustainability challenges in a context of transitions / transformation? What key characteristics shape the type of innovations required?

1.2.2 Defining differentiating individual competence to induce innovations in knowledge practice

What different individual competencies are needed to induce such type of innovations in knowledge practice at the science-policy interface? How can the development of such competences be accelerated?

1.2.3 Need and pertinence of innovations in knowledge practice

How do practitioners in the field perceive the need for and the pertinence of such type of innovations?

1.2.4 Competencies for innovation in knowledge practice

How do practitioners in the field relate to the notion of individual competence and the need for different types of competencies to induce innovations in their own knowledge practice?

1.2.5 Developing competencies for innovative approaches to knowledge practice

> *How can professionals working in the science-policy interface most effectively learn and acquire such new set of competences, given their specific organisational / institutional contexts?*

The research addresses and answers these questions focusing on the interfacing territory between science and policy and the knowledge practice. The research makes use of the notion of 'boundary organisations' (explained in the section below), exploring the reality of such organisations as a proxy for broader reflections on the questions set out above.

This thesis, therefore, explores and defines the challenges faced by those seeking to innovate their practice towards a 'new type of knowledge' for sustainability transitions, through an investigation of the thinking and the practices of 'knowledge brokers' – key actors / experts – working *within* or *with* 'boundary organisations'.

This is pursued empirically through the analysis of a varied set of collected documentation, and discourses derived from these 'boundary organisations' and related actors (staff and their consultants, advisers, or sponsors). It includes, amongst other, reports, knowledge reviews and publications, public presentations, competence frameworks, learning programmes and strategies, and interviews and focus groups.

As said above, my role as an engaged actor in one of these organisations, gives special access to some of the thinking and practices within such a space. While adopting explicit reflexivity as part of an action research process was required, it didn't alter the fundamental approach of the thesis as one which is based on the analysis of the work of 'boundary organisations' and related actors.

1.3 The science-policy interface and the role of ‘boundary organisations’

As mentioned above, the empirical research at stake in this project makes use of the notion of ‘boundary organisations’ to delimit the knowledge practice within which experts in the sustainability arena seek to generate adequate knowledge to support policy-making. As underlined by Kass et al., ”while policy-making involves a gamut of considerations and contexts, they helpfully note that the interface itself can be thought of as a particular ‘class of boundary function’. As a way forward, the figure of the knowledge-broker is championed, an individual or group of scientists/researchers who are to bridge that boundary by working proactively with knowledge asymmetries and evidence synthesis, as well as working effectively to communicate across the professional boundaries of science and policy-based communities.” (Kass et al., 2022)

The discourses, practices, and thinking of actors in these organisations therefore inform the empirical basis to address the research questions set out above.

Knowledge utilised to support policies and governance efforts responding to sustainability challenges derives from a variety of sources. Amongst those is, incontestably, knowledge produced in scientific, and academic research milieus.

Adjacent to this, is the type of knowledge generated and used within the science-policy interface. Much of the preliminary literature reviewed refers to such a space to be occupied by ‘boundary organisations’ – those where the interface between science and policy is most fertile in finding innovative approaches to knowledge practice. On one hand such organisations appear less conditioned by academic set practice; on the other hand, they can follow criteria of scientific quality and credibility sufficiently distant from core policy-making centres.

The exact boundaries of such an organisational space, the type of knowledge produced, and the praxis of knowledge generation and use in such an arena do not present however clearly defined from the outset. In order to understand it further, this section dedicates a brief introduction to the notion of ‘boundary organisations’ and explains the reasons behind the choice of such an arena to focus the empirical investigation on.

1.3.1 The relevance of boundary-organisations for this research

The specific nature of ‘boundary organisations’ positions these in a unique space to experiment and induce innovative approaches to knowledge practice.

Derived from the scientific concept of *boundary objects*[4], Guston, O’Mahony, Jasanoff, and other sociologists of science have proposed the related construct of a *boundary organisation*. Such organisations are positioned at the intersection between science and policy, and navigate the tensions between both sides of the borders, in order to seek alignment and collaboration.

In doing so, and according to David Guston, ‘boundary organisations’ attempt to solve emerging problems by meeting three key criteria: “first, they provide the opportunity and sometimes the incentives for the creation and use of boundary objects and standardized packages; second, they involve the participation of actors from both sides of the boundary, as well as professionals who serve a mediating role; third, they exist at the frontier of the two relatively different social worlds of politics and science, but they have distinct lines of accountability to each […].” (Guston, 2001)

In this context, ‘boundary organisations’ blend scientific and political perspectives, coordinating activities across various disciplines and areas of expertise, adopting roles of a policy and

[4] “Boundary objects are objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. They may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is key in developing and maintaining coherence across intersecting social worlds.” (Star, S. L., & Griesemer, J. R. (1989). Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social studies of science*, *19*(3), 387-420. A good example of a ‘boundary object’, relevant for this sphere of research, is that of Communities of Practice, as coined by Ethiene Wenger (Ethienne, W. (1998). Communities of Practice: Learning Meaning and Identity. In: Cambrigde Press.) set to allow different groups to collaborate on a given practice.

knowledge broker, issue advocate, science arbiter or pure scientist. These roles are not static, just as the process of producing and mobilising knowledge for decision-making is not linear. Through their own mechanisms, ‘boundary organisations’ induce collaboration in a way that reinforces convergent interests while allowing and preserving distinct perspectives (O'Mahony & Bechky, 2008). In the context of science-decision-making interactions, Kirchhoff and colleagues propose that the role of boundary organisation is essentially twofold:

> “First, they stabilize the knowledge production function by providing a protective layer against the undue influence of extraneous factors such as politics. Much of the early research on boundary organizations focused on their stabilizing function. Second, boundary organizations provide a bridge for and broker knowledge between the production side (universities, research institutes) and the use side (stakeholders, decision makers).” (Kirchhoff et al., 2013)

Within the sustainability science-policy arenas, ‘boundary organisations’ take different forms, sizes, and institutional identities. For the most of it, though, a typical profile in this arena would be represented by the role of *Environment Agencies* – both at European, regional, or national levels. Often set-up in the domain of public administration, these organisations are constructed as autonomous entities, independent from both political and academic spheres, although constantly seeking to navigate that tension border. Acknowledging their varied and dynamic roles and profiles, it is relatively safe to say these agencies play an instrumental role in providing credible, salient, and legitimate knowledge to inform policies on environmental or sustainability issues, and support governance efforts in these arenas. (Jasanoff, 2004; Moran et al., 2016; Zito, 2015).

In this regard, the notion of *knowledge arenas* appears as yet another useful construct to understand the special role of boundary organisations, especially under the relationship between knowledge and action (Best, 2010), (Flood, 2010), (Weichselgartner & Kasperson, 2010), (Cherney & Head, 2011). In this process, “relationships between research-based knowledge and action can be better understood as arenas of shared responsibility, embedded within larger systems of power and knowledge that evolve and change over time”. (Van Kerkhoff & Lebel,

2006) The authors claim the need for new knowledge arenas to be created in order to address sustainability challenges.

The nature of boundary organisations as described above, situates these in a unique space to experiment and induce innovative approaches to knowledge practice. Given the “plasticity” of knowledge practice in ‘boundary organisations’, practitioners within appear to have a greater scope for reflection on their own experience, seeking to discern the type of competencies that effectively contribute to innovate in their practice approach.

Additionally, in ‘boundary organisations’ work many of current sustainability professionals, those already ‘in the job’, seeking to generate knowledge to support policy-making. In environment agencies researched co-exist combinations of professional profiles, including, for example, environmental experts (in various specific fields), data analysts, and political scientists. While the findings of this research may well serve a wider variety of actors in the field, such type of experts in ‘boundary organisations’ are meant to be the primary beneficiaries of its findings.

As previously mentioned, this research seeks to investigate the thinking and practices of these actors and their views on the competencies required to generate innovations in knowledge production at the science-policy interface.

Initial readings and observations indicated most practitioners in ‘boundary organisations’ have been – and are continuously being – educated and trained mostly under paradigms of problem-solving, linear causality, discipline-based analysis, and planning. They may therefore be ill-equipped, from their education and praxis, to induce claimed innovations towards a ‘new type of knowledge’ in the sustainability arena. Their capacity to deal with wicked problems remains dependent on informal learning processes, networks and individual dispositions of willingness, purpose, and talent. (Bourgon, 2011; Candel et al., 2016; Zito, 2015).

If such indications prove valid, delimiting a praxis space as one of typical boundary organisations – as the case of *environment agencies* – appears adequate to the purpose of this research. The thinking and practice of actors in these organisations can serve as a proxy for broader findings on innovative approaches to knowledge practice.

In that regard, it is important to unfold the notion of knowledge practice as such, and why the thinking and perceptions of actors within are relevant to induce necessary innovations. The next section will provide a brief introduction to the specific theoretical framework behind this then methodological approach.

1.4 The notion of knowledge as practice, in the context of this thesis

Given the context described above, and for clarity, in this thesis, *knowledge practice* is understood as the praxis of generating, transferring and using knowledge to support policy-making – often referred to as 'usable' or 'actionable' knowledge.

While crafted to be complementary with (not in opposition to) scientific / academic knowledge, *knowledge-for-policy* in the sustainability arena seeks a greater focus on possible responses and pointers to action, rather than simply a better understanding of problems. While keeping key characteristics of *credibility*, *saliency*, and *legitimacy*, innovations in knowledge creation seek, nowadays, to provide better policy support in navigating systemic, complex challenges. That is, arguably, one of the key current challenges faced by 'boundary organisations'.

Acknowledging the complex relationship between knowledge generation and knowledge application (actionability, usability) – often perceived as a linear continuum – the choice in this thesis is to use the notion of 'knowledge practice' to include the entire spectrum of knowledge dynamics in the science-policy interface, understood not only in a linear approach, but as a system composed of different entities, flows, interdependencies and perspectives.

When investigating needed innovations in knowledge practice in this context, this thesis is primarily focused on the *process* of generating, transferring and using such *knowledge-for-policy*, from a practice-based perspective, rather than on *what* that knowledge actually *is about*, as a *product*.

In this overall context, a conceptual framework, based on ‘knowledge as practice’, seeks to complement recurrent approaches to knowledge that predominantly emphasise the object created, communicated, and used. From the perspective of knowledge practice, attention is put on the *process* of constructing knowledge, the human interactions and interpretative acts in which knowledge is needed, mobilised, communicated and used – and to which it should contribute. (do Nascimento Souto, 2013)

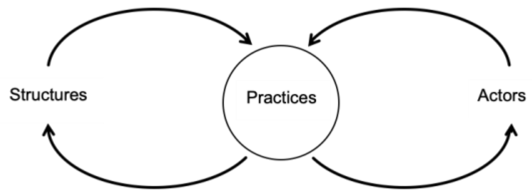
Such an approach enables encompassing perspectives such as the ‘vision for knowledge innovation’ shared in the “Responses to environmental and societal challenges for our unstable earth” (RESCUE) report, which calls for a radical *open* knowledge system, which requires “deep changes in mind-sets, as well as in the cultural and moral assumptions about what knowledge is, how it is produced, for whom it is, and for what goals.” As put by the authors, such vision seeks to “transform the current dominant framing of knowledge as a closed, uniform, linear and placeless system of insights and aptitudes to an adaptive framing that takes into account, promotes and, whenever possible, integrates a diversity of patterns of knowledge and modes of interaction produced for multiple purposes and under different representations”. (Jäger et al., 2013)

The usage of the notion of *knowledge practice* in this thesis – as described above – represents therefore an attempt to: (1) accommodate the idea of *knowledge-for-policy* within a broader framework of knowledge generation, transfer and use, beyond the perception of a linear continuum; (2) encompass the notion of knowledge as a process within a system, beyond the understanding of knowledge as a product; (3) focus the investigation on the individual and organisational mindsets, the human interactions and interpretative acts in which knowledge is needed, mobilised, communicated and used – beyond mechanistic approaches to knowledge creation and usage.

Although this thesis will not explore in depth its conceptual frameworks and application, contributions from "theory of practice" provided insightful notes on how such approach to knowledge dynamics can be approached from the perspective of actors and structures involved.

As Inge Røpke puts it, "theory of practice" can break through the classical dualism between actors and structures: (1) structures exist as a given reality and determine the actions of individuals *vs* (2) individuals are self-contained and society is just the sum of individuals. "Theory of practice" offers a different perspective where practices are core entities mediating between individuals and structures.

Figure 1 – Theory of Practice



(source: Inge Røpke)

The basic idea shared by Røpke is that in the continual flow of activities, it is possible to *identify organized constellations of activities* that can be described as entities. A 'practice' is a relatively enduring or recognizable *entity* across time and space. 'Practices' in this account are collective.

A definition of 'practice' in this perspective is proposed as a "routinised type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge." (Reckwitz, 2002)

What is also of interest in the context of this thesis, is the observation by Elizabeth Shove, according to whom, "*innovations* in practice occur when everyday entrepreneurs (people) make new connections between existing or new elements of *image*, *material* or *skill*.[5]" The dimension of *skills* is one this research project will be mostly focusing on.

In that line, this thesis follows a methodological approach and empirical research design very much focused on the thinking, perceptions and behaviours of actors in the field, as those inform the notion of knowledge practice itself and innovative approaches within.

1.5 Competencies for sustainability and competence for innovation in knowledge practice

The use of competence-based approaches to address capability issues is not foreign to management, organisational development or even sustainability transitions governance arenas. The relevance of such an approach is different from context to context. In this section a brief account of different arguments will be given, though eventually very much focused on explaining the purpose and deep meaning of a competence-based approach to enhance innovations in knowledge practice within sustainability 'boundary organisations'.

In management contexts, the use of the term competence, "synthesizing the strategic issue (task) and the managerial skills and other parts of managerial stock of knowledge, can have a particular strategic value." (Von Krogh & Roos, 1995, p.68) As Schmidt and Kunzmann put it, "competencies as abstractions of work-relevant human behaviour have emerged as a promising concept for making human skills, knowledge and abilities manageable and addressable in a wide range of application areas. (Schmidt & Kunzmann, 2007).

In this line, competence-based approaches provide a possible approximation of human performance factors beyond the notion of 'knowledge' in traditional knowledge management frameworks. Competences can represent a *set* of skills, knowledge, and abilities that belongs together and, as competencies, go beyond mere "knowing about" towards work-relevant action;

[5] These being the three elements of practice according to the author. Quotation from Elizabeth Shove's presentation slide. Main background theory and approaches explored in Hui, A., Schatzki, T., & Shove, E. (2016). *The nexus of practices: Connections, constellations, practitioners*. Taylor & Francis.

this opens possibilities to operationalise learning goals and outcomes and thus serve as a ‘control instrument’. This argument is particularly relevant for the scope of this thesis, focused on the practice of knowledge experts within ‘boundary organisations’.

The connection between organisational management challenges and the notion of competences associated to human capital or human resources is not new, and displays a large variety of perspectives and applications (Heene & Sanchez, 1997) (Nordhaug & Gronhaug, 1994). The full scope of approaches and applications will not be dissected in this thesis.

That said, the analysis of competence-based approaches in relation to sustainability work is of particular relevance. In such a space, reports like the *Future Earth* or the *RESCUE* , for example, refer to the terms “capacity development” and “skills development” instead of *competence* as such. The EEA Sustainability Transitions report though, clearly refers to ‘competencies for governing transitions’, defining competencies in this account as “a combination of knowledge, skills and attitudes, mobilised in action in a given context, towards the performance of a particular task or job (Klett, 2010).”

In general, the notion of ‘capability’ or ‘competence’ in relation to sustainability work, as found in the literature reviewed, focuses primarily on the *research* and *education* fields per se (Adomssent et al., 2007; Adomßent & Hoffmann, 2013; Crocco, Marri, & Chandler, 2013; de Haan, 2010; Wiek, Withycombe, & Redman, 2011; Zoller, 2015). Most of the propositions and approaches suggested seek to re-frame how research is (should be) conducted and/or how education programmes and curricula – especially pointing at young researchers – need to be re-designed and implemented. Much of these propositions are framed under the ‘capacity-building’ umbrella, linking into governance frameworks and funding mechanisms.

Demonstrative examples of it are the work done by Gerhard de Haan around the concept of *Gestaltungskompetenz* applied to sustainability studies (2006, 2010), or the work of Arnim Wiek towards a reference framework for academic program development on key competencies in sustainability (2011).

De Haan, for example, sets a list of key fundamental competencies that should orient educational programmes on sustainability studies. “Over the past four years, the concept of ‘Gestaltungskompetenz’ has become more differentiated and enriched with examples of topics and methods. It now encompasses the following eight sub-competencies that serve as the basis for formulating educational standards: (a) competence in foresighted thinking, (b) competence in interdisciplinary work (this calls for interdisciplinary learning), (c) competence in cosmopolitan perception, transcultural understanding and cooperation, (d) learning participatory skills, (e) competence in planning and implementation skills, (f) the capacity for empathy, compassion and solidarity, (g) competence in self-motivation and in motivating others and (h) competence in distanced reflection on individual and cultural models”

On a parallel road, Arnim Wiek and colleagues have conducted a broad literature review trying to address critical gaps in the conceptualization of key competencies in sustainability studies, synthesise contributions in a coherent framework of sustainability research and problem-solving competence. According to them, “… the goal of academic sustainability programs is to enable students to plan, conduct, and engage in sustainability research and problem solving based on the interplay of systems-thinking, anticipatory, normative, strategic, and interpersonal competencies.” (Wiek et al., 2011) The table below displays a synthesised overview of their findings.

Table 2 – Competencies for Sustainability

Table 2 Overview of core concepts and methods/methodologies as well as exemplary sources of the five key competencies in sustainability

Competence	Concepts	Methods/methodologies	Sources
Systems-thinking competence	Variables/indicators, sub-systems, structures, functions	Qualitative and quantitative modeling	Porter and Córdoba 2009; Crofton 2000; Sterling 1996
	Feedback loops, complex cause-effect chains, cascading effects, inertia, tipping points, legacy, resilience, adaptation, structuration	Institutional, decision, governance, social systems analysis	
	Across/multiple scales: local to global	Systems multi-methodologies (e.g., "thick" description methodology)	
	Across/multiple/coupled domains: society, environment, economy, technology	Participatory systems approaches, including participatory modeling	
	People and social systems: values, preferences, needs, perceptions, (collective) actions, decisions, power, tactics, politics, institutions		
Anticipatory competence	Concepts of time including temporal phases (past, present, future), terms (short, long), states, continuity (dynamics, paths), non-linearity	Scenario methodology Forecasting from statistical and simulation models	Major et al. 2001; Withycombe and Wiek 2010; de Haan, 2006; Grunwald 2007
	Concept of uncertainty and epistemic status including possibility, probability, desirability of future developments (predictions, scenarios, visions)	Backcasting and envisioning methods Anticipatory multi-methodologies Participatory anticipatory approaches, including Delphi and future workshop	
	Concepts of inertia, path dependency, non-interventions		
	Concepts of consistency and plausibility of future developments		
	Concepts of risk, intergenerational equity, precaution		
Normative competence	(Un-)sustainability of current or future states Sustainability principles, goals, targets, thresholds (tipping points)	Multi-criteria assessment methods (including Life-Cycle Assessment, Multi-Attribute Utility Theory, etc.)	Gibson 2006; Sterling 1996; Grunwald 2004
	Concepts of justice, fairness, responsibility, safety, happiness, etc.	Risk analysis Sustainability efficiency analysis	
	Concept of risk, harm, damage		
	Concept of reinforcing gains ("win–win") and tradeoffs	Envisioning methods (e.g., backcasting)	
	Ethical concepts	Participatory normative methods, including negotiation methods and consensus conference	
Strategic competence	Intentionality Transitions and transformation	Methods to design governance arrangements, policies, institutions	Bammer 2005; de Haan, 2006; Grunwald 2007
	Strategies, action programs, (systemic) intervention, transformative governance	Planning methodologies Decision support methodologies	
	Success factors, viability, feasibility, effectiveness, efficiency	Transition management methodology	
	Adaptation and mitigation	Methods to support behavioral change	
	Obstacles (resistance, reluctance, path dependency, habits) and synergies	Organizational (change) management	
	Instrumentalization and alliances		
	Social learning Social movements	Methods to support learning and reflexivity	
Interpersonal competence	Functions, types, and dynamics of collaboration (within and beyond academia) Strengths, weaknesses, success, and failure in teams	Participatory methods, including negotiation, mediation, deliberation, constructive conflict methodology	Crofton 2000; Kearins and Springett 2003; de Haan 2006
	Concepts of leadership	Teamwork methods	
	Limits of cooperation and empathy		
	Concepts of solidarity and ethnocentrism		

Much of these coincide with the key competencies for sustainability deemed crucial to advance sustainable development by the *UNESCO Education for Sustainable Development Goals* (2017).

These refer to competencies such as: *systems thinking competency*, *anticipatory competency*, *normative competency*, *strategic competency*, *collaboration competency*, *critical thinking competency*, *self-awareness competency* and *integrated problem-solving competency*.

The literature reviewed, combining sustainability issues with competence-based approaches, also led into the domain of "sustainability professionals". Although the notion of 'professionals of sustainable development' appears ambiguous, the following synthesis by Rick Woodward, Ira Feldman and Mark Edwards shadows light into the key stakes:

> "The practice of sustainable development is rapidly growing and evolving. As such, an increasing number of professionals are providing needed services in a variety of areas: planning and auditing, energy and waste management, sustainable food systems, watershed adaptive management, community economic development, sustainability science, business improvement, green building, international community development, and facilities management to name just a few. With this proliferation comes growing confusion and disparity in the quality and consistency of professional services as well as potential uncertainty regarding basic principles and concepts." (Woodward, Feldman, & Edwards, 2010)

As for works listed above, the authors also propose a set of key competencies that should inform the development of corporate sustainability managers and sustainable community development managers.

Overall, the *capability question* leads to a series of propositions and hypothesis related to the conditions and the context in which knowledge is generated – institutional settings, socio-cultural-political frameworks, set purposes, technology, etc. (Weichselgartner & Kasperson, 2010). However, contributions researched often point at the system-level, governance approaches, operational functioning, structures in place – rather than at the individual competence itself.

The previously mentioned RESCUE report is a good illustration of this. The work done by Withycombe and colleagues (Withycombe Keeler et al., 2016) is another good example of an approach that, while focusing on 'learning' aspects of 'transformational sustainability science', the emphasis is put on the types of research and collaboration efforts within international networks that can enhance such learning.

Although all of the above is relevant, this thesis situates itself in a distinct space of connection between competence-based approaches and the sustainability science-policy interface arena:

While building on the broad conceptual and practice space of sustainability competencies, this thesis focuses on the individual competencies required for professionals working at the science-policy interface to induce innovations in knowledge practice – emphasis put on *competencies* for *innovation* in *knowledge practice*.

1.6 Methodological approach and design

As exposed in the initial chapters of the thesis, this research first engaged in reviewing the literature – including public institutional reports in this arena – to explore and synthesize existing approaches to research questions 1 and 2:

RQ1: Which key innovations in knowledge practice are claimed as needed in order to respond to sustainability challenges in a context of transitions / transformation? What key characteristics shape the type of innovations required?

RQ2: What different individual competencies are needed to induce such type of innovations in knowledge practice at the science-policy interface? How can the development of such competences be accelerated?

The findings of the literature reviewed, oriented by the questions above and synthesised in chapters 2 and 3 below, set the basis for the subsequent research questions (#3, #4 and #5) underlying the empirical work conducted under this project. The questions above – and subsequent findings – are therefore to be seen as instruments (vehicles) to facilitate a deeper investigation of the thinking and practice of actors operating in the sustainability science-policy interface.

While there were substantive contributions from previous research efforts to address the questions at stake, a deeper analysis of the literature at reach exposed important insufficiencies in knowledge and research produced to date in relation to those same questions – the most important of which are described below:

a) Existing research on these questions is dispersed, fragmented, not connected, and not integrated. It derives from different disciplines and schools of knowledge. Scientific contributions on contemporary sustainability governance challenges, for example, are not connected to scientific contributions on the competence-based learning strategies; theories on system change are hardly articulated with adult learning theories. Building a coherent framework surrounding the research questions defined above, requires navigating contributions from, amongst others, sustainability and political sciences, psychology and behavioural sciences, education sciences, and management and governance studies.

   Rather than positioning within a well-defined discipline arena, this thesis would rather bring along and articulate distinct contributions in a coherent whole. The research approach should leave sufficient margin for inter-disciplinary and transdisciplinary knowledge to emerge. The methodological design, therefore, left room for a constant dialectic between reviewed literature and the experience of the researcher (observed practice) tangled in a cross-fertilising mode. This is particularly important in what the conduction of the empirical research is concerned.

b) As said before, although dispersed, previous existing research offered substantive pointers to what responses for the above questions could be. However, there was to date no demonstration that these pointers would make sense and be applicable in the particular context of boundary organisations operating within the science-policy sustainability arena. For example, what does knowledge co-creation mean in this particular context? What does it take to mobilise a '*systems thinking'* approach towards environmental assessments? How is (or can be) a notion such as *reflexivity* translated in the daily workflow of experts writing reports? What competence development approaches are actually used – in practice – in such organisational settings?

A large part of the empirical work towards this thesis was therefore designed seeking to obtain perspectives from practitioners in the field that could help interpret existing scientific and academic inputs within their specific working contexts. Would those theoretical inputs be applicable in their contexts? How do practitioners make sense of them? In what way is their practice reinforcing or challenging existing knowledge (or sometimes assumptions) around these issues?

The set of interviews, focus-groups, and practices observed were, to a large extent, chosen to fulfil the need to explore these questions. These will be explained in more detail in chapter 4 of the thesis.

c) Finally, existing literature and research didn't offer much guidance on 'what to do'. Existing knowledge didn't seem to be usable, actionable knowledge as such. As an example, should an organisation working in the sustainability science-policy interface want to develop competencies to foster innovations in knowledge practice, what competencies should it target, what frameworks should it use, and what learning strategies should it adopt? The initial analysis of literature samples didn't provide adequate, operative frameworks able to integrate available knowledge and emerging findings in this arena; existing knowledge focused on understanding certain issues, causes, and obstacles, rather than proposing possible responses for change.

   The research approach towards this thesis, therefore, sought to balance a robust understanding of the challenges and issues at stake (including the perspectives of practitioners in the field), with a constant quest for possible keys to action, and support frameworks that could be intelligible and usable in the specific context of boundary organisations operating in the sustainability science-policy interface.

In order to address the first two research questions and inherent challenges, an extensive interdisciplinary literature review was conducted. Focused on key themes – such as knowledge co-creation, transdisciplinarity, systems thinking, reflexivity and actionable knowledge, amongst others – this led to a novel synthesis of the attributes of competence considered to be required for innovations in knowledge practice at the sustainability science interface. This synthesis was then explored, tested and refined with practitioners through semi-structured interviews, focus groups and workshops.

While the key research questions were early defined and stabilised, the specific methodological approach and inherent empirical research components were as expected fine-tuned throughout the process. Conducting empirical research in such as space presents challenges – often emerging as *tensions* – between scientific validity and hermeneutical insights; between legitimacy and opportunities; between objectify and reflexivity. It also represents an opportunity to gain insights not available through other methods, as described in chapter 4 below.

From the outset of the research process, an important proposition has been drawn: that a key value-add of this thesis resided on the unique positioning of the researcher as a professional in the field within one of the main organisations operating at the intersection between science and policy in what the European sustainability arena is concerned – the European Environment Agency.

From that operating space of knowledge practice, this research therefore benefits from access to a broad and important variety of actors and respective thinking, observed behaviours and practices, individual and organisational change dynamics, discourses, decision-making processes, current debates, and tensions.

This circumstance offered an opportunity to contrast the claims argued by scholars, academic and international institutions engaged in this territory of knowledge, with the thinking and practice of those operating in the field.

Moreover, investigating the thinking and practices of these actors helps understanding in further detail (1) what type of knowledge is actually required to address complex systemic policy challenges in the sustainability arena, (2) how is knowledge to be produced in organisations positioned at the interface between science and policy and what innovations are perceived as effectively needed, (3) what obstacles and levers exist in these organisations towards knowledge innovation, (4) what individual competencies are demonstrated in this work and what are those missing, and (5) what learning approaches would help these actors develop required new competencies.

The next section indicates how the conduction of the research and inherent findings are presented in this thesis.

1.7 Outline of the thesis

The first chapters of this thesis set the context and theoretical framework surrounding the two initial research questions at stake. They explore existing literature pointers, relevant debates, controversies and arguments, institutional positioning vis-à-vis the claimed need for innovative approaches to knowledge practice in the sustainability science-policy arena, and the different type of competencies necessary to bring such innovations to life.

Chapter 2 of this thesis provides a broad characterisation of sustainability challenges surrounding policy making, which a certain type of knowledge is expected to support. It exposes some of the claims on the need for innovation in knowledge practice, as expressed by international institutions and academic research alike. While the chapters responds to research question #1, the challenges enunciated in this chapter will later configure an important part of the empirical work, where perspectives from practitioners in sustainability boundary organisations are sought in order to make sense of such claims in their own practice field. The chapter offers a synthesis of five key characteristics found critical to inform innovations in knowledge practice in the sustainability science-policy interface.

Chapter 3 sets the argument of this thesis for a competence-based approach when exploring the capability of 'boundary organisations' to induce required innovations in knowledge practice (as described in chapter 2). In doing so, the chapter addresses directly research question #2. Beyond understanding innovations claimed in knowledge practice in the sustainability science-policy interface, this thesis strongly focuses on exploring what different type of individual competencies are required to help induce such innovative approaches. Based on literature reviewed, it also offers broad perspectives on what enabling conditions are relevant for such competencies to be developed. While responding to research questions #2, this chapter is therefore also setting the theoretical framework around the notions of competence and competence development, which in turn will inform the empirical work outlined in chapters 6 and 7. In doing so, a selected list of ten broad competencies deemed critical to innovate knowledge practice is presented in this chapter.

Chapter 4 describes the empirical and methodological approach adopted in this research. It Explores the challenges of conducting empirical research in this area and how they were resolved. It dissects in further depth the relationship between my own role as the author of the thesis and at the same time as a professional engaged in one of the 'boundary organisations' investigated.

This chapter also describes in further detail the rationale behind the key methodological options, choice of organisations, and actors involved in the empirical work, as well as the process of collection, analysis, and reporting of data.

Departing from the theoretical pointers displayed in the second chapter, **chapter 5** makes use of empirical data to help interpret, in context, the needs towards innovative approaches for knowledge practice in the sustainability science-policy interface. Key questions addressed are*: How do these actors conceive of these innovations in their own knowledge practice? How do they make sense of such claims in the literature and specialised reports? How do they relate to them in their specific roles within 'boundary organisations'? How do they apply such approaches in 'practice'? What obstacles and opportunities to they encounter? In brief, this chapter offers a* perspective of how these claims in knowledge innovation are perceived inside such organisations.

Chapter 6 reveals how practitioners in 'boundary organisations' engage with the notion of individual competencies – and the idea of different type of competencies – to induce innovations in knowledge practice within their field of practice. *How are such competencies perceived in context? How suited do they seem from the perspective of practitioners? Are there examples that can illustrate the value and use of such competencies? In their 'practice', are behaviours that demonstrate the application of such competencies – or the lack thereof? What challenges do practitioners feel when trying to mobilise such competencies?*

The chapter also explores, based on data collected through the empirical research, to what extent 'boundary organisations' equip themselves with competency frameworks to facilitate and support actors in their attempts to reflect about competence for innovation in knowledge practice.

Chapter 7 addresses the last of the three key research questions: "How can professionals working in the science-policy interface most effectively learn and acquire such new set of competences, given their specific organisational / institutional contexts?". In this chapter, the thesis presents findings out of the learning programmes investigated through the empirical research work, and synthesis, key learning approaches and principles deemed critical for success in developing competencies for innovations in knowledge practice.

Chapter 8 presents the main conclusions of this thesis, addressing each of the five research questions individually. The chapters offers additional perspectives on found empirical data regarding institutional barriers and enabling conditions to induce innovation in boundary organisations' knowledge practice, as perceived by experts in the field. The chapter finally makes recommendations for further research in this arena.

2. SUSTAINABILITY CHALLENGES AND THE NEED FOR INNOVATIONS IN KNOWLEDGE PRACTICE

As mentioned in section 1.1 above, the growing complexity of sustainability challenges has brought with it the increasing recognition that existing knowledge – while invaluable over past decades – is inadequate to inform policy in response to such challenges. There is a claim for innovative approaches in knowledge practice in the sustainability science-policy interface.

This chapter addresses research question #1. It focuses on exploring the literature in relation to the claim above and provides important contextual material to frame the central issues this thesis explores of the nature of sustainability challenges and why knowledge practice associated with it is perceived as inadequate.

Such context setting, review and synthesis presented in this chapter is important as it will provide operative keys to help understand, synthesise, and stabilise the claims on the need for a 'new type of knowledge' in the sustainability arena and lead (later in chapter 3) to the argument that a different type of individual competence is required in order to innovate corresponding knowledge practice. That is the basis on which the empirical work builds.

2.1 The described nature of sustainability challenges

Contemporary studies, reflections, and discourses in the *sustainability arena* lead invariably to set sustainability challenges in a group of those characterised by great complexity, and multiple interdependencies and scales, and normally disposed in a long-term, constantly changing, horizon. Uncertainty, unpredictability, volatility, ambiguity, and reflexivity are further words often used to characterise the nature of such challenges.

The literature also often associates sustainability challenges with the notion of 'wicked problems' (Rittel & Webber), (Ison and Blackmore), (Levin,K.; Cashore,B.; Bernstein,S.; Auld,G.)[6], referring

[6] Overcoming the tragedy of super-wicked problems: Constraining our future selves to ameliorate global climate change. Policy Sci. 2012, 45, 123–152.

to problems that are difficult, or impossible, to solve (or even address) given their complex nature, and because of incomplete, contradictory, and changing requirements that are difficult to recognise. Within the 'wicked problems' literature, sustainability issues – global climate change in particular – are often indicated as contemporary examples of one of such type of problems.

Another notion often paired with sustainability issues is that of 'systemic challenges'. Planet Earth is often understood as a *system*, and by 'systemic', the literature commonly refers to the understanding of a system as a whole, with recognised properties, composed of *parts*, *processes, structures, and relationships*. It is not to be confused with 'systematic'. 'Systemic challenges' are constituted by great complexity and interdependence of elements at a system level.

Finally, one more reference frequently brought along with discourses on sustainability challenges is that of 'complex adaptive systems'. The key word in this expression being '*adaptive'* – as referring to constant loops of reflexivity engendered by all elements within the system (including human behaviour). As social-environmental systems are mentioned, Clark et al. emphasise that any interventions in such systems must be framed by a sense of tentativeness and transience of how the system works, and be treated as experiments. (Clark et al., 2016)

Recent reports – such as the *Global Sustainable Development Report 2019 (GSDR2019)*[7] or *The European Environment – state and outlook 2020 (SOER2020)*[8] – transmit the idea of reaching a *tipping point* in what the shared awareness of the nature of sustainability challenges are concerned. They also call for a greater attention and effort put on building a holistic understanding of global change in the *Anthropocene*[9] era and on societal and human interdependencies connected to such changes.

[7] Secretary-General, I. G. o. S. a. b. t. (2019). *Global Sustainable Development Report 2019: The Future is Now – Science for Achieving Sustainable Development.* [Report].
[8] Lopez, A. B., Martin, A., Killeen, B., Iversen, C., Russo, G., Andersen, H. K., . . . Jol, A. (2020). The European Environment State and Outlook 2020. *European Environment*, *2021*.
[9] "The term 'Anthropocene' has been proposed in reference to an emerging fundamentally new epoch in planetary history, a successor to the current Holocene epoch. Given that the impact of human activity is now of the same magnitude as bio-geophysical forces, this creates a completely novel situation posing fundamentally new questions, including issues related to ethics, culture, religion and human rights, and requiring new approaches and

Characteristics of sustainability challenges have by now been extensively examined from within and across a variety of disciplines, actors, and institutions – especially as such type of challenges disrupt known spaces within the science-policy and science-society interfaces (e.g., van der Sluijs, 2006; Pregernig, 2006; van der Sluijs, 2010; Koetz et al., 2011 cit. in (Jäger et al., 2013).

Many argue that the nature of sustainability challenges nowadays – their complexity and scale – make them different from those of previous decades. They call for more substantive *transitions* or *transformations*. Such transitions – system changes – "are labelled 'socio-technical' because they not only entail new technologies, but also changes in markets, user practices, policy and cultural meanings" (cit in (Geels, 2010).

'Boundary organisations' appear particularly invested in this argument. An early example of this approach, dating back to 2015, can be found in the EEA 2015 State and Outlook of Environment Report (SOER):

> "… living well within ecological limits will require fundamental transitions in the systems of production and consumption that are the root cause of environmental and climate pressures. Such transitions will, by their character, entail profound changes in dominant institutions, practices, technologies, policies, lifestyles and thinking." (EEA, 2015)

In 2016, a report produced from within the European Environment Information and Observation Network (Eionet)[10], involving mostly 'boundary organisations' in 26 countries, and 75 case-studies across 9 different environment-related sectors, pointed to that same conclusion: "Making a fundamental transition towards sustainability requires changes in interdependent societal

ways of thinking, understanding and acting. The challenges are societal, not just scientific" Jäger, J., Holm, P., O'brien, K., Palsson, G., Pahl-Wostl, C., Chabay, I., & Reams, J. (2013). Responses to environmental and societal challenges for our unstable earth. In (Vol. 28, pp. 1-2)..

[10] The European Environment Information and Observation Network (Eionet) is a partnership network of the EEA and its 38 member and cooperating countries.

systems and across multiple scales — from the operation of globalised supply chains to the behaviours and values of individual citizens”. (Agency, 2016)

In parallel to the perception of the need for such type of *transitions*, increases, as well, the sense of *urgency* in triggering and managing them. There is a growing call for *acceleration* of sustainability transitions / transformations. The perspective of acceleration is, in this context, particularly relevant. Responding to it, actors in the field put a greater focus on the need for urgent governance responses, properly targeted and steered.

The EEA SOER 2020 report stresses that particular aspect of time and scale, acknowledging a “considerable time lag between reducing pressures and seeing improvements in natural capital, and human health and well-being”, and urging for firm acceleration of transitions. “The message of urgency cannot be overstated. In the last 18 months alone, major global scientific reports […] have been published, all carrying similar messages: current trajectories are fundamentally unsustainable; these trajectories are interconnected and linked to our main systems of production and consumption; and time is running out to come up with credible responses to bend the trend.” (Lopez et al., 2020)

The same had already been acknowledged one year earlier, in the GSDR2019, emphasizing that “the urgent need for sustainable transformations requires strengthening the directionality of science on behalf of a mutually beneficial “moon landing” for humanity and the Earth.” (Secretary-General, 2019).

Altogether, this combination of *inadequacy* and *urgency* appears to nurture a vivid debate on the type of knowledge being produced to inform policy in the sustainability arena and the consequent need for innovations in this field.

As explained in the previous chapter, it is not the primary goal of this thesis to enter the core of such debate, dissect the arguments behind, or affirm a particular perspective vis-à-vis the understanding of contemporary sustainability challenges.

That said, it is, however, important to frame, synthesise and stabilise the key claims at stake, taking into account how these speak to the need for a '(new) type of knowledge' that better responds to perceived contemporary challenges in the sustainability arena. This is relevant in order to inform the subsequent work in this research project – i.e., exploring the perceived capacity to induce innovations in knowledge practice from within organisations operating in the sustainability science-policy interface.

The following sections in this chapter represent an attempt to address the above, seeking to provide operative keys to help understand, synthesise, and stabilise the claims on the need for a 'new type of knowledge' in the sustainability arena.

2.2 The existing knowledge base and the perception of a knowledge gap

As mentioned in the introductory chapter, this research first engaged in reviewing selected literature inputs – including public institutional reports in this arena – to broadly identify and situate issues connected to the first research question on the claim for innovation in knowledge practice. Inputs selected bring together material on the perception of a knowledge gap and while limited in number they are largely credible in the field and have drawn on significant body of wider work to come to their conclusions.

Such first set of literature reviewed was largely influenced by my own operating context within the European Environment Agency, having access to both referenced international reports as well as practitioners' discourses. The selection of literature was rather exploratory and opportunistic in this regard, having nevertheless given access to a valuable range of sources and views, including both academic and political institutional milieus alike.

This present section (2.2) presents reflections out of the material reviewed and represents a leaping off point and important framing material for the remaining of the thesis. The material in section 2.3 is of a more conventional literature review, where key elements found in this initial set of literature are further analysed and synthesised in a systematic way.

Through this initial set of literature reviewed, it appeared clear that sustainability challenges are no longer compatible with responses based on the classical paradigms of science and engineering – built on industrial models of problem-solving and planning approaches (Rittel H., 1973).

The existing knowledge-base, – intensively and purposefully built in the past decades – although invaluable, is deemed insufficient (or inadequate) to address, understand, and respond to the nature of sustainability challenges we have in front of us. Although there is a significant increase of information use in environmental decision-making, "the pace of use has not been commensurate with the expected need, [which] suggests a persistent gap between production and use that, to date, efforts to rethink and restructure science production have not been able to surmount." (Kirchhoff et al., 2013)

Strongly pressed by arguments within 'boundary organisations' – as illustrated by the work of researchers on the "Knowledge architecture for the wise governance of sustainability transitions" (Oliver et al., 2021) – there is a growing perception of a (so called) 'knowledge gap' that makes it difficult for players in the governance arena to embrace systemic transitions and respond to sustainability challenges. This concern basically relates to the acknowledgement of the sustainability challenges described above, for which the existing knowledge-base – mostly informed by classic paradigms of science and engineering – is not providing adequate responses.

The thinking published by the European Environment Agency (EEA) over these past years is particularly relevant in this regard. Not only is the EEA, as such, a core subject in this research, as it is a given legitimate, credible, and authoritative reference to much of the environmental policy work and praxis adopted at both a European and national level. EEA reports, briefs, and other knowledge assets, inform of the European Union policy in the field of environment and climate change, as well as guide many of national policies in this arena. The EEA is also an important player in global fora on environmental and climate change issues, (including within the United Nations System) and holds a standing articulation with hundreds of research and academic institutions around the world – through its established European Topic Centres (ETC) as well as through its statutory scientific committee.

Along with the participating role of experts and scientific organisations in its 33 members, EEA reports do voice much of the thinking and concerns of practitioners and researchers at national and local levels across Europe. For the sake of this research work, such reports are, therefore, of critical importance when dealing with the type of challenges at stake in the sustainability science-policy interface.

Based on a wide array of scientific research, the EEA summarises such challenges by commonly referring to (1) the perceived developing complexity of environmental issues and associated systemic risks, (2) the greater interdependence between environmental change, socio-economic development, and human wellbeing, (3) the uncertainty on global megatrends and related impacts, (4) the feasibility of transitions in production and consumption systems, and (5) the changing dynamics between science–policy–society.

In this regard, the EEA has indeed been particularly attentive to the so-called ‘knowledge gap issue’, and a set of its recent published reports clearly manifest that concern. Already back in 2015, the EEA was raising the concern of a “*gap between available, established monitoring, data and indicators and the knowledge required to support transitions”* (EEA, 2015). This alert has been volumed up in the *European Environment – state and outlook report 2020*:

> “Achieving sustainability transitions will require diverse new knowledge, drawing on multiple disciplines and types of knowledge production. […] Generating, sharing, and using relevant evidence to the full may require changes in the knowledge system linking science with policy and action, including developing new skills and institutional structures.” (Lopez et al., 2020)

The same line of argument had been explored in great depth in 2019 with the report on ‘Sustainability Transitions: theory and practice’, in which the EEA published an unequivocal statement that “the knowledge systems developed to support environmental governance in the 20th century were well adapted to the challenges and thinking of that time. They do not provide the evidence base needed for governance today because they fail to integrate many fundamental characteristics of transitions.” (EEA, 2019)

This report follows a line of thought and concern very much present in the EEA work done in previous years. One of such examples is the work carried on food systems assessments. In 2016 and 2017 two reports[11] illustrate, from within, such specific field or work how inadequate the current knowledge base is to fully address such complex systems and advocate for the need to change how knowledge is produced in this arena.

> "While some data are available, a more comprehensive assessment can be delivered only by bringing together different disciplines. Assessments that are just based on biophysical, economic, or social data may lead to different conclusions. Factoring in an understanding of human behaviour is especially important in the context of food, as it is connected to so many aspects of people's lives." (Agency, 2018)

In a similar line, other international reports from experts deeply involved in the sustainability science-policy interface – many of which operating within sustainability 'boundary organisations' – emphasise the importance of and seek to explore the understanding of such 'knowledge gap'.

Three of those reports have played a critical role in this debate, as they informed the motivations and arguments of those working in the researched sustainability 'boundary organisations' in Europe (1) the '*RESCUE*' report, (2) the '*Future Earth* Initial Design' report and (3) the evidence review report on "Making sense of science for policy under conditions of complexity and uncertainty", commissioned to the SAPEA[12] consortium by the European Commission Group of Chief Scientific Advisors.

As observed throughout this research journey, these reports come cited and mentioned in much of the discourses across 'boundary organisations' and researchers involved in such reports are often invited to work closely with such organisations. Their relevance therefore lies beyond the actual content, reaching out to influencing the mindset, mental models, and belief systems of practitioners in the field.

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[11] *Seafood in Europe – a food system approach to sustainability (2016)* and *Food in a green light – a systems approach to sustainable food (2017)*
[12] Science Advice for Policies by European Academies

The *RESCUE* initiative gathered contributions from approximately 100 experts in 30 countries. Based on the input of 5 working groups, it focused on contributions from social sciences and humanities with regard to the challenges of the Anthropocene; collaboration between the natural, social, and human sciences in global change studies; requirements for research methodologies and data in global change research; steps towards a 'revolution' in education and capacity building; and interface between science and policy, and communication and outreach.

On that basis, the *RESCUE* report draws a series of considerations on how knowledge towards sustainability transitions needs to be re-shaped, and issues recommendations on what research frame can help reaching such knowledge. The report largely focuses on research work as such, but its substance is easily transposable to knowledge generation in general.

The *RESCUE* authors argue for a different knowledge system – an open one – that is able to span boundaries between science and other sectors of society, as well as the 'gap' between knowledge and action. The report stresses the importance of reframing the way global environmental issues are approached and argue this will require "new questions, new approaches and new ways of thinking in research."

On such basis, the '*RESCUE* Vision for knowledge innovation' addressing sustainability issues, calls for a radical *open* knowledge system, which requires "deep changes in mind-sets, as well as in the cultural and moral assumptions about what knowledge is, how it is produced, for whom it is, and for what goals. This also requires profound changes in basic dominant attitudes and institutions and the inclusion of other legitimate sources of knowledge in truly global and, simultaneously, local, or place-oriented dialogues for sustainability."

Future Earth is a 10-year international research programme launched in June 2012, at the UN Conference on Sustainable Development (Rio+20). It aims at providing critical knowledge required to face the challenges posed by global environmental change and to identify opportunities for a transition to global sustainability (Earth, 2013).

Future Earth initial design promises to “explore new research frontiers and establish new ways to produce research in a more integrated and solutions-oriented way”. Such commitment is based on recent foresight studies that converged on the “need for a step-change in both the conduct and support of such research” (p.11).

The design report strongly emphasis the need for ‘open’ and ‘inclusive’, and ‘co-designed’ and ‘co-produced’ knowledge, generated in a ‘transdisciplinary’, and ‘solution-oriented science’ mode. More, the report argues that a “fundamental, holistic, understanding is the basis for developing transformative pathways and solutions for global sustainability”.

This same idea was later reinforced in the above-mentioned GSDR 2019 report, stating it as one of the key calls for action that, given the urgent need for sustainable transformations, all stakeholders should make deliberate efforts in order to strengthen the directionality of science on behalf of a mutually beneficial “moon landing” for humanity and the Earth. (Secretary-General, 2019) In that regard, in translating many of the current insights into practical action, such efforts “need to be informed by knowledge that emphasizes the need for urgency, forward-looking expectations about a growing global population seeking higher levels of well-being, and normative considerations such as leaving no one behind.”

The SAPEA evidence review report clearly states the unique role of science and scientific advice to inform policy decision making processes. While doing so, the report underlines that under contexts of complexity and uncertainty, many policy options require systematic knowledge that is not available, or is still in its infancy, or in an intermediate state. It goes further by stating that “making sense of science cannot be done by only looking at the empirical evidence”. While scientific outputs often represent the best available systematic knowledge on a given subject, this is not the only relevant or necessary knowledge that decision-makers should use.

The report concludes in 13 key messages that science advice can help to anticipate future challenges and assist in designing coping strategies or interventions. In that regard, the focus of science advice must be on a critical review of the available evidence and its implications for policy-making. Having said this, the report also concludes that scientific advice should not prescribe but inform policies and that science advice for policy-making involves many legitimate perspective and insights. The report argues that science advice is always affected by values, conventions, and preferences, and therefore the effectiveness of scientific advice depends on the right composition of advisors and the quality of the dialogue between advisors and policy-makers; and this, in turn, relies on trust. It goes further in concluding that stakeholders and citizens should be integrated into the process.

2.2.2 Convergence on the need for knowledge innovation

It is relevant for this thesis that the materials mentioned above converge in the argument on the need for a 'new type of knowledge' and subsequently on the need for innovations in knowledge practice.

These reports appear in line with other reviewed academic research in the field. While many of such arguments are mobilised in a wider debate on the adequacy of (scientific) knowledge to inform policy action, they also reinforce the specific need felt by those operating in the sustainability science-policy interface.

A series of recurrent arguments in this field's research arena equally suggest that the nature of sustainability challenges makes it so that solutions are not given, and purely analytical approaches will not suffice. "Dealing with persistent societal problems in the long term will require approaches that give special attention to learning, interaction, integration and experimentation on the level of society instead of policy alone" (Loorbach, 2010).

A good example of this is the perspective largely shared by advocates of '*post-normal science*', to a large extent, involved in work done with or within sustainability 'boundary organisations'. The following excerpt synthesises well the approach that informs much of the thinking amongst sustainability science-policy actors:

> "A picture of reality that reduces complex phenomena to their simple, atomic elements can make effective use of a scientific methodology designed for controlled experimentation, abstract theory building and full quantification. But that is not best suited for the tasks of science-related policy today. The traditional 'normal' scientific mind-set fosters expectations of regularity, simplicity, and certainty in the phenomena and in our interventions. But these can inhibit the growth of our understanding of the new problems and of appropriate methods for their solution. […] This situation is a novel one for policy makers. […] In such novel contexts, there is a new role for science, both natural and social." (Funtowicz & Ravetz, 2018)

To synthesise and summarise, innovations in knowledge practice are expected to generate a type of knowledge that:

- is usable, actionable in policy arenas, providing better policy support in navigating rather systemic, complex challenges (dealing with uncertainty, ambiguity, unpredictability, etc.),
- puts greater focus on possible responses, rather than just the understanding of problems,
- is co-created and transdisciplinary, involving a wider variety of stakeholders and combining multiple disciplines and perspectives to respond to new governance needs,
- engages with societal concerns, recognising different viewpoints, needs and preferences,
- and attends to 'real-world' complexities, capturing developments in existing systems and taking lessons from existing or emerging initiatives.

All this, while at the same time, maintaining key characteristics of *credibility*, *saliency*, and *legitimacy.*

Through the literature reviewed, no dissenting voices or alternative views have been encountered. The need for such type of innovations are deemed necessary by a large number of both academics and practitioners in the science-policy sustainability arena and they call not just for mechanistic innovations, but for fundamental shifts in modes of perceiving the world, learning, and conceiving science and generating new knowledge. These, in turn, call for a different type of individual competence for those seeking to induce such type of innovations (as will be later presented in chapter 3).

In the sections below, this chapter will cluster and unpack the key shifts in knowledge practice distilled through the literature reviewed. Later in this thesis, contributions from the empirical work will be used to help interpret and translate such type of innovations in knowledge practice into the praxis of 'knowledge brokers' and experts in sustainability 'boundary organisations'.

2.3 Towards innovative approaches in knowledge practice in the sustainability arena

The previous sections in this chapter have reflected on the nature of sustainability challenges as described by researchers and international organisations operating at the science-policy interface. Subsequently, they demonstrated a generalised convergence on the need for a 'new type of knowledge' and strong call from across actors for innovative approaches to knowledge practice in the field.

However, no synthesis about what key characteristics should inform such type of innovations in knowledge practice was found. Following a more systematic review of the literature, this section synthesises five key features found necessary to inform the type of innovations needed in knowledge practice, in direct response to research question #1.

The literature reviewed for this research addresses this issue in a way that seeks to provide useful pointers for discussion *and* action. Contributions from the literature have been examined in further detail, organised, and synthesised to better serve the empirical research.

Through systematic content analysis, pointers from the literature have been organised by frequency, alongside interpretative and assessment efforts based on inputs from my own professional surroundings. A good example of this are clusters related to the need for more "co-creation of knowledge" and "systems thinking". Not only these aspects where strongly present in the literature reviewed – with few to none dissenting voices – as they were regularly mentioned in internal reports, meetings, and conversations. Such type of clusters emerged rather obviously as being key to necessary innovations in knowledge practice.

Other clusters of needed innovative approaches emerged through a distilling effort of the essential practice behind widely manifested needs for innovation. Good examples of this are the need for greater "transdisciplinarity" and "reflexivity". While the terms as such do not appear invariably throughout the literature reviewed, characteristics associated to them did appear widely and intensely.

The fifth cluster selected has been more subject to iterative interpretation, contrasting regular inputs in the literature – for example, around the notion of a "generative type of knowledge" – and discourses in the field – like, for example, the need for "response-oriented knowledge".

These selected characteristics informing required innovation in knowledge practice, are also subject to controversy, as is demonstrated in the paragraphs below. However, they appear to broadly cover and synthesise a very wide spectrum of innovation needs in knowledge practice, as explored through the literature. Part of the empirical work (later described in chapter 5) was dedicated to verify to what extent such innovation features would resonate with practitioners in the field.

On this basis, this section clusters the five main characteristics shaping claimed innovations in knowledge practice in the sustainability science-policy interface, as follows:

1. the need for **co-created** knowledge involving a wider and more diverse set of actors across sectors, roles, and geographies;
2. the need for stronger inter and (especially) **transdisciplinary** approaches, beyond discipline-based processes, integrating different types of knowledge(s);
3. the need for enhanced **systems thinking**, stressing the role of *thinking differently* and *holistically* when dealing with complex adaptive systems;
4. the need for extended **reflexivity**, questioning our own mental models, assumptions, and biases, looking for a deeper level of (self) consciousness;
5. the need for a **generative** type of usable knowledge – capable of generating continuous dynamics of action-learning loops.

These five aspects are inter-related, and the features defining them (characteristics, definitions, concepts, approaches, examples, etc.) are often overlapping. The intentional disentangling into five distinct clusters serves not only an analytical purpose at this stage, but it will further help framing the empirical work when identifying specific competencies required to induce innovation in knowledge practice.

In reference to section 1.4 above, it is important to note that these five aspects associated with required innovations in knowledge practice, encompass the understanding of knowledge dynamics within a broad system of entities, relationships, perspectives and interdependencies, including given mind-sets, cultural and moral assumptions about what knowledge is, how it is produced, for whom it is, and for what goals. It encompasses dimensions of human interactions and interpretative acts in which knowledge is needed, mobilised, communicated and used. In this account the understanding of *knowledge practice* spans beyond the linear construct of the generation, transfer and usage of knowledge as a product.

The next section will take a closer look at each these clusters, briefly exploring, from the literature reviewed, key notions and theories associated, implications for work practice and controversies around each of them.

The analysis of these knowledge innovation features (individually and as a whole) reveals a number of different concepts of knowledge: creation, production, practice, paradigm, process, system etc. While this may, again (as explained in Chapter 1 above) lead to engage in a broader epistemological debate, it is important to note that, for the purpose of this research work – strongly oriented to support action – the section will seek to focus on the knowledge practice associated with boundary organisations at the sustainability science-policy interface.

At the end of each section, a text box will propose an operative approach to innovative feature at stake, in support of the empirical work later described in Chapter 5.

2.3.1 The need for co-designed and co-created knowledge

The need for co-created knowledge is often paired with the need for greater inter and transdisciplinary approaches (which this thesis will investigate in further detail in the below section). The base line is a call for greater collaboration between different actors active in generating relevant knowledge for sustainability policy. Such actors would originate not just across scientific milieus alone, they would also – and *should* also – include 'knowledge brokers' in 'boundary organisations', policy-makers, and practitioners in sustainability-related fields, amongst, possibly, many others.

Such an approach doesn't just require the convening of the parts and exchange of ideas. As phrased in the *Future Earth* report, "such co-design means that the overarching research questions are articulated through deliberative dialogues among researchers and other stakeholder groups to enhance the utility, transparency, and saliency of the research. This approach embraces the concept of a new 'social contract' between science and society (Lubchenco 1998)".

Alison Meadow and colleagues follow the same line of thought, supporting the importance of knowledge co-production:

> "By participating in its production, the information becomes more transparent to end users (Jasanoff et al., 1998); the process by which the information is produced is perceived to be more legitimate (Cash et al., 2006); the information is more likely to be at spatial and temporal scales useful to decision makers (Dilling & Lemos, 2011); the knowledge is easier to integrate with existing information because it fits into the decision framework of the agency or organization (Carbone and Dow 2005; Lemos et al. 2012); and the end users gain a greater sense of ownership over the final product because they have contributed to it (Robinson & Tansey, 2006)." (Meadow et al., 2015)

In this context, a variety of authors state the need to operate within a *knowledge system* that goes beyond *science* itself. While knowledge systems are made up of agents, practices, and institutions that organise the production, transfer, and use of knowledge, when applied to the social goal of sustainability, knowledge systems are "a network of actors connected by social relationships, formal or informal, that dynamically combine knowing, doing, and learning to bring about specific actions for sustainable development" (van Kerkhoff & Szlezák, 2016).

This line of argument is closely connected to the point raised earlier in this thesis, on the need for innovations to focus on the *process* of generating *knowledge-for-policy*, from a practice-based perspective, rather than on *what* that knowledge actually *is about*, as a *product*. In this regard, the practice of collaboration and mutual learning appears as critical to induce such type of innovations.

The same is claimed in the *RESCUE* report: "sustainability research is conceptualised as co-production of knowledge, the 'co-' standing for a process of engagement of academic and non-academic knowledge producers (Lemos and Morehouse, 2005; Robinson and Tansey, 2006, p.15-16)." The authors go further in suggesting that such a networked character of knowledge generated through these means can be referred to as a 'knowledge system(s)'. "Such a knowledge system spans the boundary between science and other sectors of society, as well as the gap between knowledge and action."

In this context, Cornell, Berkhout et al. (2013) introduce the notions of 'knowledge democracy' and 'knowledge arenas'. The term 'knowledge democracy' is meant to designate a perceived ongoing global process of "opening-up" of knowledge systems, where governance is being transformed by the mass creation and availability of knowledge." (Cornell et al., 2013)

Collaboration and mutual learning are definitely key features of co-design and co-production of knowledge. In the context of sustainability challenges, and as an example, collaboration would be needed between natural and social scientists, economists, and engineers, seeking to connect trends and policies in engineering, technology, and business to their impact on efforts to foster more sustainable individual and institutional behaviours through innovation and consumption choices.

Such an ambition is clearly shared by all international reports mentioned in the above section of this thesis and is expressed in much of the literature reviewed. It is also largely corroborated by inputs from experts and practitioners in the field, as we will later demonstrate in chapter 5 of this thesis.

In such line, as mentioned in the *Future Earth* report, it is legitimate to expect that in doing so, such collaboration and mutual learning processes will “address specific issues, encourage out-of-the-box thinking, develop new networks of people that have not worked together previously, and hopefully in many cases will involve a very wide range of backgrounds and expertise”. (Earth, 2013).

According to Daniel Lang, there are some key arguments to move into such ‘new types of knowledge’ generation through collaboration, which transcend disciplinary and interdisciplinary approaches: “first, research on complex sustainability problems requires the constructive input from various communities of knowledge to ensure that the essential knowledge from all relevant disciplines and actor groups related to the problem is incorporated; second, research on solution options requires knowledge production beyond problem analysis, as goals, norms, and visions need to provide guidance for transition and intervention strategies; third, collaborative efforts between researchers and non-academic stakeholders promises to increase legitimacy, ownership, and accountability for the problem, as well as for the solution options” (Funtowicz and Ravetz 1993; Gibbons et al. 1994; Hirsch Hadorn et al. 2006; Baumgartner et al. 2008; Wiek 2009; Talwar et al. 2011; Spangenberg 2011). (Lang et al., 2012)

On a slightly different note, but still in the overall need for stronger co-creation practices, is relevant the perspective shared by Kates et al, through which is underlined the importance of integrating geographical scales in order to “eliminate the sometimes convenient but ultimately artificial distinction between global and local perspectives.” (Kates et al., 2001)

Altogether, such considerations on the need for greater co-creation of knowledge – and inherent need for greater collaboration and mutual learning – inform the type of innovations sought in knowledge practice, also amongst ‘boundary organisations’.

Text Box 1 – Operative Synthesis – Co-creation

As an operative synthesis for the sake of this research project, innovations sought through ***co-creation***, aim at generating a type of knowledge that *is engendered through interaction between different actors, from different living, professional, organisational, or institutional backgrounds or sectors. It involves knowledge agents such as academics, practitioners, civil-servants, decision-makers, users, amongst many others. Networks, partnerships, and collaborative platforms are key features permeating open knowledge systems, beyond scientific research. In this account, co-creation is different from consultation – it calls for common mind maps, common goals, and co-owned outcomes, built on established relationships with a wider variety of stakeholders.*

In the empirical chapters below, this thesis will expose how practitioners in the field perceive, interpret, and make sense of this type of innovations in their field of action.

2.3.2 The need for stronger inter and transdisciplinary approaches

The need for greater inter and transdisciplinary approaches is often paired or used interchangeably with the need and notion of co-creation. While similar in nature, in the domain of practice, *co-creation* and *transdisciplinarity* call for a slightly different type of competences. Acknowledging there were visible overlaps between such notions, it was, therefore, deemed valuable to intentionally disentangle those, not only for analytical purposes, but also to help frame the empirical work ahead when identifying specific competencies required to induce innovations in knowledge practice.

In general, authors concerned with the type of knowledge required for addressing sustainability issues claim for a greater involvement of a wider variety of sciences, combined. From the traditional role of natural sciences to the role of social sciences, humanities, and beyond.

Perspective converge in that ‘real-world’ problems do not conform to disciplinary divides. Their complexity and scale cannot be understood by single scientific disciplines. Instead, such complexity requires an integrated knowledge base and new set of common practices, necessarily framed in an interdisciplinary and transdisciplinary way.

The GRSD2019 has multiple references to the need of more transdisciplinary science, research, and knowledge. It claims that, already now, the diversity of researchers, practitioners, knowledge users, teachers, and students attracted to sustainability science from all across the world, sets sustainability science apart from many other scientific fields. Typically, in this case, “researchers use transdisciplinary approaches, bringing together scientific, lay, practical and indigenous knowledge, as well as fundamentally different world views”. (Secretary-General, 2019) In this account, Robert Kates goes as far as setting sustainability science as a “different kind of science” (Kates, 2011).

Wolfram Mauser also converges that the knowledge produced through research activities in order to meet the standing sustainability challenges, is “obviously not only defined by the knowledge gaps as perceived by single scientific disciplines, but also by the priority which societies place on the sustainability challenge”. In an analysis of the *Future Earth* report, he wonders though whether such a model of applied research also holds true for the research that is necessary in the context of *Future Earth*. “If yes then for the upcoming decade researchers will face a clear shift from a business-as-usual basic science to transdisciplinary research approaches where — in addition to collaboration and integration across scientific fields — research questions no longer emerge from science alone but in interaction with civil society, governments and other stakeholders.” (Mauser et al., 2013)

As suggested in the *RESCUE* report, “a collective framing process” includes scientists from natural and social sciences and the humanities, as well as actors from civil society, and the private and public sectors. “Only through the analysis of the behaviours of individuals and groups within socio-ecosystems can scientifically sound methods for exploring and understanding the emergent properties of such complex and adaptive (evolving) systems be developed. In turn, it is only through the understanding of the emergent properties of the socio-ecological system that the capabilities needed for any approach targeting global change can be developed. (p.18)"

In a similar note, Reid et al. (2010) claim, for example, that "understanding the non-linear dynamics in sustainability issues will require integration of environmental and complexity sciences, two fields that have developed largely separately (p.2)". In other words, the authors advocate for an integration of two separate sciences to help make sense of the sustainability challenges as they appear less and less linear in their causal dynamics.

It is convergent in the literature that research dominated by the natural sciences must transition toward research involving the full range of sciences and humanities. Not just this, but also that "a more balanced mix of disciplinary and interdisciplinary research is needed that actively involves stakeholders and decision-makers" (Reid et al., 2010).

Such a formulation calls not simply for an inter-disciplinary approach, but rather for a *transdisciplinary* one.

Within the sustainability knowledge arena, transdisciplinarity, interdisciplinarity, multidisciplinarity, pluridisciplinarity, and crossdisciplinarity (and their mutual relationships) are terms and concepts largely present in in the literature in general. Despite being often used interchangeably, the terms have been subject to intensive debate in research and policy circles alike (Mauser et al., 2013). This originates a large number of contributions and perspectives, which naturally make it difficult to clearly define the concepts and distinguish them from one another.

For the sake of this thesis, it was deemed important to further explore the notion of transdisciplinarity, in particular, as the understanding of its intrinsic characteristics which raise a new set of questions when it comes to the domain of knowledge practice – especially with which individual competencies to induce when transdisciplinarity is concerned.

The notion of transdisciplinarity

In the *CIRET*[13] approach, *transdisciplinarity* is radically distinct from *interdisciplinarity*. The latter concerns the transfer of methods from one discipline to another, allowing research to spill over disciplinary boundaries, but staying within the framework of disciplinary research.

In contrast, transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond each individual discipline. Its goal is the understanding of the present world, of which one of the imperatives is the overarching unity of knowledge.

Basarab Nicolescu appears in the literature as one of the most acknowledged advocates of transdisciplinary approaches towards a unified knowledge. In his "Manifesto of Transdisciplinarity" (2002) he explains that the term 'transdisciplinarity' first appeared "to give expression to a need that was perceived – especially in the area of education – to celebrate the transgression of disciplinary boundaries, an act that far surpassed the multidisciplinary and interdisciplinary approaches". It was originally coined in the 70's, following the work of scholars such as Jean Piaget, Edgar Morin, and Erich Jantsch. Today though, "the transdisciplinary approach is being rediscovered, unveiled and utilised rapidly to meet the unprecedented challenges of our troubled world". (Nicolescu, 2002)

Although radically distinct from interdisciplinarity, transdisciplinarity is not to be seen as antagonistic, but complementary to the former. Transdisciplinarity is nourished by disciplinary research; in turn, disciplinary research is clarified by transdisciplinary knowledge in a new, fertile way. Transdisciplinarity is used to signify a unity of knowledge beyond disciplines.

Transdisciplinarity is defined by Nicolescu through three methodological postulates: the existence of levels of reality, the logic of the included middle, and complexity. Transdisciplinarity concerns the dynamics engendered by the action of several levels of reality at once. The

[13] International Centre for Transdisciplinary Research (http://ciret-transdisciplinarity.org).

discovery of these dynamics necessarily passes through disciplinary knowledge. Yet disciplinary research alone cannot grasp all that information between and beyond disciplines.

Hans Dieleman is another cited contributor to the understanding of the role of transdisciplinarity in how research is conducted, and knowledge is generated. According to him, transdisciplinarity explores the epistemological, ontological, and methodological consequences of quantum physics, and discloses a world of complexity and systemic thinking.

Sharing the same postulates as Nicolescu, Dieleman sets the first ontological axiom of transdisciplinarity in that there are, in nature and in our knowledge of nature, different levels of reality and, correspondingly, different levels of perception. Knowledge is not “out there”, neither is it “inside of us”, but, more importantly, is like a “reservoir of infinite potentialities”. While interdisciplinarity aims at “the transfer of methods from one discipline to another”, transdisciplinarity deals with “that which is at once between the disciplines, across the different disciplines, and beyond all discipline” (p.72). This opens up an immense space of potentially available knowledge. (Dieleman, 2013)

Dieleman brings a further relevant contribution – relevant in the context of this thesis, looking at individuals’ competence to enhance transdisciplinary work – to a more comprehensive understanding of transdisciplinarity. That is the proposition that an integrated unity of knowledge needs necessarily to include ‘analytical intelligence’, ‘emotional intelligence’ and the ‘intelligence of the body’. As he puts it:

> “[…] disciplines have little meaning when we do not see the spaces between, across and beyond them. When we want to reach a stage of more complete – transdisciplinary – knowledge, we need to explore the vacuum that is full of potential “knowing”, find ways to open ourselves to this knowing and incorporate it in a more complete knowledge system. It is here where – in my interpretation – “sensitivity” and “action” come into being, or in other words the unity of analytical intelligence, emotional intelligence, and the intelligence of the body.” (Dieleman, 2013)

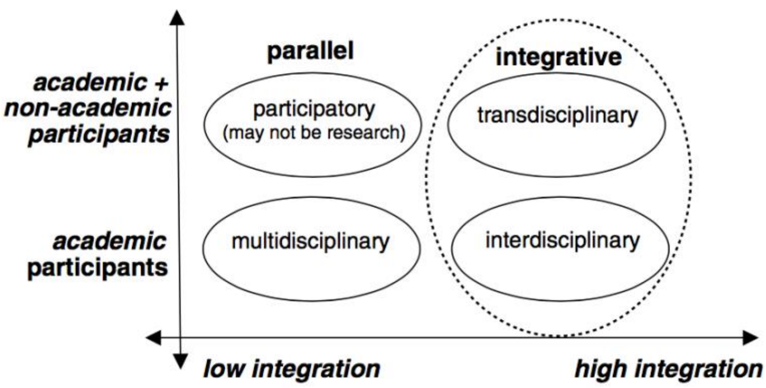
According to Dieleman the *included third* – or the intelligence of the body – only comes into existence in a process that is inherently "more-than-analytical" through integrating various emotional, imaginative and sensory ways to relate us with our interior and exterior world. (Dieleman, 2013)

This approach to transdisciplinarity will be of critical relevance when defining key competences to engender innovation towards a 'new type of knowledge'.

Another recurrently referred defining characteristic of transdisciplinary research is the inclusion of stakeholders in designing the knowledge production process. As seen in the previous section, collaboration between stakeholders is deemed essential. Transdisciplinary collaboration requires engaging with different ways of knowing the world, generating 'new knowledge', and helping stakeholders understand and incorporate the results or lessons learned throughout the process.

The following scheme by Tress et al. (2005) provides a simplified illustration of the degrees of stakeholder integration when addressing transdisciplinary work:

Figure 2 – Degrees of integration and stakeholder involvement



in (Tress et al., 2005)

This relationship between transdisciplinarity and stakeholder integration brings us back to the previous section of this work, on the need for more co-created knowledge.

Text Box 2 – Operative Synthesis – Transdisciplinarity

As an operative synthesis for the sake of this research project, innovations in knowledge practice sought through the perspective of increased ***transdisciplinarity*** would undertake that k*nowledge* practice *cannot be bound by existing disciplinary borders. Also, it cannot be simply generated through interactions between different disciplines (interdisciplinary). Transdisciplinary knowledge* practice *seeks for sources of knowledge in areas that are not necessarily defined by specific disciplines – it deals with what's between, across and beyond all disciplines. Transdisciplinary knowledge concerns the dynamics engendered by the action of several levels of reality at once. It requires accepting as valid knowledge originated beyond scientific domains and embrace disciplinary complementarities rather than intrinsic antagonisms.*

2.3.3 The need for enhanced systems-thinking

Most of the literature reviewed sets sustainability challenges as 'systemic challenges' – whose nature relates to the understanding of a system as a whole, with recognised properties, and composed of *parts*, *processes,* and *structures*.

In many of the articles and reports, planet Earth itself is seen as *a system*, set as such at the centre of sustainability work. In others, it is the interdependency between various systems that is at the core of sustainability challenges – the energy system, the food system, the mobility system, etc. In either case, the relevance of systems thinking in addressing the so-called "knowledge gap" is deemed critical. "*Addressing this gap requires investment in better understanding of systems science, forward-looking information, systemic risks and the relationships between environmental change and human well-being."* (EEA, 2015)

In the same line, the *RESCUE* and the *Future Earth* reports refer to the need of rather holistic approaches as to how issues are described, meaning is made explicit, and knowledge is constructed. As they place sustainability challenges within those types of 'complex adaptive systems', they claim that only a holistic understanding of such systems' dynamics can support an inter and transdisciplinary generation of relevant knowledge.

The reports emphasise the challenge of understanding and exploring avenues for human development within Earth system boundaries. This "fundamental, holistic, understanding is the basis for developing transformative pathways and solutions for global sustainability". (Earth, 2013)

A similar approach is shared in the *RESCUE* vision. As put by the authors, such vision seeks to "transform the current dominant framing of knowledge as a closed, uniform, linear and placeless system of insights and aptitudes to an adaptive framing that takes into account, promotes and, whenever possible, integrates a diversity of patterns of knowledge and modes of interaction produced for multiple purposes and under different representations" (p.28). According to the authors, this requires approaches to science that focus on a "holistic perspective of the complex human-social-ecological interactions and dynamics". (Jäger et al., 2013)

There is yet another often-mentioned argument for the role of systems thinking in generating a 'new type of knowledge' for sustainability. That of sustainability challenges perceived as one of '*wicked problems'*. Wicked problems are commonly referred to as problems that are difficult or impossible to solve (or even address) because of their complex nature and because of incomplete, contradictory, and changing requirements that are difficult to recognize as they evolve. (Rittel H., 1973)

Cabrera identifies the following key aspects involved in wicked problems: (1) many interlinked issues, cutting across the usual silos (e.g. Economy, health, and environment), making for a high degree of complexity, (2) multiple agencies (across the public, private, and voluntary sectors) trying to account for multiple scales (local, regional, national, and global), (3) many different views on the problem and potential solutions, (4) conflict over desired outcomes or the means to achieve them, and power relations making change difficult, and (5) uncertainty about the possible effects of action. (Cabrera & Cabrera, 2015)

This perspective is highly coincidental with how the *RESCUE* report portraits sustainability challenges, defining long-term environmental challenges as "public policy issues that last at least one human generation, exhibit deep uncertainty exacerbated by the depth of time, and engender public goods aspects both at the stage of problem generation as well as at the response stage. (Sprinz, 2009, p. 2; CCSP, 2009)." (Jäger et al., 2013)

Pointing to the long time-scales and structural uncertainty inherent in global environmental challenges, the report emphasises that, by now, the role of uncertainties related to the complexity of the global environmental change and the human actions has already been extensively examined. The report emphasises how that is especially important in what the role at the science-policy and science-society interface is concerned.

In that line, the report stresses that "the denial of the complexity of global change issues, as sometimes observed, or attempts to over-simplify can also lead to problems, such as putting blame on the wrong people or developing a conviction that there is no need to act". (Jäger et al., 2013)

The arguments above – framed by the entire array of literature reviewed – lead to the importance of systems thinking in addressing such type of wicked problems as sustainability issues can be. Generating a type of knowledge that helps responding to the type of sustainability challenges described, will necessarily require a greater understanding of complex adaptive systems. Not only this, but it will, additionally, require a different way of *thinking* – one that questions the role mental models play in how we co-generate knowledge. As G.P. Chapman puts it: "if the world can be explained in a reductionist manner, then 'complexity' is not qualitatively different from 'simplicity', but merely quantitatively different." (Chapman, 1985)

The critical importance of systems thinking – in itself often framed as a competence – for the generation of knowledge that helps informing policies to respond to sustainability challenges, requires a closer look at the concept itself, its origins and evolution, and applicability.

While such an emphasis may appear at first exaggerated in the context of this thesis, the need for a closer dissection of the notion of system thinking is connected to the observation of discourses in which the term is often used to mean “thinking about systems” – which, as such, would lead practitioners towards a significantly different type of competence in knowledge practice.

In other words, in much of the discourses encountered, ‘systems thinking’ is used to designate an extra effort to understand, describe and think of existing, known, systems (for example, the energy system, or the mobility system). Such a simplistic approach may lead to believe that the usual package of professional competencies suffices to understand and address the challenges described above – in that way, underestimating the intrinsic nature of systems thinking as a competence.

This section will therefore take a deeper look at the notion of system thinking and how it may shape and inform the thinking of practitioners in the sustainability arena.

The notion of systems thinking

It is firstly important to acknowledge that the notion of systems thinking is embedded in a vast field of concepts, theories, and approaches, populated with intense debates, and varied contributions from a wide range of disciplines extended through a considerable large period of time.

Given the extent and variety of systems thinking applications in virtually any domain, it is impossible in the context of this work to be in any sense exhaustive or comprehensive when reviewing related literature. The option under this work was to concentrate on contributions that are closer to the core purpose of this research, i.e., the type of competencies required to induce innovations in knowledge practice towards a ‘new type of knowledge’ for policy in the sustainability arena.

It is difficult to infer the emergence of systems thinking as a concept, a discipline, or a body of knowledge. It is often pointed at the 1950's, correlated with the foundation of the Society for General Systems Research (nowadays, International Society for the Systems Sciences (ISSS)). Others see it originated in biology and then spread into other areas including cybernetics, ecology, psychology, operational research, information systems, and management science.

Until the 1970's, systems thinking was quite close to natural sciences approaches: systems could be identified and described by empirical observation of reality. In order to analyse further or intervene in such systems, the same methodological approach would suffice. Systems thinking until the 1970's was dominated by positivism and functionalism. (Jackson, 2001) This approach to systems thinking is also often known as 'hard systems thinking'.

From the 70's, and 80's onwards, this traditional *systems thinking* approach became heavily criticised, especially given its inability to (1) confront highly (higher and higher) complex systems, (2) handle human and society aspects of the problems and (3) move from its innate conservatism. The emergence of 'organisational cybernetics', 'soft systems thinking' and 'systems heuristics' came somehow as a response to those.

Out of these, the notion of 'soft systems thinking' (SST) – or 'soft systems methodology' (SSM) – appears to be particularly important in the context of sustainability transitions / transformations, as it implies the role of learning loops. Peter Checkland, one of the precursors of SST, describes the process out setting the emergence of the approach as a new paradigm, "a different way of thinking about the core image of a human being relating to the perceived world." (Checkland, 2012)

Checkland's proposition that SSM is "a learning system aimed at 'action to improve'" is particularly important in the context of this thesis. It sets 'systems thinking' as a process of *learning towards action*. It puts the focus on the actor – the knowledge broker, the researcher, the practitioner, or the policy-maker – and not in the "system out there".

Similar to the approach of Williams and Hummelbrunner (2011), who decode the notion of 'systemic' in this account as a combination of (1) an understanding of relationships, (2) a commitment to multiple perspectives and (3) and awareness of boundaries. (Williams & Hummelbrunner, 2010)

In the same line, Ray Ison sets what he calls "systems practice" as arising in social relations as part of the praxis and daily living, as learning, intimately related to the notion of "action research" (Ison, 2008).

Nowadays systems thinking is found to be actually quite popular. Its applicability ranges a wide variety of fields, from education to business management and governance, from planning to evaluation, from sustainability issues to health and cybernetics.

Córdoba-Pachón (2011) summarises some of these applications as follows:

> "In systems thinking, new theories and ideas are being explored, studied, and incorporated. People developing research in systems thinking have made some further inferences to unveil certain regularities, strengths, and weaknesses that systems methodologies could have in practice (Jackson 2003); others look at incorporating ideas of complexity theory into systems thinking (Cabrera et al. 2008). Others apply existing abstractions to project management (Checkland and Winter 2006), information systems (Clarke 2007, Checkland and Holwell 1998, Wilson 1984), and the development of the information society (Córdoba 2009). Additional efforts in the field include short textbooks (Checkland and Poulter 2006, Wilson 2002) that aim to make the use of systems methodologies more accessible to different audiences of students and practitioners. These developments signal important contributions of systems thinking to professions in the public and private sector."(Córdoba-Pachón, 2011)

Many would argue that the reason for such popularity is anchored in systems thinking promise to offer a 'different way of thinking' (Cabrera et al., 2008; Checkland, 2012; Jackson, 2001).

Actors in the sustainability knowledge arena are also drawn into systems thinking – from scholars, to policy-makers, to field practitioners. They face problems that are complex, and traditional ways of approaching and thinking about such problems is seen as inadequate to solve them. They, therefore, perceive the need to change *how* they – or others – *think*.

As Cabrera argues, "systems thinking is not necessarily a matter of drawing an entirely new skill-set out of the intellectual ether; rather, it is a unique perspective that transforms the approach taken to evaluate any program, policy, or initiative". (Cabrera et al., 2008) Systems thinking carries an intrinsic transdisciplinary character that services the required bridging between the physical, natural, and social sciences.

Mike C. Jackson, an influential advocate of methodological pluralism in what systems thinking is concerned, draws two key reasons for the perceived success of systems thinking methodologies as proposed to address complex problems. Both of them link directly to the notion of transdisciplinarity as presented in the previous section of this thesis. Systems thinking emerges as a response to the need of transdisciplinary practice, combining both inter and multidisciplinary work, with a commitment to "holism when looking at the world" (Jackson, 2001).

The need to think more holistically is also underlined by Peter Checkland. He argues that "what in the end justifies systems thinking is the fact that any whole has properties – the so-called emergent properties – that exist only in relation to the complete whole". (Checkland, 2012)

Cabrera et al (2008), start from the same proposition of a system being a 'complex whole of related parts'. However, they claim that in contrast with 'thinking *about* systems', 'systems thinking' is a more formal, abstract, and structured cognitive endeavour".

Cabrera and his fellows offer a "unifying theory of systems thinking and application", based on a set of four key simple rules: distinctions, systems, relationship, and perspectives (DSRP). They suggest that DSRP[14] is actually the essence of systems thinking: four cognitive patterns that are

[14] In a more schematic approach, the four rules are:

Distinctions rule: any idea or thing can be distinguished from the other ideas or things it is with universal to various subfields and methods, but also to human thought in general. “We make distinctions between and among things and ideas, each implying the existence of another. We identify systems, which are composed of parts and wholes. We recognize relationships composed of actions and reactions. We take perspectives consisting of a point (from which we see) and a view (that which is seen).” (Cabrera et al., 2015)

These “simple” rules have been defined also with a great pedagogical purpose behind. It is a postulate of the authors that systems *thinking* can only be effectively and widely applied in the way we seek to understand reality, produce research, or generate knowledge if we are able to develop systems *thinkers*.

More, Cabrera and fellows take a step forward in their work and analyse the implication of DSRP into psychosocial domains. Important to this analysis is the realization that systems thinking – and the application of DSRP – is connected not only with highly intelligent thinkers but also with “emotionally intelligent, prosocial people, with an ethical compass”. “Our minds are not only responsible for our cognitions, they also process feelings, thoughts, emotions and motives.” (Cabrera et al., 2015)

What is the relevance of systems thinking in domains traditionally associated with psychology and sociology? How exactly does ‘systems thinking’ encourage balance between the needs of oneself and the other as well as between our emotional and cognitive natures? How does it increase empathy and understanding and general interpersonal awareness? How does it promote introspection and prosocial behaviour?

These questions formulated by the authors are fundamental to the core root of this research. They call upon the exploration of domains of competence that are intrinsically “emotion-laden”,

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Systems rule:	any idea or thing can be split into parts or lumped into a whole
Relationship rule:	any idea or thing can relate to other things or ideas
Perspectives rule:	any thing or idea can be the point or the view of a perspective

and therefore often left outside traditional approaches to capability analysis.

The same converges with the work of Pamela Henning and Wan-Ching Chen. In 2012, they analysed the fourteen most popular (best-selling) books on *systems thinking*. The work, based on that set of literature, was as focused on describing the 'knowledge domain' required to engage in systems thinking as it was to describe the 'welcoming cognitive conditions' that enable it. (Buckle Henning & Chen, 2012)

An interesting note by Wilson, Hayes et al. in this regard, says that "learning how to accomplish positive change in systems that are too complex to make accurate predictions about requires us to combine the best of our knowledge with experimentation. This observation might seem mundane, but explicit experimentation is by no means the norm in many policy circles". (Wilson et al., 2014)

As can be seen above, the way systems thinking is being rethought in recent years, sets the capacity to think systemically in a level beyond mere rationality or intellectual cognition. It blends in dimensions of emotional intelligence, empathy, intuition, self-awareness, and inter-personal awareness, and leads inevitably to the role of *reflexivity* in knowledge generation processes. The next section we will look into the latter in more detail.

Text Box 3 – Operative Synthesis – Systems Thinking

As an operative synthesis for the sake of this research project, innovations in knowledge practice sought through the perspective of increased systems thinking would undertake that such process *embraces both systemic thinking and being. It seeks different perspectives of one same reality (is holistic). It is integrative in responding to complex, systemic challenges, and wicked problems. It dissects distinctions between parts of a system, but also emerging properties, relationships, and different perspectives of that same whole. Systemic approaches to knowledge* practice *require a robust set of tools and methods that enable the individual to relate to and experience the system at stake from different perspectives.*

2.3.4 The need for intense reflexivity, transparency, value-(based) knowledge

Inherent to the perspectives displayed above is the idea that in whatever form new knowledge is to be generated, in order to embrace and engage with the adaptive complexity of systems at stake, knowledge actors need to take into account own mental models, assumptions and beliefs, values and perspectives, and deeper sources of motivation and inspiration.

Such an "accounting" exercise requires an attention *on* and an awareness *of* one's own self in forms and quantities that are normally not taken in classic scientific methods of research. As Otto Scharmer would say, it requires 'shifting the structure of our attention'.

> "Collectively seeing our field structure of attention—that is, collectively becoming aware of our inner places from which we operate in real time—may well be the single most important leverage point for shifting the social field in this century and beyond, for it represents the only part of our common consciousness that we can control completely."(Scharmer, 2009)

Such an exercise of introspection and exposure, unveiling inner drivers, perspectives, and assumptions on the reality being engaged, is frequently referred to as "reflexivity". In this context, *reflexivity* also refers to circular relationships between cause and effect. A reflexive relationship is bidirectional with both the cause and the effect affecting one another in a relationship in which neither can be assigned as causes or effects. In sociology, reflexivity therefore comes to mean an act of self-reference where examination or action "bends back on", refers to, and affects the entity instigating the action or examination. "Reflexivity occurs in social systems when an actor observes and thinks about his or her actions and their consequences and then modifies his or her behaviour." (Umpleby, 2007)

In such an account, reflexivity includes both the study of social behaviour with reference to theories about social relationships and a subjective process of self-consciousness inquiry.

As noted above, reflexivity is intimately related to the latest contributions on the notions of transdisciplinarity and systems thinking. The articulation of analytical intelligence, emotional intelligence, and the intelligence of the body, appear as critical to innovate the way knowledge is produced to respond to rather complex and systemic challenges.

Using the framing proposed by Scharmer: “So far, the primary focus of our modern sciences has been, by and large, limited to episteme. But now we need to broaden our view of science to include the other capacities to grasp the truth, including applied technologies (techne), practical wisdom (phronesis), theoretical wisdom (sophia), and the capacity to intuit the sources of awareness and intention (nous).” (Scharmer, 2009)

While the former is somehow considered in many of the social sciences, the latter – the *nous* – is not commonly related to the institutional mark of ‘credible knowledge’. Components of self-awareness are found to be foreign to usual conceptions of quality knowledge, scientific validity, and objectivity. And yet, such dimensions of knowledge are precisely at the core of the debates on required innovations in knowledge practice in the sustainability science-policy interface.

The controversy is abundant, though, leading entities like the *Science Advice for Policy by European Academies*, to state the following:

> “Scientists, as well as policymakers, should be sensitive to various biases and interests when drawing inferences from data and information. (…) Science advice is always affected by values, conventions, and preferences.” (SAPEA, 2019)

While perceived as obvious by some, from the perspective of knowledge-for-policy generation this comes as a significant shift in focus. The stress is not only put on the quality and indisputable credibility of the data used to inform knowledge and policy; the emphasis in terms of credibility is also steered towards the person – the human mind – behind the scenes. It drives attention to domains of self-awareness, critical introspection, and, ultimately, reflexivity in the knowledge generation practice.

Given the core purpose of this thesis, the aspect above is particularly relevant as it points once again to the question of capability and competence: are actors in the field willing and able to embrace such type of approaches?

Also relevant to note is that, from the science-policy perspective, this type of reflexivity is often expressed by means of *transparency* in what knowledge brokers' biases, mental models, beliefs, preferences, and assumptions might be.

The focus on transparency – and transparency vis-à-vis European citizens in this account (Mair D., 2019) – appears to generate greater attention, interest, and traction from within the science-policy interface, rather than the argument of potential new knowledge to respond to more complex challenges.

As mentioned above in this section, such a mindset at the science-policy interface seems to be largely influenced by advocates of the post-normal science paradigm, suggesting that in the debates informing policy responses to sustainability challenges, typically, facts are uncertain, values in dispute, stakes high, and decisions urgent. As argued, "some might say that such problems should not be called 'science'; but the answer could be that such problems are everywhere, and when science is (as it must be) applied to them, the conditions are anything but 'normal'". (Ravetz & Funtowicz, 1999)

To illustrate the level of importance such type of approach assumes in the sustainability science-policy arena, the work done by the Dutch Agency for Environmental Assessment (PBL) can be used. In the early 2000's, PBL 'unwittingly' embarked on a transition from a technocratic model of science advising to the paradigm of ''post-normal science'' (PNS). In response to a scandal around uncertainty management in 1999, a Guidance for ''Uncertainty Assessment and Communication'' was developed with advice from the initiators of the PNS concept and was introduced in 2003. In a later paper, the extent to which the PNS paradigm had delivered new approaches in the agency's practice was assessed. The authors concluded that an openness to other styles of work than the technocratic model has become visible, but that the introduction of the PNS paradigm was still in its early stage.

Relevant to this thesis is how that assessment was structured by referring to three key elements in the PNS paradigm:

1. The management of uncertainty: PNS acknowledges that uncertainty is more than a technical number or methodological issue. Ambiguous knowledge assumptions and ignorance give rise to epistemological uncertainty;
2. The management of a plurality of perspectives within and without science: complex problem solving requires scientific teamwork within an interdisciplinary group and joint efforts by specialists from the scientific community and from business, politics, and society;
3. The internal and external extension of the peer community: an extended peer community includes representatives from social, political, and economic domains that openly discuss various dimensions of risks and their implications for all stakeholders.

(Petersen et al., 2011)

In a particular manner, this assessment stresses the importance of pondering critical reflexivity in the knowledge practice, at the risk of giving rise to epistemological uncertainty – and consequently, credibility concerns.

On a parallel note, it may be relevant to note that the three dimensions of analysis described above – in brief, management of uncertainty, management of multiple perspectives, and management of extended communities of peers – clearly link to domains of competence relevant to this research project and to the overall question of how well organisations in the field are equipped to induce necessary innovations in knowledge practices.

While the need for greater reflexivity comes expressed within institutional contexts in the form of greater transparency, legitimacy, quality, and credibility, the literature also associates it with the depth of innovations in knowledge production required to engender responses to rather systemic and complex challenges. In other words, not just because reflexivity builds credibility, but also because it is essential to generate a new type of knowledge, despite how disruptive it may sound.

> “There are no cheap tickets to mastery. You have to work hard at it, whether that means rigorously analysing a system or rigorously casting off your own paradigms and throwing yourself into the humility of Not Knowing'” (Meadows, 1999).

In chapter 5 below, this thesis will further describe how such notion and need for enhanced “reflexivity” is perceived and valued in the field, from the perspective of practitioners. Just as an example in this section, from the notion of complexity and complex adaptive systems applied to food system, the authors of the *EEA Seafood in Europe* report share from their own experience how ‘embracing complexity’ is found to go beyond research and policy alone. Instead, “it is a process that includes analysing how one relates to oneself and to others, and it involves significant efforts across actors and society. Applying this new type of knowledge in order to for make sense of the world and support transformations will require learning and experimentation”. (Belchior et al., 2016)

Reflexivity and experimentation (or reflexive action) are indeed often mentioned along in the literature reviewed as being critical constituent parts of a heuristic path where awareness of the self is as important as the object or subject of knowledge.

The EEA report on sustainability transitions places a great emphasis of the need for “’real-world’ experimentation for transformative innovation” (EEA, 2019). The key argument being that “innovations are explored through learning-by-doing and trial-and-error processes”. While this position is held pointing to actual sustainability transition innovations, the same approach would arguably be used for what innovations in knowledge practice are concerned.

The intrinsic dimensions of tentativeness and transience in systemic interventions and reflexivity are, indeed, unequivocal components of innovations in knowledge practice. Simply put, there seems to be “no realistic choice but to treat the introduction of new knowledge as an experiment that presents us with opportunities to learn”. (Clark et al., 2016)

In the section below we will explore the connection between this and the need for a generative type of knowledge that induces, through its practice process, constant action-learning loops.

Text Box 4 – Operative Synthesis – Reflexivity

As an operative synthesis for the sake of this research project, innovations in knowledge practice sought through the perspective of enhanced reflexivity would undertake that *knowledge is to be generated through constant reflexive learning loops, through which values, beliefs, mental models, and worldviews of the knowledge broker (or institution) are questioned and made explicit. It requires opening room for multiple perspectives, making sense of complex, ambiguous data. Self-consciousness and tolerance to exposure are instrumental. Transparency is a key criterion in reflexive knowledge* practice.

2.3.5 The need for a generative, action-oriented, and response-based type of usable knowledge

As perceived through the literature reviewed, one of the greatest concerns regarding the type of knowledge required to support governance for sustainability transitions / transformations, relates to how "actionable" the existing knowledge actually is. Available knowledge, produced in past decades, points to a wealth of accumulated and growing understanding of the problems generating contemporary sustainability challenges, but very little indications of what possible responses or solutions are. Moreover, the nature of knowledge isn't often directly usable within a policy-making context.

The notions of "actionable knowledge" or "usable knowledge" or even "knowledge for action" (Clark et al., 2016; Dilling & Lemos, 2011; Grunwald, 2007; Kirchhoff et al., 2013; Palmer, 2012; Van Kerkhoff & Lebel, 2006) are, indeed, quite present in the literature reviewed and to a large extent express a common view on this specific type of innovation required in knowledge practice.

The concern is well synthesised in the following lines by Clark, van Kerkhoff et al. (2016): "[…] too much potentially valuable knowledge produced by committed researchers languishes in libraries, unused by society; and too many of society's greatest needs for new knowledge remain relatively unexplored by researchers. A transition toward sustainability thus requires not just more knowledge, but more usable knowledge." (Clark et al., 2016)

The idea of "usable" or "actionable" knowledge is particularly treasured in the science-policy interface, and to a large extent, such a quality in knowledge generated in that space fulfils the sense of purpose and value of organisations and individuals operating in that arena. As mentioned in chapter 1 above, boundary organisations are uniquely positioned to make use of the growing contributions from science in this domain and to transform such knowledge into one that is actionable for policy.

So, while the notion of 'knowledge for action' is already embedded in the thinking and practice of boundary organisations – if nothing else, by its own definition – the extent and scope of its application is expanded through the literature reviewed.

As perceived through this research, and in the particular context of the sustainability science-policy arena explored, the idea of enhancing a type of knowledge that is "more" actionable, comprehends in itself three key perspectives.

Firstly, that the substance of knowledge created – the content itself – needs to incorporate more views and evidence on possible solutions to contemporary challenges, rather than just deeper and finer analysis of the challenges themselves. "Science has, up-to-now, tended to provide, mainly, understanding but not answers or comprehensive solutions (e.g. Funtowicz and Ravetz 1990, Klein 2004)". (Earth, 2013).

This calls for knowledge outputs that provide, content-wise, responses (and not just understanding of the problems) to the sustainability challenges at stake. "Integrating global environmental change issues with development and sustainability issues involves many complexities and uncertainties and must incorporate understanding of societal norms, values, and perspectives." (Kates 2011)

In what the required innovations for knowledge practice are concerned, this perspective leans towards a greater attention to the focus of knowledge created. It relates to many of the aspects discussed above in this chapter, namely the variety of and dynamics between actors involved in the knowledge practice (including in that process those that are 'recipients and users' of knowledge assets), the transdisciplinary nature of the search for "useful" knowledge (beyond disciplinary divides), the questioning of assumptions, and the mental models and belief systems that may condition the discovery of novel responses to existing problems.

Secondly, the idea of "more" actionable knowledge is found to comprehend the need for a more 'digestible' type of knowledge, made available in a form and language that is more easily understood, made sense of, and used by – in this case – those involved in policy-making.

While not much direct inputs to this were found in the literature reviewed – rather indirect mentions to it as a concern – the experience and observation within science-policy space as such offers quite a strong indication that, not just the *content in* knowledge, but also the *form of* knowledge are important aspects to consider when it comes to innovations towards a more actionable type of knowledge in the sustainability arena. Chapter 5 below will explore this in further detail from the perspective of practitioners in the field.

Thirdly, some of the reports and literature reviewed indicate that in the notion of actionable knowledge, is also the idea of a knowledge practice that induces, per se, constant action-learning loops.

Actionable knowledge is, in this regard, one that is crafted from the outset through a pre-defined process that comprehends, in itself, regular cycles of application, experimentation, testing, and prototyping – and learning. This connects to the idea of the process of knowledge practice being, in itself, generative of action. To some, such a process embeds in itself a political dimension and therefore helps bridging the gap between science and policy. (Wittmayer & Schäpke, 2014)

In this latter account, innovations towards a “more” actionable type of knowledge call for a deeper transformation on how knowledge is produced, and that, in turn, triggers the question on the capacity of organisations and professionals in the field to conduct such type of transformation:

> “Understanding what makes knowledge usable for sustainable development is of limited value unless we also have the capacity to transform such understanding into practice. ‘Capacity’, as we use the term here, includes the capability to act and the competence to do so effectively (34).” (Clark et al., 2016)

This is, to a large extent, the approach of relevance in this thesis. While the search for policy responses to existing challenges features in most institutional and scientific domains researched, the capacity to co-design action-oriented knowledge processes is, at least, legitimately questionable. Later on in this thesis, this question will be addressed from the perspective of actors in the field.

Text Box 5 – Operative Synthesis – Generative Knowledge

As an operative synthesis for the sake of this research project, innovations sought under the need for more action-oriented knowledge undertake that knowledge in this account is to be created, from the outset of the process, in view of generating possible responses to challenges at stake, be transformative, point to action, and promote change. Experimentation during knowledge practice *periods is instrumental to test applicability and usage, on the go. It requires processes to be intentionally designed as inductive, tentative, and transient – and therefore intrinsically non-predictive and non-prescriptive. Design thinking and prototyping are key components in such iterative learning processes.*

3. DEVELOPING INDIVIDUAL COMPETENCE FOR INNOVATIVE KNOWLEDGE PRACTICE – an operative framework

In the previous chapter, this thesis explored some of the characteristics surrounding claimed innovations in knowledge practice required to better support sustainability transitions and transformations. It synthesised the need for five key innovative approaches: (1) the need for **co-created** knowledge, involving a wider and diverse set of actors across sectors, roles, and geographies, (2) the need for a stronger inter and (especially) **transdisciplinary** approach, beyond discipline-based processes, integrating different types of knowledge(s), (3) the need for enhanced **systems thinking**, stressing the role of *thinking differently* and *holistically* when dealing with complex adaptive systems, (4) the need for extended **reflexivity,** questioning our own mental models, assumptions, and biases, looking for a deeper level of (self) consciousness, and (5) the need for a **generative** type of knowledge – capable of generative continuous action-learning loops, focused on knowledge usability and possible responses and solutions for rather complex, systemic problems.

This chapter explores, from the literature reviewed and substantively based on my own professional expertise in the field, issues associated with research question #2, on the type of individual competence required to induce innovate approaches to knowledge practice in sustainability 'boundary organisations'.

In doing so, the chapter explains the relevance of a competence-based approach to the question of *capability*: *are the various actors operating in 'boundary organisations' – do they feel – capable of inducing such type of innovations in knowledge practice?*

It is important to note that the broad field of "competencies for sustainability" is not the primary focus of this thesis. Instead, the research focuses on the differentiating individual competencies of experts working at the science-policy interface to induce innovations in their knowledge practice.

Overall, the question of institutional / organisational capability to induce innovations in knowledge practice appears rather implicitly in the literature reviewed (as later described in section 3.1). Yet, based on the inputs described in chapter 2 above, it can be concluded that articulating the type of innovations required calls for mindsets, approaches, methods, practices, and attitudes that have not (yet) gained mainstreamed traction in what the knowledge practice is concerned in these organisations.

Also, such type of innovations render the knowledge practice more complex, different from most current approaches, disrupting existing *modus operandi* and *status quo* within longstanding scientific paradigms as well as those present in the work of boundary organisations' research.

While these challenges can be addressed from a broader scope of institutional capability analysis, this research project took the specific lenses of the role of *individual competence* within it – the main reason being that it was found rather absent or insipient in observed discourses and reviewed institutional reports.

Also, it was found that discussions on institutional capability within researched 'boundary organisations' would often lead to the thinking about dimensions of capability other than individual competence – for example, references to modes of institutional governance, budget and prioritisation, political agendas, organisational management and incentive mechanisms. The dimension of individual competence to induce innovations in knowledge practice was, again, rather absent.

Often found in both the literature and the field is that individual capacity to induce innovative approaches to knowledge practice is a factor of individual's knowledge or expertise in the themes or challenges at stake. The current chapter starts, therefore (section 3.1), by setting the argument for the use of the notion of *competence* instead / beyond the component of *knowledge* or *expertise* within it. In this account, *being competent* to induce innovations is more than just *knowing about* it.

Given the core role of the notion of competence for this thesis, the chapter then explores (section 3.2) in greater depth the concept of competence as such, including some of the key theorical frameworks, applications and controversies associated.

The purpose of a deeper theoretical immersion as displayed in section 3.2 is not only to reassure the robustness of the concept, but also to support validation of the operative framework proposed in section 3.3. Given the exposed complexity of the notion of competence per ser, such an operative framework is useful to engage with the empirical work associated with research question #4 on "How do practitioners in the field relate to the need for different types of competencies other than those existing institutional competency frameworks?"

From the literature reviewed and an interpretative exercise based on my own expertise in the field, section 3.3.3 offers a list of distilled competencies, different from those usually present in institutional competency frameworks, that appear to be rather critical to induce the required innovations in knowledge practice. Through the empirical research – as exposed in chapter 6 – this list will be used to sound practitioners in the field on how they relate to the need for such type of individual competencies at their work within boundary organisations.

In section 3.4 below, are presented findings from the literature reviewed on broad theoretical approaches that support the development of such type of competencies.

3.1 From 'knowing about' to 'be competent at'

Work practice and discourses in boundary organisations – largely experienced through my own professional immersion in the field – often suggest that by simply *knowing more about* contemporary sustainability challenges – being able to understand, describe, analyse, and map them in a credible and scientifically sound fashion – actors in the science-policy interface would be able to induce innovations in knowledge practice and generate the type of knowledge required to inform policies responding to such challenges. In this perspective, innovation in sustainability knowledge practice is primarily a factor of *scientific mastery* and *expertise* in sustainability challenges.

In this account, changes in knowledge generation, transfer and usage would constitute less of innovative practices and more of incremental doses of the same type of knowledge, possibly geared to include greater amounts of data or different disciplinary contributions. As such, it wouldn't necessarily imply a significant change in knowledge practice as such.

The literature reviewed is ambiguous in this regard. While it points to the need of, for example, different mental models, relationships between knowledge stakeholders or greater reflexivity, it also implicitly suggests that experts in the field would be competent in doing so, as long as they'd be aware of it. In different terms, the literature and discourses analysed, suggest that once defined and agreed the type of innovations required, experts in the science-policy arena would *simply need to implement* those – assuming they'd be competent at it.

Under this perspective, there isn't much room for discussion on the actual capacity of organisations and practitioners in the field to also question and change their own practice of knowledge creation, transfer and usage – including their mindsets, attitudes, mental models, and belief systems – accordingly. It seems to be assumed that using the same type of competence acquired in their academic and professional life, experts in the field would be capable of implementing required innovations.

In a parallel argument, some discourses in the field would suggest that once leaders in boundary organisations define what innovations in knowledge practice are required, actors at stake would end up changing and adapting their practices, including dimensions such as own world views and attitudes towards, for example, better dealing with uncertainty, ambiguity, collaboration, interdisciplinary work, etc. Such type of naturally adaptive processes would happen organically, as many other transformations in work cultures occurred in the past.

To this regard, though, the literature reviewed raises the question of the pace of change at stake. Such type of organic, adaptive changes in organisational practices and cultures do take time to be embedded. While much of such adjustments may indeed be effective in the long term, they would not be fast enough to respond to the urgency required in the science-policy arena. As mentioned in chapter 1 of this thesis, there is a quest for a significant acceleration in the generation of a ‘new type of knowledge’. Innovations in knowledge practice need to be induced and adopted at a much faster pace in order to timely serve urgent decision-making and governance (Jäger et al., 2013; Kirchhoff et al., 2013). The urgency for such transitions in the sustainability arena actually calls for swifter, more rapid transformations in the mode of generating actionable, usable knowledge, which, in turn, is not compatible with un-steered or un-governed organisational adaptations.

With these perspectives in mind, this thesis explores the gap between the capacity to *understand* and display intellectually (formally or informally) what it takes to generate such ‘new type of knowledge’, and the capacity to *actually do it.* Simply focusing on what is known about required innovations in knowledge practice is not enough. The findings presented in this chapter, therefore focus on what different type of individual *competences* are required to effectively induce innovations in knowledge creation, transfer and usage, and to institutionalise those through practice.

Literature on institutional theory or institutional development often describes such contexts as frequently privileging *transactional and mechanistic* approaches to the notion of capability, validating traditional forms of performance assessment (Chapman, 2014). This makes room for a legitimate question of concern in what knowledge innovation in ‘boundary organisations’ is concerned: are they addressing the issue of capability and competence beyond the perception of ‘knowing about the challenges and the innovations required’?

More so, as Jake Chapman poses it, when in such institutional contexts, “people who are promoted to higher positions of authority interpret their promotion as a validation of their *knowing best*.” The assumption of “knowing best” transpires across the entire organisation and closes the door to continuous reflexive, experiential learning, which is found to be vital to deal with complexity and generate systemic innovation in knowledge practice.

Focus put on individual 'expertise' and 'intellectual capacity' tend however to neglect other dimensions of competence. As suggested by Fanny Klett, in this account "intellectual assets incorporate knowledge and skills, and it is quite often excluded of consideration that these assets involve also attitudes and behaviours." (Klett, 2010)

Yet, as explained in chapter 2 above, the type of innovations required in knowledge practice call for profound transformations that span beyond the close remit of intellectual knowledge and *knowing* – they call, as well, for developments in domains of attitudes, behaviours, and values. "By integrating knowledge, skills, attitudes and behaviours to a new operational element, we introduce the term *competency*." (Klett, 2010)

The use of competence-based approaches to address capability issues is found in many management and organisational development, and also in sustainability transitions governance arenas.

Competence-based approaches provide an approximation to human performance factors beyond factors such as 'information', 'data' and 'knowing about' in traditional knowledge management frameworks. Competences can represent a *set* of skills, knowledge, and abilities that belong together and, as competencies, go beyond mere "knowing" towards work-relevant action; this opens possibilities to operationalise learning goals and outcomes and thus serve as a 'control instrument'. This argument is particularly relevant in the context of this thesis.

The competence-based approach proposed in this thesis, therefore provides a framework to enable addressing the question of capability to induce innovation in knowledge practice, not only from the perspective of expertise but accounting as well domains of *skills*, *attitudes and values*.

The following section will explore in further depth the concept of competence, demonstrating, from the literature reviewed how it encompasses such diversity of integrated dimensions.

3.2 The concept of competence

The term "competence" is widely used nowadays in a variety of contexts and across a range of disciplines. There is no consensus though on what the exact meaning of the term is. A wide diversity of perspectives have tried, over the course of many years, to understand and define what competence is all about. While there is a vast array of literature on the concept of "competence", there isn't a *theory of competence* as such. The perceived ambiguity in the attempts to propose theoretical definitions and respective boundaries gives room to diverse epistemological approaches, usages, and criticisms on the concept.

A revealing expression was used by Guy Le Boterf in his 1994 book, referring to the concept of competence as an "attracteur étrange" (strange attractor) – given that the difficulty in defining it seems to co-relate with the need of its usage. (Le Boterf, 1994)

Appendix 1 presents a table with key contributions to the concept of competence. An excerpt from CEDEFOP's 2006 publication on the "Typology of knowledge, skills and competences: clarification of the concept and prototype" is also transcribed there, in order to illustrate the myriad of approaches to the term "*competence*", and how such diversity has been expressed in research. (Winterton, 2006)

Through the literature reviewed, it is evident that the term itself is often used interchangeably with other terms like *capacity*, *ability*, *capability*, *skills, performance,* or even more with *competency*. Some argue this somehow negligent use of the term is lacking clear and sufficiently theory-grounded definitions. (Durand, 2016)

The concept appears to be clearly multidimensional and polysemous. It comes often associated with prefixes like *functional* competencies, *operational* competencies, *soft* / *hard* competencies, etc.

The wide variety of usages and approaches to the concept led Ana Pires (2002) to propose the concept to be "dynamic, embedded in culturally and socially constructed meanings". The culturally framed attributes to the concept are further explored by other authors when trying to understand and define the concept (refer to *Appendix 1* on the concept and definition of *competence*). (Pires, 2002)

Despite such ambiguity over the definition of *competence* as such, many researchers converge in the idea that the concept of *competence* only started to be significantly used in the late 50s, and 60s. The use of the terms "competence" and "competency" can be found in a variety of writings in the early 20th century. However, in these texts, "competence development was not yet a professional practice itself (Mulder, 2014).

Some would refer to Richard White as the first to introduce the concept of competence in psychology literature. He proposed competence as a key concept understood by him as "an organism's capacity to interact effectively with its environment." (White, 1959)

Others point to the first significant use of the concept of *competence* to be attributed to Chomsky. It was his work (mostly in the 60s) in the field of linguistics that first made use of the notion of *competence* as opposed to the notion of *performance*. Chomsky establishes the distinction between the two terms, considering *competence* as the capacity of an individual to produce a language, and *performance* the effective usage of that language in given contexts.

Since then, the concept was adopted and developed by various disciplines. Those that appear to have given a greater contribution to the development and usage of the term were *Psychology*, *Education Sciences* and *Management*. Some authors also refer the contribution of *ergonomics* and *sociology of work*.

Back in 1979, Grant et al. (cit. in Mulder, 2014) set the "competence movement" to be emerging from the disconnection between education (qualifications) and the labour market. Mulder argues that the concept of competence was used in the context of learning and performance from the outset, and that competence and professional and practice-based learning are intrinsically related to one another.

In 1973 David McClelland (psychologist) challenges the use of traditional tests (biased) and proposed testing for competence. In 1982 Richard Boyatzis conducted extensive research of successful managers and publishes "The Competent Manager". Since then, the notions of competence and competencies have become embedded into a variety of organisational management practices, especially within Human Resources (HR).

The concept is now institutionalised, not only within professional organisations and education institutions, but also at a wider political spectrum, for which the "European qualification framework" is be a good example. (Cohen-Scali, 2012)

Different authors have proposed different epistemological approaches to conceptualize and study *competence*. Some the authors listed in this thesis have tried themselves to map such epistemological efforts. Exploring and further analysing result of their work appeared unproportionate for the sake of this research, with an estimated marginal value add.

Instead, rather than seeking a single suitable definition of competence, this thesis opts to follow a few authors that suggest looking at the concept as a *social construct,* comprehending a particular set of features that, displayed in a given context and situation that are likely to provide satisfactory operative definitions of the concept.

Wittorski, for example, understands *competence* as a *process* rather than as a *state*. However, he argues that competence can be inferred from performance. According to him, competence is always competence of an individual or individuals in situation. It is finalised (rather than abstract), contextualised, specific, and contingent. In an attempt to propose a "minimalist", comprehensive definition, Wittorsky suggests competence as a "mobilisation of a set of *knowledges*[15] combined in action in a specific manner, following the built perception of the individual over a given situation". (Wittorski, 1998)

[15] In the French original text, "knowledges" refer to "savoirs", including the classic combination of *savoir*, *savoir-faire* and *savoir-être*.

In 2002, Angela Stoof and her colleagues wrote an article in which they propose “a constructivist aid for understanding and using the concept of competence” (Stoof et al., 2002). This article argues that the use of objectivist approaches in the epistemological efforts to define the concept of competency are leading to a “dead-end road”. Seeking a “one and only true meaning of competence” is not the way forward. Instead, they propose a “constructivist” approach[16].

> “A constructivist approach does not aim at describing a concept that is extremely hard to grasp, but it rather redirects the attention of the people concerned to their own situation and their own needs to construct a viable competence definition.” (Stoof et al., 2002)

Such a constructivist approach to defining the concept of competence in a given context appears of relevance to this research. It opens theoretical room to use the concept in a plastic way in order to facilitate the empirical work at stake, permeating the notions practitioners themselves have of the concept of competence.

In this line, seeking a construct that serves the purpose of this research project, two key theoretical approaches appear to influence the concept of competence in a rather polarised manner: *behaviourism* and *subjectivism*.[17] Both of them apparently too weak or insufficient to reflect the complexity of the concept.

Under the *behaviourist* influence, *competence* is understood closer to the notion of observable performance; the emphasis is placed on the result of a task, the final product, the outcome – *one*

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[16] The authors propose a “boundary approach” to define the concept of competence. The method is based on the analysis of a given situation where competence is mobilised, focusing on three key variables: *people*, *goal* and *context*. From there the method suggests three steps. The first one, the *inside-out approach*, describes the dimensions of competence that are at stake in that given situation (for example, personal vs task characteristics, individual vs distributed competence, specific vs general competence, etc.). In the second step, the *outside-in approach*, one should set the difference between competence as described in that given situation and related terms (for example, competence vs performance, competence vs qualification, competence vs capability or ability, etc.). The final step is to define the concept based on the ingredients provided by the previous steps.

[17] Another known entry to this polarised view of the competence debate is the everlasting discussion on the difference between *competence* and *competency, whereas competence would relate to the behaviourist approach and competency to the subjectivist one. That is nevertheless subject to great controversy still nowadays.*

is (or is not) competent in performing a task. Under this approach, "competence is conceived in terms of separated behaviours, associated with the finalisation of atomised tasks", not necessarily valuing the relationship between tasks. (Hager and Gonczi, 1996:247 cit in Pires, 2002).

Under the *subjectivist* influence, the understanding of *competence* emphasises the potential and attributes of the individual – *one holds (or not) enough competencies in order to successfully perform a task*. Under this approach, competence is based on generic attributes despite the context where these are to be performed. The same attributes can be applied in a variety of contexts. Within such generic attributes are for example included competencies related to critical thinking, creativity, autonomy, or communication. (Pires, 2002)

This subjectivist / behaviourist dichotomy can be translated into the recurrent differentiation between the terms *competency* and *competence*. The table below offers a synthesis of distinction between the two approaches:

Table 3 – Competency and Competence

COMPETENCY *(HOLDING A COMPETENCY)*	**COMPETENCE** *(BEING COMPETENT)*
Subjectivist approach	Behaviourist approach
A set of attributes	Observable behaviours
Generic, transferable	Specific, Contextualised
Input (stock)	Output (performance)
A state	A process
Competencies (plural) is applicable	Not used in plural

Beyond these two approaches there seems to emerge a distinct approach to the concept of competence, one that "puts in evidence its dynamic and complex character, valuing the attributes of the individual on one hand, but also articulating it with the specific context where the individual is situated. [...] This perspective can be positioned in those of systemic approaches, valuing the global, dynamic integrative and contextualised character of competencies". (Pires, 2002)

Under the systemic approach, competence is understood in a more comprehensive manner as a dynamic process, not as a given state or attribute. Being multidimensional, defined as a combination of various attributes playing interdependently in a given situation, competence is meant as a complex system. It is also relational, as it can only be understood in relationship with the out-setting conditions, with the task that is to be performed and the given context the individual is situated. In this account, such process can – and does often – encompass ethical judgements and values in a reflexive loop of integration of attributes (or "*knowledges* / know-how" as proposed by Le Boterf). *Reflexivity* actually has in this process an instrumental role as the "individual takes a distance from the tasks performed and the act of learning about knowledge itself is already a transformation". (Pires, 2002: 259)

Therefore, under this approach, the socio-cultural dimension framing the individual's mindset, values, and meanings is of utmost importance. That dimension will, to a large, extent orient his / her actions, the construction of representations of reality and a certain self-image, influenced by the social and cultural system the individual is living in.

To better understand the application of the concept of competence in the context of this research, the sections below will offer an operative framework, including examples to illustrate to usage of the concept.

3.3 An operative framework towards the use of the concept of competence

As displayed above, many efforts undertaken in the past decades to define and stabilise the concept of competence have struggled to emancipate from concepts, notions, and theories firmly anchored in disciplines like psychology or education sciences. With that, little margin was left for a definition of the concept that remains at the same time solid from a theoretical, scientific perspective, and an understandable operative from the perspective of applicability and usage.

The later paragraphs in the section above have nevertheless indicated room for a constructivist, systemic approach to help understand the notion of competence and its usage in context.

For the specific purpose of this work, – and not as a general theory on the concept of competence – this thesis proposes an operative framework regarding the concepts of *competency* and *competence* (used for the moment being in this work, interchangeably).

Similar frameworks are present in multiple competency frameworks in organisations and institutions all over the world. This research analyses some of those competency frameworks in relation to sustainability 'boundary organisations' investigated. Some of these will be presented in chapter 6 of this thesis.

This particular framework seeks to articulate the notion of competence combining theoretical contributions as those described above with institutional approaches encountered in my personal professional experience in this domain of work.

The boxes at the end of each section seek to illustrate the application of the framework to the innovation features identified in chapter 2 – those that are found to be key in order to enhance innovative approaches to knowledge practice in support of sustainability transitions or transformations.

As an illustration of the applicability of this framework, this thesis will mostly focus on the need for enhanced systems thinking, stressing the role of *thinking differently* when dealing with complex adaptive systems.

3.3.1 Knowledge, skills, and attitudes

As an operative framework, it is proposed to understand *competence* as a combination of *knowledge*, *skills,* and *attitudes*, mobilised in action in a given context towards the performance of a particular task or job. Being competent in a particular task or job, requires therefore (1) *knowing about* that particular job, topic and related information or data, (2) *being able to* execute certain sub-tasks and perform sub-sets of that job in an integrated manner and (3) *being* (or behaving) in some sort of way that makes the job possible and successful in a given context.

This proposal comes very much in line with the definition of competency used by a number of European Institutions and bodies. The European Commission, for example, defines it as “a coherent set of skills, attitudes and knowledge that manifests itself in observable behaviour and that has a predictive value towards effective delivery of a certain performance.”[18]

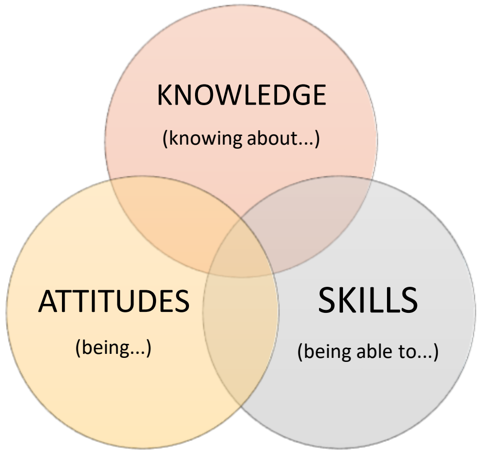
The European Environment Agency, for example, defines competency as a “coherent set of skills, abilities and knowledge that manifests itself in observable behaviours. Competencies provide clear definitions of the essential behaviours required for a job and define the behaviours associated with high performance within an organisation.”[19]

The pertinence of this framework is also related to the familiarity it may bring to practitioners in the field. The articulation of *knowledge*, *skills,* and *attitudes* can also be found in much of the literature in French, as a combination of *savoir*, *savoir-faire* and *savoir-être* (Durand, 1997, 2016; Le Boterf, 1994; Pires, 2002; Wittorski, 1998) – which was gradually popularised in much of the educational and management milieus. It can also be related to the ancient Greek notions of *episteme* (knowledge), *techne* (practice) and *phronesis* (attitude) and from more contemporary theoretical approaches, such as the one of Pestalozzi’s theory of education, speaking of the three key “Hs”: *head*, *hand* and *heart* (cit in (Durand, 2016).

The scheme below sets the basis for exploring this framework and the section below will look in detail into each of these three dimensions of competence: *knowledge*, *skills,* and *attitudes*.

[18] European Personnel Selection Office
[19] EEA Core-Competency Framework

Figure 3 – Knowledge, Skills and Attitudes



Knowledge

In this proposed framework, *knowledge* is to be understood as "knowing about". It is mostly about cognitive load of information and facts. It is about knowledge that is able to be verbalised or reproduced. Often commonly referred to as the "theory" or the so-called "encyclopaedic knowledge". One could know *more* or *less* about a certain topic or discipline and an individual can be expected to reproduce or transmit such knowledge by, for example, verbalising it.

Knowledge in this account can also encompass the notions of *awareness* and *understanding*. Beyond the cognitive load of data and information, knowledge is also the result of one's capacity to analyse, relate, categorise, abstract, generalise, etc.

The acquisition of this type of knowledge is mostly processed through listening, reflecting, reasoning, reading, interacting, expressing ideas and concepts, etc. This type of knowledge – this dimension of competence – has been granted great value through the classic paradigms of science and education approaches, mostly based on cognitivist learning models. (Wortham, 2003). Still nowadays, formally assessing competencies in professional contexts is mostly triggered by an initial assessment of knowledge – *what one individual knows about something*.

In this account, knowledge is just one dimension, one aspect of competence. As an example, one thing is to *know about*, another is to *be able to* work and think transdisciplinary, co-generate knowledge, think systemically or be reflexive.

Text Box 6 – Competency Framework – Application example 1 – Knowledge

> *In order to innovate sustainability knowledge practice, one would be expected to <u>know about</u> systems dynamics and complexity. One would need to know about different approaches to systems thinking, would need to understand the meaning and application of terms like 'system properties', 'feedback loops', 'perspectives', 'mental models', 'patterns of attention and consciousness', etc. It would be important to know some of the methods proposed to apply systems thinking and deal with complexity. One would be expected to relate concepts of system thinking to one's own reality and specific challenges, let alone understanding how important that is and why. One would need to mentally explore reasoning behind and conceptual implications of using all such notions.*

<u>Skills</u>

Under this framework, skills are understood as "being able to…". In its strict account, skills are taken here as almost mechanical, operative capacities. It is about something an individual can actually *do* (and not just talk about). It requires breaking a task down into smaller pieces and being able to execute them all, one by one or simultaneously, in an integrated manner.

As individuals normally internalise and embed a wide variety of skills in their daily routines – including professional performance – they often find it difficult to enunciate each of the individual skills required. For example, when driving a car as an experienced driver, the ability to steer, set the gears, press the break and speed pedals, look at the mirrors, etc., all appear with time to be irrelevant skills (operational mechanical capacities). They tend to become covered by a one single competence called “driving a car”. And yet no one would become a good driver if not able to perform all those mechanical tasks in a coordinated and integrated way.

The same applies to speaking a language, typing in text into a “Word” document or conducting a meeting. Performing all such tasks in a competent manner requires mobilising sub-sets of skills, very often uncovered or unperceived – and in many cases even underestimated, as easily taken for granted.

A *skill* in this context is not always as observable and mechanical as the examples above though. Being able to do something might well refer, for example, to the capacity to think introspectively or the ability to provide feedback while listening by using facial expressions in a deliberate manner.

Within the territory of sustainability challenges explored throughout this thesis – especially related to innovations in knowledge practice – such skills are indeed of a rather profound, complex, and often intangible nature. They often refer to inner, discrete rather than explicit practices.

Individuals acquire skills mostly through practice and repetition. The more the practice, the more a specific skill set gets embedded in performance in a way that individuals don’t even think about what it takes to get such skills in action. Repetition, trial, and error are particularly powerful mechanisms for learning a skill. They need therefore to be not just permitted but rather encouraged in the context one is operating.

Text Box 7 – Competency Framework – Application example 2 – Skills

In what systems thinking is concerned, innovating approaches to knowledge practice would require practitioners to be able, for example, to detect and examine own mental models, to describe own assumptions, meanings, preconceived ideas, values, and beliefs, to inquire inwardly towards oneself, to perceive, recognise and map own emotions. It could be relevant for a systems thinker to be able to visually represent distinctions, systems, relationships, and perspectives (DSRP) of a given reality.

Attitudes

In this framework, attitude is understood very closely to the notion of "knowing to be", as imported from the French expression "savoir-être". An attitude can be swiftly defined as an individual's evaluative response to a specific object of thought (Vogel & Wanke, 2016).

Competence-wise, attitudes are complementary to *knowing about* something or *being able to do* something, as they refer to a predisposition for *being* in some sort of way – for example being resilient, curious, empathetic, open-minded, respectful, or cautious. Attitude objects can be concrete or abstract, they may be inanimate things, persons, or situations. Attitudes can encompass affective, behavioural, and cognitive responses as summarised in the *Tripartite model of attitudes* by Allport (cit in Vogel and Wanke 2016).

As many would expect attitudes to be innate, they should not be confused with personality traits or properties of identity. One might have multiple attitudes in different moments of time or space. An attitude is declared in context. In other words, one is only "cautious" or "tolerant", or "pro-active" in relation to a situation. One doesn't hold an attitude in absolute terms.

Although attitudes can be learned they are not easily, simply "acquired" as such (similarly to a specific piece of knowledge or a trained skill). An attitude needs to be grown, cultivated, nurtured. It usually requires transforming something from within (in many cases involving emotions, feelings, or perceptions). Growing a certain attitude in adulthood, deliberately, can be done through experience itself. It is not gained through encyclopaedic knowledge. It does require a good combination of judgment, value-base reflection, change in perspectives, modifications in meanings and purposes or perceptive awareness, to give a few examples. Role modelling and feedback are known powerful mechanisms for developing specific attitudes.

Text Box 8 – Competency Framework – Application example 3 – Attitudes

Back to the system thinking capacity, innovating knowledge practice will require a set of critical attitudes like being tolerant to ambiguity and uncertainty, being appreciative of the mental models of others, being mindful about imposing own judgements or being acceptant and accommodating to vulnerability and mistakes.

Recapping, a competency is therefore a combination of *knowledge*, *skills*, and *attitudes*, when mobilised in action, in a given context and towards the performance of a particular task or job.

Being competent therefore requires holding a specific (type of) knowledge that is relevant for the job. It requires as well being able to perform a sub-set of tasks. It finally requires a specific set of attitudes without which that same task or job would not be completed to the extent expected or towards the desired outcome.

Whether a person is considered by others to be competent as a system thinker (using the example given), such an assessment will be based on observable behaviours. Behaviours in this account are translators or *proxies,* observable expressions of competencies (knowledge, skills, and attitudes) in action, in a given situation and context.

3.3.2 Personality, values, and purpose

As seen through the literature mentioned above, the notion of individual competence is dynamic, embedded in culturally and socially constructed meanings. It cannot, – or should not – therefore, be detached from three key elements proposed in this operative framework: the individual's *personality traits*, core set of *values* and intended *purpose*, and meaning connected to the actions performed. Competencies are mobilised in action, in a given context, framed by these three key dimensions. The combination of knowledge, skills, and attitudes in action can only be integrated successfully if congruent and aligned with this wider set of three features.

In brief, *personality traits* in this context refers to lasting personal characteristics that are revealed in particular patterns of behaviour, thought, and emotion, in a variety of situations. In this account, traits are relatively stable over time, differ across individuals (e.g., some people are outgoing, whereas others are shy), and influence behaviour. *Traits* contrast with *states* which are more transitory dispositions. In some theories and systems, personality traits are something a person either has or does not have, but in many others personality traits are dimensions such as extraversion vs. introversion, with each person rating somewhere along this spectrum.

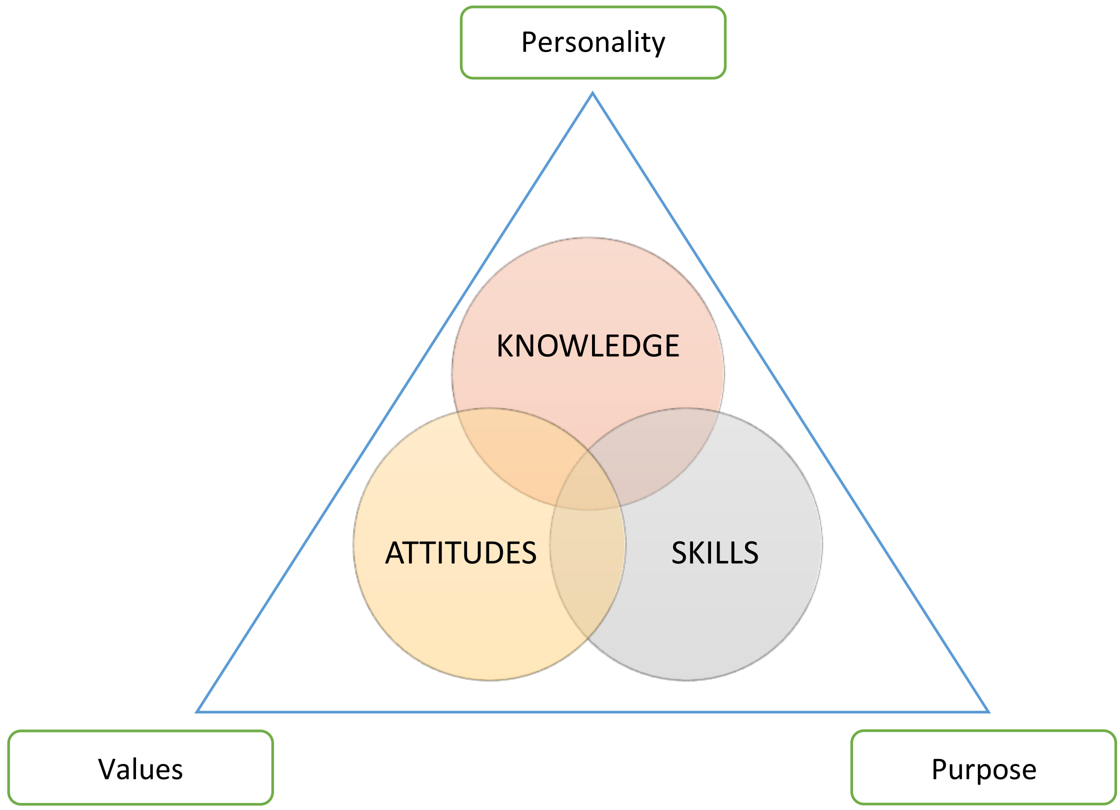
To a certain extent in our operative framework, one could extrapolate the role of personality traits to the sense of *identity*. An individual's sense of identity – very much conditioned by cultural meanings and processes of socialization – might well operate the same influence in the mobilisation of competencies.

Values in this framework refer to a set of ethical, moral, doctrinal, ideological, social, cultural, and aesthetical values. Personal values in this perspective provide an internal reference for what is good, beneficial, important, useful, beautiful, desirable, and constructive. Values in this account influence the choices made by an individual.

Values can also be understood in this context as broad preferences concerning appropriate courses of action or outcomes. As such, values reflect a person's sense of right and wrong or what "ought" to be. "Everyone has the right to be heard", "excellence deserves admiration", and "people should be treated with respect and dignity" are representative of values.

The reference to *purpose* – or rather, the sense of purpose – in this framework is to be understood in line of the desired outcome from the outset: the product, change or transformation to be achieved through the mobilisation of particular competencies. It has components of motivation, intentionality, attributed meaning, and an insight towards a desired ultimate goal. The sense of purpose in this context is therefore close to the notion and role of foreseeable futures.

Figure 4 – Personality, Values and Purpose



In the perspective of this work, the integrated articulation of these six features in a given context will define the notion and perception of competence. As such it will also relate to the individuals' willingness and capacity to develop new and specific competencies.

This operative framework allows a deeper exploration of what competencies – what combination of knowledge, skills, attitudes, personalities, values, and purposes – are therefore critical to induce innovations in knowledge practice at the sustainability science-policy interface.

The section below will outline some of such competencies, as distilled from the literature reviewed. The whole framework will then be used to conduct the empirical research (as described in chapter 4 below), seeking to sound the relevance and pertinence of such competencies from the perspective of practitioners.

3.3.3 Different types of competencies for innovations in knowledge practice

A wide array of institutional competency frameworks is publicly available for consultation and analysis. Some of these will be further analysed in chapter 6, in connection with the empirical investigation through boundary organisations.

As referred to in previous sections, competencies in such competency frameworks are in general and to a large extent described as essentially *transactional: i.e.,* applying a given, well defined competency, translated into a well described behaviour, is expected to generate a desired known output, performance-wise.

This approach to competency frameworks and competency descriptors is popular amongst many organisations around the world – from corporate to public or academic arenas. It would be sensible to assume that such an approach most likely depicts and replicates the predominant, institutionalised working and learning culture of the organisation the frameworks pertain to.

While such type of 'transactional' competency frameworks appear of significant importance to the work of sustainability 'boundary organisations', for the most of it, they don't incorporate and describe the type of knowledge, skills and attitudes required to induce the type of innovations in knowledge practice synthesised in chapter 2.

This perspective is reinforced by my own personal experience in the field, where it is clear the type of competencies described in mainstreamed institutional competency frameworks are not those deemed critical to induce innovative approaches to knowledge practice within 'boundary organisations'.

As an example, using the approach by Williams and Hummelbrunner (2011) exposed in section 2.3.3 above, engaging in systems thinking would require a combination of competencies related to (1) an understanding of relationships, (2) a commitment to multiple perspectives and (3) and awareness of boundaries.

“Understanding of relationships”, “commitment to multiple perspectives” and “awareness of boundaries” are not dimensions of competency – or competencies as such – commonly expressed in institutional competency frameworks. And yet, they are critical to innovate knowledge practice through greater systems thinking.

There is a challenge in describing the type of competencies needed to innovate knowledge practice: the expected output of applying such competencies is, from the outset, unknown as such. The type of competencies at stake are those expected to generate innovations towards a practice that is not yet clearly defined. The type of behaviours to be demonstrated through the application of such competencies is only vaguely known – and not broadly acknowledged. In this regard, ‘transactional' approaches to competency definitions do not serve.

There is also a significant difference between the type of competencies presented in mainstreamed competency frameworks and those required to innovate knowledge practice. While the former are mostly described based on components of *knowledge* and *skills*, the latter are mostly informed by dimensions of attitudes, values and purpose.

What is primarily at stake in this type of competencies is their capacity to fundamentally change not just individuals’ mechanistic praxis, but mostly some of their assumptions, mindsets, and mental models. Collectively applied, they are better capable of changing the paradigms in which these actors operate.

Therefore, when exploring in depth the five key features informing innovation in knowledge practice – as presented in chapter 2 – this research extracted from within the literature reviewed perspectives, suggestions, propositions and definitions that point to different type of competencies required to induce such type of innovations. It focused particularly on different paradigms of knowing, learning, working, and being, which in turn lead to different dimensions of competency not usually present in institutional competency frameworks.

For example, the following excerpt from Otto Scharmer constituted an important input to section 2.4.4 of this thesis on the need for greater 'reflexivity' towards innovative knowledge practice:

> "Collectively seeing our field structure of attention—that is, collectively becoming aware of our inner places from which we operate in real time—may well be the single most important leverage point for shifting the social field in this century and beyond, for it represents the only part of our common consciousness that we can control completely."(Scharmer, 2009)

In this proposition, it is notable, from a competence perspective, the implicit capacity to *see one's own field structure of attention*. This type of competency is not commonly referred in institutional frameworks; and yet it is deemed critical to engender greater *reflexivity* in knowledge practice.

In identifying and highlighting competencies like the example above, a subjective judgement exercise was done in order to select those that appeared less common in mainstreamed competency frameworks. Such an option was taken based on propositions explained in section 1.2 of this thesis. Essentially, based on the assumption that, in order to generate a *different* type of knowledge practice, actors in the field would need to perform somehow *differently*, and would therefore need to mobilise *different* types of competencies.

The same exercise was conducted throughout all literature reviewed in relation to the five features for innovative knowledge practice displayed in chapter 2, with support of content analysis methods.

While some of the competencies extrapolated can be directly associated with one or another innovative features, for the most of them there is no direct, linear association as such. For instance, while the example above can be directly associated to the need for greater reflexivity in knowledge practice, the capacity to "tolerate ambiguity" can possibly serve all of the five innovation features together.

Similarly, while some of the competencies distilled below could be unpacked into distinct dimensions of knowledge, skills, attitudes and values, for the most of them such an exercise was deemed too heavy (and unnecessary) for the core purpose of this thesis. The option was therefore to maintain competencies described in its generic, integrated form.

The systematic application of this method of analysis – coupled with an interpretative and sense-making effort based on my own personal expertise and immersion in the field – resulted in a list of ten key competencies deemed critical to innovate approaches in sustainability knowledge practice[20]. Such list is summarised below.

20

Important to note that this list of competencies does not claim to be the-one-set of competencies required for practitioners in sustainability boundary organisations to perform successfully in their various capacities. Also, it does not claim to be the-one-set of competencies to guarantee further innovations in knowledge practice. Instead, it is a list of competencies that was deemed critical to – alongside with other known competencies in existing organisational competency frameworks – contribute to induce innovations in knowledge practice through greater co-creation, transdisciplinarity, systems thinking, reflexivity and generative action loops.

Table 4 – Summary of key competencies for innovative knowledge practice

KEY COMPETENCIES FOR INNOVATIVE KNOWLEDGE PRACTICE
1. **Translating and mediating knowledge** The capacity to share knowledge and learning (rather than imposing knowledge), promoting distinct forms of communication among potential collaborators who have no history of talking with one another; possibly involving translation or mediation of mutually incomprehensible concepts, sets of assumptions, norms, or values. 2. **Humility, curiosity, and appreciation for the unknown, coping with vulnerability** The capacity to recognise, with humility, the limitations of one's own knowledge and perspectives in dealing with complex issues; being able to expose unknowns, doubts, weaknesses; coping with vulnerability. Developing a vibrant curiosity, actively and openly inquiring toward other systems of thought, disciplines and worldviews and other sources of knowledge and learning, both formal and informal. Nurturing an appreciation for the unknown, recognising the invisible / unseen behind the material, looking after one's own blind-spots. 3. **Self-awareness and introspection** The capacity to acknowledging oneself as part of the system, recognising and accepting inherent partiality and bias; detecting and examining own mental models, describing own assumptions, meanings, preconceived ideas, values, and beliefs, inquiring inwardly towards oneself, perceiving, recognise and map own emotions. 4. **Tolerating ambiguity, uncertainty, and unpredictability** The capacity to tolerate ambiguity, engaging in a "both/an" rather than "either/or" type of thinking. Dealing with uncertainty and unpredictability as part of a natural heuristic journey towards new knowledge. Capacity to integrate feedback loops. 5. **Thinking systemically, beyond analytical approaches** The capacity to hold a holistic worldview, describing systems dynamics, made up of interdependent parts, understood in their relationship to the whole. Be able to identify and map distinct entities in a system, multiple relationships amongst them, as perceived from a variety of different perspectives. 6. **Embracing complexity and disruption** The capacity to embrace – not 'tame' or 'mitigate' – complexity, non-linear dynamics, and disruption as informative components of (instrumental sources of knowledge about) adaptive systems. 7. **Nurturing empathy, compassion, and trust** The capacity to nurture empathy and compassion, integrating mind and heart, opening, and holding spaces of interconnectedness and shared purpose; being able to connect to one's deepest source of will and intention. 8. **Visualising possible futures and design thinking** The capacity to mobilise forward looking, scanning horizons, building scenarios, and possible futures; engaging in tentative efforts of visualisation, imagination and design thinking. Being capable of ideating, prototyping, and testing. 9. **Entrepreneurial and resilience capacity** The capacity *to deeply commit with transformative approaches, accepting risks, keeping the drive, energy, focus, sense of purpose and motivation in contexts of continuous barriers and constant personal and institutional opposition.*

> **10. Mobilising intuition and sensing**
> The capacity to appreciate, trust and mobilise own intuition involving decisions related to discerning "relevant" data and knowledge. Mobilising domains of 'feeling' and 'sensing' beyond factual, intellectual or logic criteria for decision-making.

This set of described competencies were later used throughout the empirical work in response to research question #2 on *how do practitioners in the field relate to the need for different types of competencies other than those existing institutional competency frameworks?* Findings of that work are presented in chapter 6, below.

3.4 Accelerating competence development for innovations in knowledge practice

This section of the thesis provides a conceptual framework to address research question #3 on *how can professionals working in the science-policy interface most effectively learn and acquire the type of competences required to innovate their knowledge practice* – as identified through previous sections.

Initial observations and interactions in the field suggest that the type of competencies described in section 3.3.3 above are perceived by practitioners as personal attributes rather than learned (professional) competencies. However, a substantive body of literature reviewed demonstrates such type of competencies are subject to be developed. Development of such competencies can be facilitated and accelerated in given institutional contexts. As for that though, specific paradigms of adult learning, approaches and strategies need to be put in place – and not let at the discretion of individuals alone, without robust frameworks and processes.

This proposition has been briefly presented in section 1.2 of this thesis. The paragraphs below will explore this proposition in great depth, in support of the empirical work later presented in chapter 7.

Given all theoretical inputs exposed in section 3.2 above, it is safe to affirm that competencies are developed by individuals every day, at all times, in a natural process of growth, socialisation, and performance. In a professional context, most significant competencies to perform in a given job are developed "by doing", i.e., they are developed through the performance of specific tasks and assignments inherent to the job itself (Jennings, 2012). Competencies are also developed through social interactions (collaboration and networking) and through formal instructions (like technical training, e-learning courses, or academic programmes). A popular description of these domains of competence developed comes through the so-called 70:20:10 model. Charles Jennings popularised the model based on the principle that: (1) *70* percent of learning comes from experience, experiment, and reflection, (2) *20* percent derives from working with others and (3) only *10* percent comes from formal interventions and planned learning solutions.

In general, it is commonly accepted that competencies developed in adulthood grow organically, mostly through experience, driven by specific individual needs and interests, and take relatively long periods of time to come to shape. This proposition is not only sufficiently evidenced in academic research to date, as it is currently embedded in many organisational and academic management practices.

In the case of individuals operating in sustainability 'boundary organisations', the development of required professional competencies wouldn't be expected to be different. To a large extent, important competences required to perform in the job would be developed throughout time and energy invested in completing job assignments as such. Should such assignments, goals, contexts, or conditions change, sustainability professionals would be expected to adapt and, eventually, develop the competencies needed to adequately perform in such given job. With additional organisational support, this process of competence development would benefit from internal mechanisms of collaboration and, where applicable, formal training.

While this could induce a sense of confidence and conformism, inputs in the literature reviewed point to a different direction – one of a concern, based on two key perspectives.

Firstly, the type of challenges and sense of urgency described in chapter 1 of this thesis, point to a necessary shift in working and learning modes that needs to occur as quickly as possible. The development of required competencies to induce innovations in knowledge practice (such as those listed in the section above) needs to be *accelerated*. Also, it needs to target those on the job right now – not future generations of sustainability professionals. As explained earlier in this thesis, this accounts to the vast mass of civil servants, researchers, practitioners, and other knowledge actors working at the science-policy interface – 'boundary organisations', and academic and policymaking institutions alike – who need to undertake additional efforts to acquire as quickly as possible new professional competencies. (EEA, 2019) Such an exercise, to be effective, is not compatible with long periods of time.

Secondly, the type of competencies required to innovate sustainability knowledge practice may be perceived as contrary to the "status quo" of relevant, credible, and legitimate knowledge – supported by professionals in the field. Most of such 'reputation' has been built over the years based on broadly accepted paradigms of science and knowledge practice. How can these very same '*regime* actors'[21] be now motivated and engaged to question and adapt their own competency set in such a profound way? For example, how can these same players be now encouraged to tolerate uncertainty and ambiguity when they were trained to produce indisputable definitive answers? How can they be asked to induce disruption when they were educated to tame complexity? How can they mobilise intuition when only their intellectual cognitive load was tested and valued in their professional careers?

Moreover, transforming the existent set of competencies of a larger set of professionals in a relatively short period, within science-policy organisations, cannot be achieved by the same learning and training approaches that were geared to develop the rather transactional, mainstreamed competencies commonly presented in institutional competency frameworks. Those appear ill-equipped to develop the different type of competencies required for innovation in knowledge practice as described in section 3.3.3 above.

[21] Making use of the Multi-Level Perspective (MLP) model proposed by Geels and colleagues and often used in the sustainability transitions community. Geels, F. W. (2010). Ontonlogies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, *39*, 495:510.

The set of arguments above, present the need for exploring alternative learning approaches that can help accelerate the development of competencies for innovative knowledge practice.

The following sections offer a conceptual framework that encompasses the arguments above in a more comprehensive manner, providing a clearer understanding of such type of alternative learning approaches.

In brief, the sections below will further explore the pertinence and value behind the adoption of diversified and integrated learning strategies, to be used in the subsequent empirical work – as later presented in chapter 7.

3.4.1 The need for diversified and integrated learning strategies

As explained towards the end of section 3.3.3 above, the type of competencies required to innovate knowledge practice are less of a “transactional” type (focused in components of knowledge and skills), but more ‘transformative’ in nature, anchored in dimensions of attitudes, values and purpose.

Based on the literature reviewed, it is clear that the deliberate and oriented development of such type of competencies calls for approaches to adult learning different than those commonly encountered in formal education and training institutions and programmes.

Accelerating the development of such type of competencies requires from organisations to rethink organisational learning and training strategies. As for this, it appears important to understand not only *what* type of competencies are to be developed and *why* that is relevant (as exposed in previous sections), it is also critical to understand *how* those competencies can be better and effectively developed given available research and best practices to date.

In the paragraphs below, this thesis will give an account of conceptual approaches to this issue, based on the literature reviewed, in combination with the professional experience of the researcher in this field.

As previously explained, the notion of competency used for the sake of this research is articulated by the combination of *knowledge*, *skills,* and *attitudes*. These are framed by individual profiles that combine *personality* traits, *values,* and *purposes*.

The way individuals – as adult learners – develop *knowledge*, is not necessarily the same as they transform *attitudes* or acquire new *skills*. And that, in turn, is not necessarily the same for, as an example, an experienced professional educated as an environmentalist in southern Europe as it is for a young graduate trained in executive business in north America.

Developing each of those competence dimensions, taking into account a variety of individual profiles, will therefore require a diversified set learning strategies, methods, and approaches, articulated in an integrated manner.

The array of adult learning theories available in the literature is substantive. Scanning and dissecting all those in a systematic way was deemed an unproportioned effort for the sake and purpose of this thesis.

Based on the literature reviewed, the following approaches to learning stood out as being particularly relevant for this thesis: the *behaviourist*, *cognitivist*, *constructivist,* and *humanistic* approaches to learning. Firstly, because they encompass many of other theories and respective variations (and applications). Secondly, because they appear to be directly connectable to each of the dimensions of competence at stake in this thesis: *knowledge*, *skills*, *attitudes*, *values* and *purpose*.

The literature being significantly loaded with contributions to define and explain these learning theories, the main distinctive aspects between them are synthesised below:

> *Behaviourist* learning approaches very much lie on the assumption that learning is mostly about changing behaviour. The focus is put on the observed outcome stimulated by

external input. Individuals learn following positive or negative reinforcements that steer the expected results.[22] The emphasis is put on observable behaviours or measurable outputs. Schooling practices of test-based assessments or organisational incentives are good expressions of such type of approaches. Learning in this account is conceived as a reaction to the external environment rather than an active part in the discovery or questioning of that environment. What is valued is the application of learned knowledge in new ways or situations. In behavioural learning theories, transfer is a result of generalisation.

Cognitivist learning approaches, unlike behaviourist ones, distinguish between genuine understanding and simply producing the right behaviour.[23] The focus is therefore mostly about the internal processes of thinking and cognition, and in the collection, analysis and systemisation of information. Learning in this account is concerned not so much about what individuals do with what they learn – the outcome or behaviour generated – but rather with what they know and how they come about to acquire such knowledge. Learning involves deeper grasping of the subject matter – which individuals need to do by themselves. In this line, learning cannot be "pushed" to people (individuals cannot be "forced" to learn). Learning involves expanding – through incremental stages of knowledge – mental models individuals use to perceive and understand reality. That's what helps assimilate new situations around them.

Constructivist approaches to learning are mostly based on the proposition that adults learn from their own experience, in a process that is, simultaneously, a combination of cognition, sense-making, and social interaction. Notions of *situational learning*, *self-directed learning*, *transformative learning*, *experiential learning, learning-by-doing,* and *reflexive learning* mostly lie on this approach. Unlike behaviourists and cognitivists, constructivists do not believe the "real world" is "out there" and is mind-independent.

[22] Key scholars behind this approach are: B.F. Skinner, Ivan Pavlov, Edward Thorndike, Edwin Guthrie, and John Watson.
[23] Key scholars behind this approach are: Jack Mezirow, Paulo Freire, Jean Lave, Lev Vigotsky, John Dewey, and Philip Candy.

> Therefore, according to them, it cannot be mapped onto a learner. "Constructivists do not deny the existence of the real world but contend that what we know of the world stems from our own interpretations of our experiences. Humans create meaning as opposed to acquiring it. Since there are many possible meanings to glean from any experience, we cannot achieve a predetermined, 'correct' meaning. Learners do not transfer knowledge from the external world into their memories; rather they build personal interpretations of the world based on individual experiences and interactions." (Ertmer & Newby, 2013)

The three broad theories above inform the main overarching theories of learning. A *fourth* approach is often derived from those and is worth being noted in the context of this research: the *humanistic* approach. The main focus of this approach is on the *development potential* of individuals and on their capacity to respond to human nature in terms of relationships, emotions, and affections.[24] In this account, learning is more than just adaptive behaviour or cognitive processes – it derives mostly from intrinsic motivation and implies choices and accountability (sense of responsibility). Many of the adult learning theories – including the notion of *andragogy* itself – are anchored in this humanistic approach.

The synthesis above describe simplifications of rather broad and complex overarching theories of learning. Each of them individually and combinations of those do provide room for a much wider set of theoretical derivations and applications. Key questions around these theories in adult education contexts often point to (1) how knowledge is transferred and developed, (2) what the role of teachers (trainers / facilitators), the role of students, (learners) and the role of the surrounding learning environment is, (3) which factors influence learning, (4) what the role of memory, personality, values, and intrinsic motivation is, (5) how can and in which cases organisations should apply one or another of these approaches, or (6) how learning is assessed.

It is not the purpose of this thesis to explore in depth all the intricacies of these theories and respective derivations. They are mentioned here simply to provide a supporting theoretical

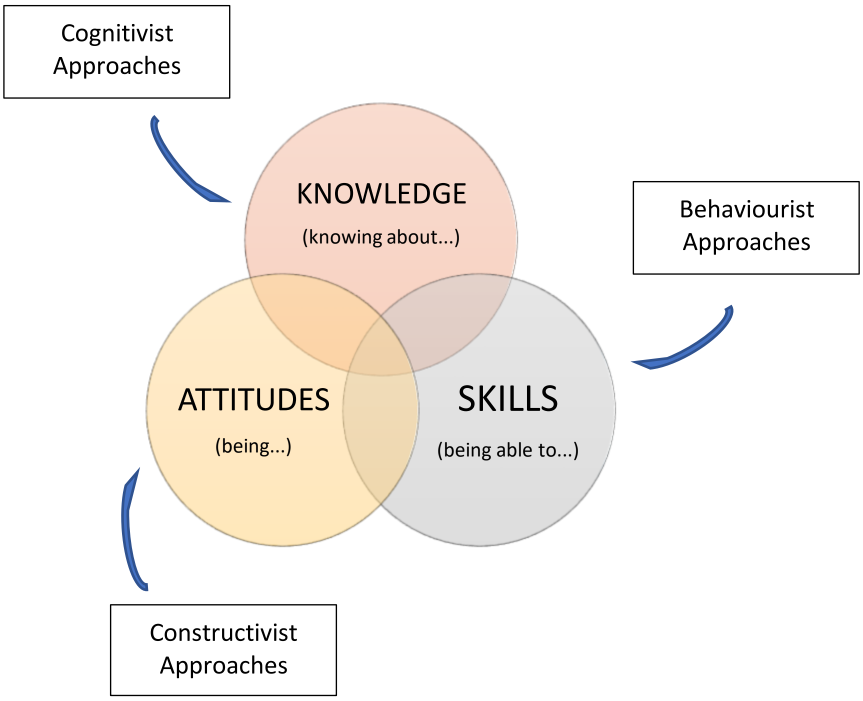
[24] Key scholars behind this approach are: Malcom Knowles, Carl Rogers, Abraham Maslow, and Albert Bandura.

framework to approach key factors and principles that should inform learning strategies to develop competencies for innovations in knowledge practice (as those described in section 3.3.3. above).

For the sake of simplicity (and actionability), the following paragraphs and schemes will seek to explain how the learning theories described above articulate with the different dimensions of competence (development) in an integrated manner.

Taken the notion of competence as a combination of *knowledge*, *skills,* and *attitudes*, this conceptual framework suggests that cognitivist approaches would likely serve primarily the development of *knowledge*, the behaviourist approach is best suited to develop new *skills* and the constructivist approach should be at the core of *attitude* transformation.

Figure 5 – Cognitivist, Behaviourist and Constructivist Approaches

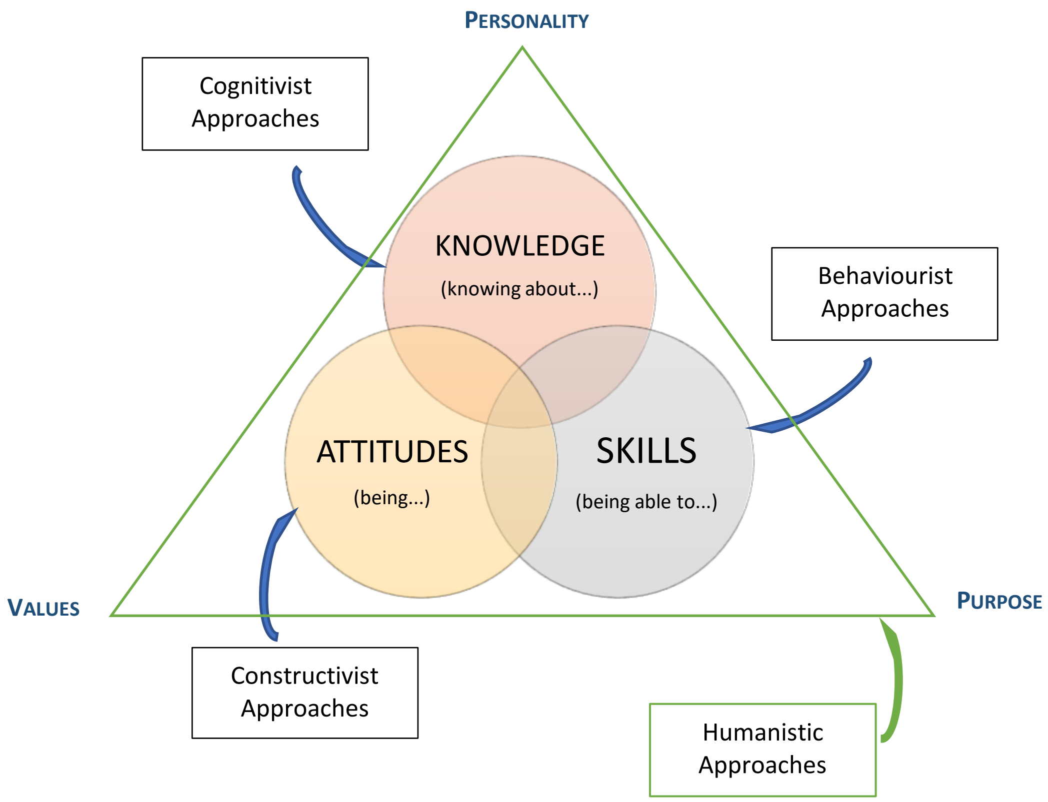


In addition to the above, *humanistic* approaches are of paramount importance, especially when referring to competencies for innovative knowledge practice, mostly focused on dimensions of *attitudes*, *values* and *purpose*:

> "In adulthood, the task is to strengthen and build on this foundation *[shaping children's learning]* in order to assist the *[adult]* learner to understand new subject content, but, in the process of doing so, to become (1) more aware and critical in assessing assumptions—both those of others and those governing one's own beliefs, values, judgments, and feelings; (2) more aware of and better able to recognize frames of reference and paradigms (collective frames of reference) and to imagine alternatives; and (3) more responsible and effective at working with others to collectively assess reasons, pose and solve problems, and arrive at a tentative best judgment regarding contested beliefs. (Mezirow, 1997)

Hence the need to blend into the framework above room for *humanistic* learning approaches, given those regard learning processes as ones that integrate individuals' personalities, values, and purposes.

Figure 6 – Including Humanistic Approaches



A diversified and integrated learning *strategy* to develop the type of competences described in section 3.3.3 of this thesis, would therefore require a combination of these four learning approaches.

An illustration of the application of such a framework into the example of *systems thinking* previously used – in this case, developing *systems thinking* as a competency – would look like, for example:

- The use of cognitivist approaches would be used to expand the understanding of systems (definitions, properties, dynamics, etc), explore the notion of systems *thinking*, as opposed, for example, to analytical thinking, and transfer information about known approaches, methods, and applications of systems thinking. Well known lecture-type of inputs, recommended readings, group or peer discussions, and a few knowledge assessments would help developing this knowledge.

- Behaviourist approaches would help developing a set of skills required to apply systems thinking. For example, the capacity to "slow down one's own intelligence" and break cognitive processes into smaller steps; being able to discern, on the spot, between produced observations or interpretations; being able to spot one's on judgements, to describe and verbalise where those come from; to apply in each moment a predefined set of rules and steps, etc. Such type of skills can only be developed through practice. Lecture-type of inputs or purely cognitivist approaches will not suffice. Well-crafted workshops or training courses and selected routines to apply in daily work contexts are needed. Making room for trial and error is important and needs to be accompanied by positive and negative reinforcements to guide the learner into the "right" action.

- Developing a *systems thinking* competence requires a set of critical attitudes like, for example, being tolerant to ambiguity and uncertainty, being appreciative of the mental models of others, being mindful about imposing own judgements or being acceptant and accommodating to vulnerability and mistakes. Developing these attitudes will require substantive critical reflection on one’s individual experience, constant feedback loops, role modelling, etc. Supporting this type of learning requires going beyond lecturing or training. It demands learning to be fully embedded in the work / life flow, and supported through methods like stretch assignments, coaching, or communities of practice. Such type of learning can only succeed in context of high trust, openness, and sense of mutual care and support.

- Finally, developing systems thinking competence will require a deeper understanding of one’s own values and motivations, intrinsic beliefs, and assumptions. Self-consciousness is instrumental in systems thinking processes as any personal biases, prejudices, or preferences will condition the capacity to discern systems boundaries, relationships, and properties. Developing such an awareness will strongly depend on the learner’s willingness to undergo introspection and self-questioning in a rather critical, inquisitive, and open way. In this process, the learner becomes his / her own trainer and self-accountability for that inner process is important. This type of learning can be stimulated by, for example, inducing disruption (or “disorienting dilemmas"). When faced with induced disruption, people are forced to reconsider their beliefs in a way that will fit this new experience into the rest of their worldview. This often happens through “critical reflection" in the context of dialogue with other people. Other methods used for this sake would be critical incidents, metaphor analysis, life histories, or learning portfolios, for example.

The integration of diversified learning approaches is critical for the development of specific attitudes towards one’s own approaches to knowledge and work, which are instrumental do induce innovations in knowledge practice within the sustainability science-policy arena.

Devising such an integrated learning strategy can be a demanding endeavour, especially in institutional context where learning and training programmes are often segmented by disciplinary domains – and not integrated, based on whole-competence approaches.

To be effective, this type of learning strategies requires profound transformations in the way organisations work and learn. Professional exposure in the field shows that the complexity of such type of pedagogical engineering tends to provoke further inertia, refraining organisations' from further engagement in deeper transformation towards innovations in knowledge practice.

Chapter 7 of this thesis will present learning programmes that were deemed suitable to illustrate how such type of learning strategies can be put together, serving to develop the type of competencies required to innovate sustainability knowledge practice.

4. EMPIRICAL RESEARCH AND METHODOLOGY

Introductory chapters of this thesis provide an account of the existing claims and needs for innovative approaches knowledge practice. The focus is put on the work of sustainability ‘boundary organisations’, operating at the intersection between science and policy. Also, they set the argument for a competence-based approach in what organisational capacity to induce such innovations is concerned. As explained above, a different set of individual competencies is needed for practitioners in the field to innovate their own knowledge practice.

While this thesis engages an important set of literature pointers to the type of innovations required, the different type of competencies needed and how to accelerate the development of those in organisational context, the core of this research focuses on the views of practitioners in the field and on how the theoretical frameworks above contrast with the reality of ‘boundary organisations’.

Recapping, the five research questions are:

1. Which key innovations in knowledge practice are claimed as needed in order to respond to sustainability challenges in a context of transitions / transformation? What key characteristics shape the type of innovations required?
2. What different individual competencies are needed to induce such type of innovations in knowledge practice at the science-policy interface? How can the development of such competences be accelerated?
3. How do practitioners in the field perceive the need for and the pertinence of such type of innovations?
4. How do practitioners in the field relate to the notion of individual competence and the need for different types of competencies to induce innovations in their own knowledge practice?
5. How can professionals working in the science-policy interface most effectively learn and acquire such new set of competences, given their specific organisational / institutional contexts?

Under this framework, the empirical research was designed targeting a wide-ranging set of investigations of actors working in 'boundary organisations', and associated practices. In that regard, it was deemed relevant to use my own immersion in the field – both as a researcher and a staff member of the EEA – as an opportunity to better understand and analyse such domain of practice at the sustainability science-policy interface.

An action-research approach to this empirical research appeared therefore a suitable methodological option for this project. Section 4.1 below will provide an overview of main arguments behind this choice as well as inherent opportunities, challenges, risks and strategies to mitigate those.

Section 4.2 will present in more detail the combination methods used in this empirical research, including the choice of actors and organisations investigated and the use of documentary evidence harvested through participatory observation.

4.1 Between action-research and research-to-action

As mentioned above, an action-research based approach was initially considered appropriate to this project. In this context, action-research was to be understood as an approach in which the researcher works together with members of the same organisation or operating network in seeking to diagnose a problem and develop possible responses to it.

Action-research involves actively participating in a deliberate effort of change or transformation, often in an existing organisation, whilst simultaneously conducting research. As invested stakeholders, researchers work with others to propose a new course of action to help the organisation improve its work practices.

Applying the above to the particular case of this research project, myself as the researcher would work together with peers to explore how they engage in discussions about which competencies would be required for those same actors to be able to induce innovations in the practice of knowledge for policy on sustainability transitions / transformations.

In this process, although knowledge would be emerging through practice, in a vastly inductive manner, the ultimate purpose would not be to “solve a practical problem” as such, but rather to produce useful pointers, interpretations, and guidelines for best practice (Denscombe, 2014).

Such an approach and methodological option sounded suitable for the type of research at stake and, therefore, merited further investigation and discernment on whether it was an adequate avenue to pursue.

4.1.1 Conceptual background and motivations for methodological options

As many indicate MIT professor Kurt Lewin as the first to coin the concept of “action-research” back in 1944, the approach has in the meantime gained a much wider array of enthusiastic advocates in recent years, including in the interface between science and policy. The paragraphs below provide a brief account of some of those views, which in turn inform the motivations for the use of an action-research approach in this thesis work.

One of the most popular definitions of action-research is that of Rapoport's (1970): “Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework.” (Susman & Evered, 1978)

The ambitious and innovative proposition of action-research, to some understood as a “participatory, democratic process” (Reason & Bradbury, 2001), is well reflected by Hillary B. Huang’s affirmation: “We may therefore say that action research represents a transformative orientation to knowledge practice in that action researchers seek to take knowledge production beyond the gate-keeping of professional knowledge makers.” (Bradbury-Huang, 2010)

Approaches and definitions like the above set action-research at the intersection between "traditional science" and much of the claims for the new type of knowledge enunciated in this research – co-created, transdisciplinary, systemic, reflexive, and generative, as explained above.

The choice of an action-research-based approach though is not immune to risks and criticism. As easily encountered in the literature reviewed, and despite considerable scientific production on action-research as a subject, the approach is still nowadays considered by some as a non-traditional research method, and definitely not short of academic controversy. (Brydon-Miller et al., 2003; Dick, 2004; Greenwood & Levin, 2006).

Under an action-research approach, knowledge is to be gained through action and for action; and from such a perspective "to question the validity of social knowledge is to question, not how to develop a reflective science about action, but how to develop genuinely well-informed action." (Reason & Bradbury, 2001)

Following this line, action research does challenge traditional social science by moving beyond reflexive knowledge created by outside experts sampling variables, to an active moment-to-moment theorizing, data collecting, and inquiry occurring in the midst of an emergent structure. In this sense, performing action research is equivalent to performing an experiment.

Despite the anticipated challenges and controversy – which will be further explored in the section below – the above appeared very much is in line with the substance of this research as such. If an essential enquiry in this research was to question the type of knowledge produced to inform policy in the sustainability arena, then a methodological approach that was in itself set at the intersection between classical scientific methods and the need to generate knowledge-for-action sounded rather suitable.

4.1.2 Criticisms, challenges, and risk mitigation

As said above, despite its attraction and popularity, action-research is by no means immune to severe criticism from academic arenas. Action-research is not rarely seen as 'not real science':

> "One criticism is that action research is 'unscientific', at least in so far as scientific is understood in terms of the positivist approach to research. Given its engagement with problem solving in a particular context, questions can also be asked about the relevance of any findings beyond the immediate research setting." (Rose et al., 2014)

The authors also point to problematic ethical issues potentially at stake in action research: "The principle of informed consent, for instance, may be hard to apply in a rapidly evolving research situation or where the boundaries of the project are ill-defined and there can be unforeseen political consequences as a result of the research." (Rose et al., 2014)

Action research also raises a number of practical challenges for the action researcher. They flag the potential tension between the demands of the practical problem and the research and the inherent risk of the researcher becoming over-involved in the situation or of being used as a tool in organisational politics.

This line of concern is shared by Judy McKay and Peter Marshal. The title of their article synthesises the challenge related to action-research in a compelling way: 'driven by two masters, serving both'. (McKay & Marshall, 2007). In this work, the authors expose how action research projects need to respond to two different needs, not always or necessarily in synchrony. On one hand, the researcher is expected to engage in 'real-world' (organisational) challenges, being part of the process not just finding solutions for problems, but also contributing to the definition of the problem itself and the needs in terms of knowledge and know-how. The researcher is therefore an integral part of the organisational system, subject to the same dynamics of performance, management, and internal politics. On the other hand, the researcher is expected to formulate research questions (and seek to respond to those) in a way that makes them valid from a 'scientific' point of view.

For the action research to succeed, both streams of work – and therefore both sources of interest, need to agree a contractual space of mutual legitimation. In other words, the researcher needs to be acknowledged by the organisation not just as one of its members, but also as a researcher, legitimating room for research questions and approaches. In return, the research project needs to acknowledge the researcher as part of the organisation (whose "problem" is being subject of study) and, therefore, conditioned by the same systemic challenges as any other in that organisation.

This exact tension was experienced in the context of this research project, in which I was simultaneously a researcher and an EEA staff member.

A critical step into a process of action-research "contractualisation" within a given organisation, is the set-up of an adequate communicative space on the action-research process itself. (Wicks & Reason, 2009). Such a space embodies a tacit consent that legitimates on one hand the role of the action-researcher, and on the other hand opens room for the discussion of issues or problems in-situation and fosters open, participatory expression of views. Achieving such a synthesis of understanding revealed to be more challenging than expected.

Although the relevance of this research was notable to the EEA and the organisational need to address such challenges, it has become apparent that, given the practical institutional barriers encountered, the project could hardly take the form of a formalized action-research case study fully embedded at the EEA. Instead, it involved a wider (still challenge-led) empirical exploration of innovations in knowledge practice and competence initiatives elsewhere which is closer to more 'traditionally' accepted research methods, while at the same time of relevance to the EEA, in view of action.

As the research project evolved and developed – with expected challenges and variations – the notion and the pertinence of an action-research approach remained substantively present. When needed to adjust and adapt through the empirical research journey, such a framework did support most of the heuristic reflections and options.

The section will describe how such challenges and anticipated risks were resolved in the specific context of this research project.

4.1.3 Action-research in the context of this project

This research project could not be detached, at any stage, from my own professional working context, at the European Environment Agency (EEA)[25]. The EEA naturally immerses all those working there in a constant flow of opinions and discussions, lectures, articles, reports, and a variety of other inputs directly or indirectly related to sustainability challenges. In many different ways, a researcher in such a working context is continuously confronted in direct discourse with the challenges faced by all those seeking to generate knowledge that is relevant to support governance efforts towards sustainability transitions / transformations.

Such constant interaction frequently leads not only to new research questions and insights, but also to intriguing literature pointers, referred authors, key actors, or other research projects. The options taken through the research journey and especially in what the empirical research is concerned, were strongly nurtured by such professional and personal context.

As examples, the initial set of literature reviewed, the draft lists of key actors in the field, organisations to investigate or materials to analyse in greater depth – all these were in initial stages of the research project significantly influenced by the direct exposure to the EEA work.

While all this offers understandable advantages with what efficiency and effectiveness are concerned, it also raises obvious concerns; some of those is linked to the issue of research validity.

Making this aspect explicit – all throughout the thesis – is, in itself, an attempt to respond to such a challenge. Exposing the 'reflexive' dimension of this operating context, as Alan Bryman's puts it, entails a certain sensitivity to the researcher's cultural, political, and social context. As such

[25] I have worked at the EEA from November 2009 to November 2019.

then, “’knowledge’ from a reflexive position is always a reflection of a researcher’s location in time and social space” (Bryman, 2016).

Within such a framework it was critical to endeavour a constant effort to discern the appropriate distance between the researcher (myself), the subject of research, and the social (or organisational) context nesting this relationship. It also required an additional effort to focus on the use of data extracted from the empirical work to validate findings, beyond my own mental models, assumptions, meanings, and preconceived ideas that are, naturally, strongly influenced by my working context.

The design of the empirical work was therefore crafted with the above context in mind. The following paragraphs give a brief account of the methodological mechanisms put in place to successfully take advantage of opportunities created by and mitigate risks associated with my direct exposure to the EEA work.

From the outset of the research design, it was clear the importance of explicitly responding to criticisms and mitigating risks associated to the choice of an action-research approach – especially in what the empirical work was concerned. Below is a synthesis of some of the actions taken in order to explicitly address and resolved such challenges:

- Action-research was set not as the only research design approach to this project, in isolation. It was paired and combined from the outset with “traditional” social research methods such as semi-structured interviews and focus-groups.

- The scope of the empirical research was extended beyond the remit of the organisation subject to action-research – in this case, the EEA. It included actors and organisations from other institutions, from other countries and different professional contexts.

- The empirical questions were set in order to respond to challenges not unique to the EEA, but rather cross-cutting a variety of organisational / institutional settings in Europe. The findings would definitely be expected to contribute to address EEA challenges but also go beyond that remit and serve a wider network of practice.

For most of the duration of this PhD project, the so-called ‘contractual framework’ as described in the above section – between a research purpose and the resolution of an organisational challenge – was, as said, not a formal contract but rather a tacit one. In brief, EEA management deemed such a framework to risk a potentially perceived conflict of interest.

Acknowledging it, the research project pursued an adaptive approach navigating the formal conditions at stake, seeking to maintain the essence of an action-research framework in what the substance of the empirical work was concerned. The outcome of this effort came in a rather satisfactory way, in which the evidence collected and analysed could be enriched with interpretative efforts from the researcher based on his – my – embedded experience in the field. The combination of factual data with participatory observation and subjective interpretation raised new enquiring loops on the go, which revealed themselves instrumental the overall purpose of contributing to new knowledge in the field.

Key principles of an action research approach were used in the course of entire research. The findings out of the research journey were very often present in my work within the EEA (in internal discussions, meetings, seminars, and presentations on related topics). In turn, such conversations, inputs, materials circulated, and training events, collected and noted ‘as they came’, constituted an integral part of the empirical research.

In specific instances, mutual contributions from the literature review or particular conversations were made explicit. Examples of these are: (1) the working paper drafted as a deliberate contribution to the EEAcademy Winter School on “Integrated Environmental Assessments”; (2) the design of capacity-building workshops on “Co-creation and Reflexivity” and “Systems Thinking and Assessments”; (3) the set-up and facilitation of the community of practice on systems thinking and knowledge innovation; (4) direct contributions from this research to the SOER Stakeholder Involvement Process (SiP2); (5) feedback requested from EEA colleagues on their struggles introducing more co-created, reflexive, and systemic knowledge generation processes towards SOER 2020.

Moreover, much of the work done within the umbrella of the EEAcademy was extraordinarily rich as an empirical source for this research project.

4.2 Research design and methodology

In what the overall research design and methodology adopted for this project is concerned, the action-research approach explained above was combined with a set of interviews and focus-groups involving actors from other institutions and organisational settings. This was then combined with documentary evidence organised through a period of active participatory observation, set approximately between early 2016 and late 2019.

In brief, the research strategy for this work was mostly constructed as a *qualitative* one, emphasising *inductive* approaches in what the relationship between theory and research is concerned. Given the nature of the research questions, greater emphasis was put in the generation of new approaches, concepts, and frameworks.

Behind this option resided the observation – through the literature reviewed at that stage – that not much research had been done so far on these particular questions. That called for a rather exploratory approach through the empirical work.

The research strategy therefore embraced a rather *interpretivist* and *constructivist* approach, in an attempt to understand individuals' interactions with their social world, incorporating a mental model of social reality that is one of a "constantly shifting emergent property of individuals' creation" (Bryman, 2016).

In this account, and for the sake of this thesis, a *constructivist* approach simply refers to the role played by the researcher in using his experience, previous knowledge, and inherent judgement as a basis to construct new understandings and meaning of the reality researched.

From an epistemological perspective, that is combined with an *interpretative* effort applied to the data collected through the empirical work, seeking to contribute to generate new knowledge clues and possible new theories.

As often under this type of research approaches, two key methodological questions were raised: (1) on the *validity* – and especially the external validity – of the research itself, and (2) on the *values* and *reflexivity* embedded in both the epistemological and heuristic journeys.

As said before, it was important to make explicit that not only the choice of the research questions in the project, but also the choice of the research strategy and consequent methods were strongly influenced by my professional and personal context, having worked at the European Environment Agency (EEA) for nearly 10 years.

The EEA presents itself as a European public organisation operating as an interface between science and policy. As we take stock of this particular working context, three aspects set out as especially relevant in what the research methodology is concerned:

- The EEA is known as a 'knowledge-based' organisation. Its main goal is to support sustainable development and to help achieve significant and measurable improvement in Europe's environment, through the provision of timely, targeted, relevant, and reliable information to policy-making agents and the public. The EEA can be indisputably set as one of the key boundary organisations working in the sustainability science-policy arena. In such a role, the EEA operates within a large network of specialists, researchers, civil servants, and practitioners all over Europe. Working at the EEA gives relatively easy access to such networks, discussion fora, and individuals. The choice of research strategy and methodology took advantage of this opportunity.

- The EEA had recently gone through a comprehensive, organisation-wide exercise, setting-up a Competency Framework. Through that exercise the organisation experienced the use of specific methodologies to generate discussions, reflections and conclusions about key knowledge, skills, and attitudes to perform in the job. As the EEA L&D coordinator, I was directly involved in – and to a large extent, in lead of – such a process. That specific know-how was transferred to this research project.

- The EEAcademy is a project set up within the EEA and one of its main purposes is precisely to support inducing innovations in knowledge creation within the sustainability science-policy interface. In my last two years of work at the EEA, I coordinated the set-up and initial activities of the EEAcademy, coinciding for a large part of it, with this PhD research period. These parallel processes were for most of the time cross-fertilising each-other.

The empirical work sought to collect data at both European and national level, and with that to engage in a rather 'comparative research design'. This would favour gaining greater awareness and deeper understanding of the knowledge generation challenges – and also responses – in a variety of contexts, thereby seeking to gauge robustness of findings revealed on the way. The process was, therefore, designed as a *cross-sectional* research with some methodological *triangulation* (incl. data from individual interviews, focus-groups and participatory observation).

In this particular regard, the empirical work sought to:

a) Identify 'boundary organisations' other than the European Environment Agency, operating at European and national levels in the interface between sustainability science and policy.

   At European level, the choice was deliberately to look at materials and practices within other European Union (EU) institutions, such as the *Joint Research Centre* of the European Commission and the *Science and Technical Options Assessment (STOA) Panel* of the European Parliament. At national level, the choice was to identify 'environmental agencies' and professionals working within the scope of their work as boundary organisations.

b) Sound out expert professionals working within the realm of these organisations in order to:

  - Check their own understanding of the innovations required to generate a 'new type of knowledge' to help policy making processes address contemporary sustainability challenges.
  - Use their own field practice and reflexivity to help interpret in context – and eventually validate or not – what international reports and scientific research had been pointing to.
  - Explore their own experience as practitioners to further substantiate the type of competencies required to induce innovations in knowledge practice within the science-policy space their operate within.
  - In the same line, collect their views on how they would best see themselves and their peers further develop such competencies.

c) Contrast data collected from direct interviews with expert practitioners in these organisations, with data collected through participatory observation (and tacit action-research, as described above).

d) Obtain direct feedback from some of these actors – my peers in the field – on evolving findings of this research.

With this, methodologically, the options chosen for this qualitative research used four main vehicles of data collection: (1) ongoing literature review, (2) semi-structured interviews, (3) focus groups, and (4) participant observation. *Appendix 2* provides a schematic overview of these different methodological features, including specific objectives and expected outcomes for each of them.

4.2.1 Literature overview

The review of literature evolved from an initial, rather informal snowballing to a more structured and systematic identification of articles, authors and content. It included throughout the process iterative reviews focused each time on particular themes of interest.

The literature reviewed was initially organised in four key areas: (1) the field of contemporary sustainability challenges, (2) the field of knowledge generation and contemporary challenges posed to science and research, (3) the field around the concept of "competence", and (4) the field of *learning* and *education* in relation to the sustainability arena.

As the reviewing evolved to sketch out the main features of the required 'new type of knowledge' towards sustainability transitions / transformations, four subsets of literature fields arose; those on: (a) the idea of knowledge co-creation, (b) the notion of transdisciplinary knowledge, (c) systems thinking and complexity, and (d) reflexivity and self-awareness.

Later, through the empirical research, a fifth key field was added to these, around the notions of "actionable" or "generative" knowledge.

As mentioned, a significant piece of literature reviewed is set around the concept of "competence". As for this it, the research benefitted from previous work of the researcher explored literature written not only in English, but also at contributions in French, Spanish, and Portuguese.

All those combined constituted the literature base to inform and refine the research questions, set the theoretical frame, and situate the research within the relevant fields. The literature review has therefore been taking the form of narrative reviews. On one hand, it sought to bring about a more robust critical interpretation of the key issues at stake. On the other hand, it tried to identify what was already known and researched, and where there would be gaps in the research conducted so far – hence indicating room for further, relevant contributions.

4.2.2 Semi-structured Interviews

The interviews targeted a list of professionals operating within the sustainability science-policy interface. The list of interviewees includes staff of the EEA, European Commission, National Environmental Agencies, but also sustainability professionals and researchers working in collaboration with those seeking to produce usable knowledge to support sustainability transitions' governance.

Appendix 3 provides as overview of the interviewees' profiles and an outline of the questions to be engaged during interviews.

These group of selected interviewees was deemed representative of the broad thinking of practitioners in 'boundary organisations'. However, it should be considered that this set of interviewees has been chosen given their proximity to the broad territory of work of the EEA (directly or indirectly) and most of them had somehow already been engaged in reflections about their knowledge practice. While this may imply a potential bias, it was not deemed significant to influence the findings and conclusions of this thesis, given the variety of profiles and institutional affiliations at stake.

As mentioned above, these interviews were primarily aimed at translating the claimed need for a 'new type of knowledge' into concrete, tangible examples based on the interviewees' specific professional experiences and contexts. The interviews were used to verify the applicability of the approaches and propositions collected from the literature, and to find illustrations of it in "real-case situations" from the interviewees' personal experiences and narratives.

The interviews then addressed the competencies required to generate such innovations in knowledge practice, as perceived by the interviewees within their own working context. Complementary to these, the interviews also served to question these actors on perceived institutional obstacles that prevent such type of innovations in knowledge production. Finally, the interviews addressed their own professional learning and what could help enhance the acquisition of such competencies.

Section 4.3 below provides details about the mechanics, number, nature and content of interviews, as well as an account of how collected data was treated, analysed and reported as part of the empirical research.

Of a qualitative nature, these interviews contributed to qualify some of the findings out of the literature reviewed. They also identified gaps or oversights in the framework crafted to date, assembling a wider, critical perspective over the theoretical framework proposed.

Having said this, the most relevant gain expected out of the interviews was that they contributed to translate generic propositions into concrete situations in context. The interviews sought to pull interviewees personal perspectives and experiences, mobilising as much illustrative examples as possible.

Much of the contributions out of these interviews are expressed in chapters 5 and 6 of this thesis.

4.2.3 Focus-Groups

The focus-groups were organised and centred around three national environmental agencies, operating as 'boundary organisations' within the science-policy interface – in Portugal, Netherlands and the UK. These focus-groups sought to capture the views of actors involved in generating usable *knowledge-for-policy* in those contexts, combining agencies' staff, consultants and researchers.

Appendix 4 provides an overview of the focus group's participants' profiles and a tabled outline of the session's proposed methodology and key discussion content.

As for interviews, section 4.3 below provides a better account on how data collected from focus-groups was treated, analysed and reported as part of the empirical research.

Following content-wise a similar structure than that of the interviews, the focus-groups sought to address more fundamentally the issue of organisational and individual capability and explore any existing controversies. The focus-groups also questioned more systematically the existence of institutional strategies to develop individual competencies required to generate innovations in knowledge production by boundary organisations at stake.

In brief, these focus-groups were expected to: (1) through group discussion, discern patterns of levers or obstacles towards innovations in knowledge practice in the science-policy sustainability arena; (2) to identify any symptoms of tension or disagreement amongst participants that might help understanding what enhances or conditions the development of competencies to induce such innovations in knowledge practice; (3) to illustrate and contrast from the personal perspectives of the participants, their own personal experiences, and arguments, with the propositions emerging through research (as described in the earlier chapters of this thesis). Based on a pre-defined methodology, participants were invited to engage in discussions that explored the meaning, importance, and applicability of such propositions.

The discussion dynamics engendered through the focus-groups allowed as well to tap into some of the institutional leverages or barriers to the development of a new type of competencies. Some of the controversy generated in the discussion helped illustrating, for example, commonalities across different professional settings or different institutional priorities as responses to similar needs.

In the focus-groups, participants' individual contributions mutually stimulated a mindset of collective enquiry. That contributed, for example, to identify (often isolated) experiences – both within their own organisations or elsewhere – that could illustrate some of the perspectives at stake in this project.

The work done with the focus-groups also helped dissecting required competencies for knowledge innovation beyond its simple description. The contribution of participants was important to qualify different competencies, helping to get them translated in terms of *knowledge*, *skills*, and *attitudes* – to the extent possible, manifested through observable behaviour.

Focus-groups were designed and run in three different countries: in Portugal, in the Netherlands, and in the UK.

- In Portugal, the Portuguese Environment Agency (APA) had recently been seeking to promote initiatives that foster the understanding of what skills are needed to face new sustainability challenges. In this endeavour, the APA had been partnering with organisations like, for example, the Business Council for Sustainable Development (among others). Hosting one Eionet (European Environment Information and Observation Network) meetings, that topic was brought to the agenda. The Agency had moreover a sound record of expertise in what foresight / scenario studies are concerned.

  Alongside with the APA, a set of civil society organisations (mostly consultancies) were seeking to explore the same avenues of transformative knowledge / learning in the sustainability arena.

  Altogether, this set the scene for the first focus-group for in this research project (02 November 2017).

- In the Netherlands originated some of the first efforts to define key competencies for governing sustainability transitions. Some of the works by Rob Raven, Suzanne van den Bosch, or Flor Avelino are good examples of significant embryonic questions in this domain. Much of that reflection has now been captured through the work done by DRIFT (https://www.drift.eur.nl), within which *Transition Academy* is of particular interest for this PhD work.

The Dutch Environmental Assessment Agency (PBL) has also been active in enhancing innovation in what the generation of knowledge is concerned. The agency has developed a great amount of expertise in what horizon scanning and forward-looking scenarios are concerned and has been piloting some of the possible responses and innovation explored in this thesis.

Together with other researchers and practitioners in the field, this set the scene for the second focus-group (10 April 2018).

- In the UK, the *Department for Environment, Food & Rural Affairs* (DEFRA) engaged in recent years in a process to keep under review the capability and quality of science and evidence across the DEFRA group, including the core Department and the eight DEFRA group bodies that have a strong science and evidence capability.

  Through EEA-Eionet activities DEFRA representatives got in touch with this PhD research project and the opportunity for a joint workshop / focus-group emerged. This also linked well with initiatives run under the framework of the Centre for the Evaluation of Complexity Across the Nexus (CECAN), which has brought along quite some intriguing questions around the issue of 'capability'.

  This focus-group gathered participants across these two organisational constellations, bringing together civil-servants and researchers from both arenas. This focus-group took place in York (UK), the 3rd of September 2018.

At the end of each focus-group, a questionnaire was circulated for participants to mark and qualify what they believed were the most important competencies to support innovations in their knowledge practice (out of the ten provisional competencies proposed)[26]. The results of these questionnaires are used in chapters 6 and 7 below.

[26] See *Appendix 6*.

4.2.4 Participant observation

One of the propositions underlying this research project was that most of the competencies required to induce innovations in knowledge practice were not deliberately acquired (or mobilised) by knowledge actors in the performance of their work within boundary organisations. Either they were simply not present, or they were expressed through behaviours driven by experience, instinct, or intuition.

When possible, the empirical work would seek to observe the behaviour and the discourse of such players in concrete situations where they are called to innovate in their knowledge praxis within the sustainability science-policy interface.

While the interviews and focus-groups sought to capture primarily the *experience* and *views* of actors in relation to innovations in knowledge practice and related competencies to carry such work, participant observation therefore looked at specific *practices* and *behaviours,* particularly within the EEA.

The aim was to observe and document, events, actions, and discourses related to innovations in knowledge production. Participant observation also enabled to identify, understand, and illustrate more clearly the type of challenges, concerns, and obstacles met by individuals and the organisation as a whole, while trying to define and implement such type of innovations.

Through participant-observation it was expected as well (1) to track and record a series of *critical incidents* that help make explicit, in a reflexive manner, the perspective of the researcher; i.e., it was expected to be able to describe with higher accuracy the context in which the research takes place, the set of values, beliefs, mental models, and worldviews embedding the heuristic journey; (2) to acknowledge those critical incidents as important factors influencing, through constant reflexive loops, the choice of methodology, and approaches on the go; (3) to discern more systematically, the controversies, dilemmas, and narratives informing the work of key players in the field of knowledge for sustainability.

For the most of it, participant observation was conducted in an ad-hoc manner, embedded in the regular workflow within the EEA, very much under the action-research framework described in section 4.1 above. Only a few projects were identified from the outset as critical observation objects (see below). Instead, I, as the researcher, embedded in the 'organisational practice', would simply note – as systematically as possible – observations that could relate to the key questions broadly set out for this research project. As the research project evolved, the focus of attention was more and more guided by the particular questions raised through the empirical work and analysis of data collected through interviews and focus groups.

A set of documentary evidence was collected[27] throughout this empirical phase, containing a combination of working documents, presentations, and written discussions, as well as a systematic collection of notes into a 'research diary recording' of bilateral conversations, meetings, and other relevant critical incidents. Such battery of documentation informs part of the empirical findings expressed in chapters 5, 6, and 7, as will be detailed below.[28]

Two particular projects were selected to apply a more structured, systematic, and explicit participatory observation. These were activities taking place under the broad European Environment Academy (EEAcademy) project:

a) The EEA Winter School on "Integrated Environmental Assessments" – an EEA effort contributing to strengthening the current knowledgebase on integrated assessments, improving coherence across assessments through establishing a common, foundational understanding of key theories, concepts, and approaches. The Winter School builds on the EEA and expertise and scientific advances in the field of Integrated Environmental

[27] See *Appendix 7.*

[28] Part of this documentary evidence was used explicitly in the reporting of data in (mostly) chapters 5 and 6, often through the form of direct quotes or references. As for that, explicit consent was provided by the EEA senior management. Other parts of it were used to support interpretation of data, though not used explicitly for the sake of anonymity and confidentiality.

Assessment. It is designed to enhance critical reflection and develop key competences within a vibrant and collaborative community of practitioners.

b) The process setting-up the EEAcademy *Knowledge Innovation Lab* – based on a set of exploratory activities, the knowledge innovation lab's primary aim was to enhance knowledge innovation through experimentation, prototyping and co-generation of new ideas and practices. The lab sought to provide opportunities to critically reflect on current knowledge practices, approaches, and mental models within the EEA-Eionet context, to experiment with new avenues of enquiry, and to transform (or consolidate) existing modes of thinking and operating.

Actively participating in these activities provided – more than tangible empirical data as such – a wide range of insights that have proven extremely useful when interpreting empirical data, as exposed in the following chapters. As an illustrative example, expressed, visible discomfort from participants in a workshop with a particular question, would help indicate potential controversy around that theme – which could then be further explored through direct interaction, in interviews or in focus-groups.

4.3 Organising, making sense of, and using empirical data

During the research, data was collected and processed using a variety of artifacts and documentary evidence, for multiple purposes. This section seeks to guide the reader into how empirical data was organised, analysed and used in chapters 5, 6, and 7 of this thesis.

4.3.1 On the collection and organisation of data

Technically, all 16 interviews were manually transcribed and imported as data sources into *NVivo* (software). Those sources were then reviewed one-by-one and sorted according to an ongoing coding system. Different *nodes* (clusters) were created, including quotes, excerpts of answers or key expressions used by interviewees.

The initial set of nodes sorted inputs from interviewees by research questions (example: *understanding of new type of knowledge needed*, or *competencies required to innovate*, or *learning strategies used to develop new competencies*).

A second layer of nodes clustered data inputs into the five types of knowledge innovation needs emerging through the literature review: co-creation, transdisciplinarity, systems thinking, reflexivity, and generative action.

Finally, a different set of nodes collected inputs into emerging clusters such as 'areas of controversy', or 'organisational barriers' or even 'motivational factors'. The choice of this type of data clusters is based on the propositions explained in the first chapter of this thesis. This research was intrigued from the outset – given my work experience in the field – by a sort of perceived "inertia" that was preventing the needed acceleration inducing innovations in knowledge practice. Both from the literature reviewed, as well as from my work practice, there were significant indications that, even in cases where new types of knowledge or certain type of innovations were meaningful and welcomed in the field, for some reason they were not immediately adopted, especially not at an institutional level. Seeking patterns of thinking, practices, or controversy in these arenas sounded pertinent for addressing the initial research questions at stake.

Although not fully transcribed, focus-groups recordings were reviewed one-by-one and significant particularly relevant comments, findings, or direct participant inputs were also inserted into *NVivo*, under the already existing *nodes*.

Once again, the choice of specific inputs from focus-groups discussions, was mostly based on a subjective judgement of what could be "significant" for the research questions at stake. In turn, such subjective choice was informed by a combination of literature pointers collected to date with my own experience as an actor in the field. The focus was mostly on what could be taken as clearly recognisable pattern in the discourse of practitioner or, instead, what could be perceived as a dissonant claim, a different perspective, a hint that was not based on "business-as-usual", institutional information (which could otherwise be obtained through desk reviews).

Participatory observation gave room to a very relevant set of data collected from a variety of sources: ad-hoc conversations with colleagues at work, direct observation of work practices (in meetings or events), presentations within the EEA or in EEA-related contexts, and a series of internal documentary pieces, such as email exchanges, meeting agendas or minutes, memos and briefings, PPT presentations, etc.

This broad set of data was collected and organised on the go into two main documentary containers: (1) a diary of key events; observations and thoughts noted throughout the empirical research period, and (2) a digital folder recording all relevant pieces of evidence; organised chronological by events (see *Appendix 5*).

Quantitative data collected – such as feedback surveys from EEAcademy activities or questionnaires used in focus-groups – was used as an integral part of the qualitative analysis – not taken separately.

The data collected through this process constitutes a wide-ranging set of empirical investigations that has been done of actors working in boundary organisations. The process was a broad and open-ended investigative enquiry that allowed for cross-fertilization and further enquiring as the research developed.

At the end of this process, there was, therefore, a significant amount of empirical material to select from. What is presented in the empirical chapters of this thesis is actually a very small amount of what has been collected.

The choice of what to use and expose was not obvious from the outset. It derived from the epistemological process itself, marked out by three key guiding criteria: (1) primarily, and above all, the extent to which data would connect and contribute to respond to the key research questions, (2) at secondary level, the potential of data collected to identify areas of seeming controversy and / or pointers to further research, and finally, (3) at a lower level, specific pieces of data that could provide actionable pointers to the organisations investigated to help address some of their most pressing challenges in connection to the research questions at stake.

4.3.2 On the analysis and use of data in empirical chapters

The analysis of the data collected – for the most of it available and previously organised in *NVivo* – broadly followed the sequence of research questions, which, in turn, are addressed in the three empirical chapters below.

Recapping the five key research questions (RQ):

- RQ1: Which key innovations in knowledge practice are claimed as needed in order to respond to sustainability challenges in a context of transitions / transformation? What key characteristics shape the type of innovations required?
- RQ2: What different individual competencies are needed to induce such type of innovations in knowledge practice at the science-policy interface? How can the development of such competences be accelerated?
- RQ3: How do practitioners in the field perceive the need for and the pertinence of such type of innovations?
- RQ4: How do practitioners in the field relate to the notion of individual competence and the need for different types of competencies to induce innovations in their own knowledge practice?
- RQ5: How can professionals working in the science-policy interface most effectively learn and acquire such new set of competences, given their specific organisational / institutional contexts?

Chapters 2 and 3 of this thesis address research questions #1 and #2. That provides the basis to engage in the subsequent empirical work, at a later stage.

Chapter 5 responds to RQ3. Data was scrutinised and analysed for inputs that could contribute to address related questions such as:

- Do practitioners in boundary organisations recognise the need for such a 'new type of knowledge', as described in chapter 2 of this thesis?
- How do they make sense of it, from their own, specific, working context and experience?
- Are there examples that can illustrate, in contexts, either the *need for* or *tentative applications* of innovations in knowledge practice?
- How do they perceive their own role in it – both as individual actors, and boundary organisations as such?
- Do their views and practice of actors in the field recognise each of the five innovation needs synthesised in chapter 2?
- In the field, are there aspects of significant controversy (or consensus) surrounding the need for innovation in knowledge practice at the science-policy interface? If so, what are the interviewed actors' positions on those?

While it was initiated under a quite systematic *match-to-match* approach to data analysis, as explained above, the research process evolved in a rather *interpretivist* and *constructivist* approach, seeking to discern striking patterns or significance out of the whole.

In this account, quotes in chapter 5 are mostly selected and used to illustrate a particular finding of the empirical work, using the practitioners' own languages and/or descriptions of context. The use of direct quotes is in this regard represents a deliberate attempt to illustrate and support the argument being made, which is to a large extent also based on interpretation and judgement.

Chapter 6 addresses RQ4. It presents findings from data that could help understand *how practitioners in boundary organisations engage in the discussion about individual competence* and, in particular, a different type of competencies required to induce innovations in their own knowledge practice.

As explained in chapter 3 above, in preparation for this, the research identified a selected list of competencies, curated with the intention to highlight dimensions of knowledge, skills, and attitudes that were deemed critical to innovative knowledge practice, beyond mainstreamed sets of existing competencies.

Combining the literature reviewed and the experience of the researcher in this domain, the selected list focused on those competencies that addressed what individuals would need to be doing differently in order to generate innovations in knowledge practice, in relation to co-creation, transdisciplinarity, systems thinking, reflexivity, and generative action loops in knowledge practices.

The empirical artifacts – mostly interview questions and observation pointers – were then devised to explore such differentiating qualities and to what extent they would be significant in the practice domain of experts in field, in view of enhancing further innovations in knowledge practice.

The empirical work then followed a systematic review of the data, seeking to find inputs from practitioners that could help address RQ4, interpret and qualify each of the individual competencies suggested in chapter 3 above. In doing so, the research was particularly attentive to data inputs that could help address related questions such as:

- How are data inputs perceived in context?
- How suited do they seem from the perspective of practitioners?
- Are there examples that can illustrate the value and use of such competencies?
- In their practice, are there behaviours that demonstrate the application of such competencies – or the lack thereof?
- What challenges do practitioners feel when trying to mobilise such competencies?

The empirical analysis then focused on a different sub-set of data collected. This additional research piece was triggered by the practitioners' views that there was a lack of organisational references or frameworks to help them further engage in discussing about needed competences to enhance innovation in knowledge practice. The research, therefore, analysed the data already collected through the empirical work, to explore how – if at all – boundary organisations were framing required competencies to support this type of innovations, and whether that was suitable for the type of needs expressed by practitioners. If that was the case, was there documentary evidence of it?

The three sections in chapter 6 correspond almost directly to the analysis of empirical data for each of the three domains of focus referred above. It then concludes with some of the key insights and interpretations from the empirical work, linking them all together in addressing the overall question of how actors in boundary organisations are engaging in the discussion on individual competencies required to enhance innovations in knowledge practice.

Chapter 7 addresses RQ5. It uses a slightly different approach in terms of data analysis – and respective exploration of findings – than the previous ones. It takes a more inductive approach, seeking to find within the available data, contributions to address the broad question of how organisations in the sustainability science-policy interface envisage the development of competencies to enhance innovations in knowledge practice.

The initial analysis of data in this regard indicated a lack of good practices and examples that could illustrate possible learning strategies to help develop the type of competencies at stake. The research therefore looked into identified learning programmes (and subjacent organisations) – collected through the empirical work – pointing to existing organisational practices, curricula, or experiences in that regard.

The criteria subjacent to the identification and analysis of such learning programmes was relatively straight forward: the research was looking for tangible, existing proposals, pedagogical approaches, methodological principles, and used learning tools that were devised to address the development of the type competencies described above. The summary of these findings was subsequently systematised in an operative table for further analysis.

The result of that analysis was then combined with data collected through interviews, focus-groups, and observed practice. When navigating through the practitioners' inputs, it was empirically viable to organise those findings in a way they could help understand what – from the perspectives and experiences of practitioners in this field – would constitute effective learning approaches to help develop the type of competencies at stake.

5. PRACTITIONERS' VIEWS ON REQUIRED INNOVATIONS IN KNOWLEDGE PRACTICE

This thesis has looked at the broad frameworks and propositions for innovations in knowledge practice at the sustainability science-policy interface. Combining the literature reviewed and the immersed analysis and experience of the researcher in these working domains over the years, chapter 2 above proposes a synthesis of the five key needs – as claimed by both academic research and institutional reports alike – in shaping innovations in knowledge practice within so-called 'boundary organisations'. These broadly refer to:

1. the need for **co-created** knowledge, involving a wider and diverse set of actors across sectors, roles, and geographies;
2. the need for a stronger inter and (especially) **transdisciplinary** approach, beyond discipline-based processes, integrating different types of knowledge(s);
3. the need for enhanced **systems thinking**, stressing the role of *thinking differently* and *holistically* when dealing with complex adaptive systems;
4. the need for extended **reflexivity,** questioning our own mental models, assumptions and biases, looking for deeper levels of (self) consciousness;
5. the need for a **generative** type of usable knowledge – capable of generating continuous action loops, focused on possible responses and solutions for rather complex, systemic problems.

As detailed in Chapter 4, this empirical research has engaged through various forms with actors, practitioners inside these organisations, so they could share on their own views *of* and approaches *to* these five knowledge practice innovation needs as described above. In essence, this work addresses research question #3 on *how do practitioners in the field perceive the need for and the pertinence of such type of innovations*?

In this chapter, the thesis will use the data out of such empirical work to help interpret, in context, the needs towards a new type of knowledge in the sustainability science-policy interface.

In doing so, it will address related questions such as: *How do these actors conceive of these innovations in knowledge* practice*? How do they make sense of such claims in the literature and specialised reports? How do they relate to them in their specific roles within boundary organisations? How do they apply such approaches in practice? What obstacles and opportunities to they encounter?*

In brief this chapter offers a perspective of how these claims in knowledge innovation are perceived from the inside of such organisations. It will also touch upon the perceptions of boundary organisations' capability to implement such innovations, as perceived from the perspective of their own experts / staff.

The nature of the topics and questions at stake – notions of co-creation, transdisciplinarity, reflexivity, etc. – make so that perspectives on these issues may sound themselves "confusing". As initial chapters of this thesis anticipate – and will be later confirmed through the empirical findings – these are to a great extent unchartered conceptual territories for many of the actors in the field. While the essence of the challenges at stake may resonate in practitioners' specific working contexts, they are not necessarily coherently articulated in logical frameworks or institutional collective perspectives.

The sections below seek to maintain a fair account of such sense of "messiness" as it emanates from empirical data as such. This said, throughout the chapter, this thesis will also offer some pointers to help make sense and interpret practitioners' views, based on the frameworks provided by the literature reviewed and, reflexively, by the professional experience of the researcher himself.

5.1 The need to change how knowledge is generated in the sustainability science-policy interface – a contested assumption?

The empirical research demonstrates that practitioners in the field do acknowledge the need for a new type of knowledge in the sustainability science-policy arena. In no moment of the empirical research – be it through interviews, focus-groups or discussions within participatory observation

– was this proposition ever contested as such. There was, however, ambiguity regarding *what* new type of knowledge is needed, the corresponding required innovations in *knowledge practice* and the institutional implications related to such a claim.

Analysis of all data collected reveals that not only do experts in 'boundary organisations' recognise the need for a new type of knowledge, they also do it with a certain sort of concern; they wonder what that means exactly, how to bring it about and whether it applies to all and everything they do. As the data collected is explored, more signals come to the surface that the practice in the field appears yet tentative. Straight forward answers are rarely encountered and more often than not practitioners' perspectives come in the form of questions, doubts or hesitations. In interviews, for example, they often lead to a variety of dispersed thoughts, topics and areas of work, rather than suggesting an already matured analysis of the questions.

The following excerpts from EEA experts are a good illustration of such type of feedback:

> "…we really have to consider what is the alternative to the way we do it [produce knowledge]... what is the aim... it helps if we'd have an idea of what we'd rather have instead... understanding what it takes to instil commitment and buy-in, what is the knowledge that you lack. (I.13)"

> "Currently, in the field of transitions, we are aligning with the EU policy frameworks (circular economy, etc...). We do lack reflexivity on those though. We have to make our knowledge of use to policy makers and relevant to policy frameworks; but relevance doesn't mean blind alignment. (…) … we need to create this knowledge that will maybe challenge some of the assumptions that are underlying the policy frameworks. (…) We don't have currently the appropriate knowledge to make these policy frameworks work." (I.05)

> "We have a lot of difficulties going from the conceptual thinking to the practice. We are very good at developing concepts, but not so good in applying them. It takes a lot of time to understand how does that concept fits into our reality. For example, when we talk about the concept of planetary boundaries." (I.14)

> "... and then there is the experimentation part... which we in [my organisation] are not allowed to... I cannot say that aloud, but it is not a practice, it is not desired... it is also difficult as it requires resources and is difficult to discern whether we have the right competencies for it." (I.15)

Although not organised as such, the inputs above (used as examples of the thinking of experts based on their own *praxis)*, refer to the need for transformations of knowledge practice in what *co-creation* and *reflexivity* and *generative practices* are concerned. This said, the observation is that, in their own reality, perspectives don't come across organised is such categories.

In other words, in line with the literature reviewed, experts in the field are indeed concerned that the way knowledge is currently produced: (1) does not integrate a sufficiently wide variety of stakeholders which are critical to apprehend the complex reality and specific contexts such knowledge is meant to respond to; (2) the perspectives, conditions, assumptions and political motivations under which knowledge is produced are not sufficiently made explicit, in a reflexive way; (3) does not allow room to tentative methodological experiments in knowledge production, leaving no room for innovation, and therefore little room for significant transformation in the way such knowledge is generated.

Experts also clearly manifest that not all challenges faced in environmental policy are systemic and complex in nature. Therefore, such a new type of knowledge might not be necessary for all fronts in which knowledge-for-policy is required. The following excerpts of interviews with European Commission officials are a good illustration of such thinking:

> "A new type of knowledge... it's a very normative statement. (…) Even if you know about that need, we don't really know what that new type of knowledge is about." (I.08)

> "Since it is not known, it is difficult to characterise. You hit an important point: we shouldn't throw out what we know, that is important knowledge. I do think that whatever new knowledge is generated, needs to comply also with some of the scientific principles which we have been using so far." (I.08)

> "It's not surprising that people would not disagree with the need for this type of knowledge. The question is whether they would like this type of knowledge to be dominant. I - myself - would want more of this type of knowledge, but I'm not sure to what extent I'd like it to be predominant. The disagreement would be to what extent..." (I.09)

These excerpts above suggest that, from the perspective of some actors in boundary organisations, the call for a "new type of knowledge" in the sustainability science-policy interface shouldn't be generalized as a cross-cutting need. It raises words of caution in what the extent of usage and relevance of such a "new type of knowledge" actually is. In a way, these inputs sound a credible proxy to voices in the field that seek to emphasize the value of the type of knowledge produced to date, and how that is actually today still informing extremely critical environmental policy.

Broadly put, some voices in 'boundary organisations' manifest that while the need for a new type of knowledge is unequivocally manifested, it can't be generated at the cost of existing knowledge bases, knowledge flows and knowledge production practices. On the contrary, it needs to be complementary to it.

These views are actually in line with inputs collected through the empirical research that point to existent resistances towards innovations in knowledge practice. These will also be exposed in the sections below.

5.2 From a new type of knowledge to innovations in knowledge practice

Data collected within sustainability boundary organisations also strongly exposes practitioners' concerns to point not as much to *what* type of knowledge is needed, as it does to *how* such knowledge is to be differently crafted at the science-policy-society interface. The discussion at the focus-group in the Netherlands was particularly emphatic in this point, which led to a re-analysis of the data to cross-check the argument with other data sources.

The perspective vastly shared was that, if the intention is to generate a new type of knowledge, replicating the same "modus operandi" to produce such knowledge will not do; a different type of knowledge requires a different type of knowledge practice, necessarily; adopting the same *praxis* as so far will only lead to the same type of outcomes. The question should thus be, according to experts in the field: *what needs to fundamentally change in the process of* *knowledge creation, transfer and use, so that a new type of knowledge can be generated in the science-policy interface*?

This striking insight out of the empirical work led the data analysis to focus not only on the practitioners' perspectives on the claimed knowledge *outputs* but rather on needed *innovations* in knowledge practice within the science-policy interface.

In this regard, an important empirical observation is that *actors in the field do – indeed – claim a role in "knowledge production" within the science-policy interface*. This is a confirmation of previous indications through the literature reviewed that 'boundary organisations' see themselves (and are perceived by key knowledge players in the sustainability policy arena) as instrumental actors in crafting knowledge for policy. Not just that, as actors in the field perceive 'boundary organisations' as critical to induce the required innovations in knowledge practice at the science-policy interface.

From the perspective of practitioners, knowledge produced for the sake of policy governance is not – and should not be – exclusive to academic, scientific institutions. On the contrary, it is precisely the particular positioning of 'boundary organisations' at the interface between science and policy that seems to add critical value to the type of knowledge produced for policy. "It's a contribution to that knowledge about the state of some elements of nature, that at a certain point in time we have valued and given a highlight." (I.01)

While this nuanced distinction could be academically contested, the practice reality of knowledge brokers working in the 'boundary organisations' is rather straightforward through affirmations like "we produce knowledge, not science", or more clearly: "… we are not a scientist organisation; we are not communicating science; we are communicating knowledge to policy makers. We have interpretations that influence part of the validation process." (I.14)

The following excerpt illustrates in further detail, from the perspective of experts in the field, how their role as knowledge brokers is perceived within the science-policy interface:

> "[in my role as] an environmental analyst, I would pick some data or gather data and build some analysis to it, either by myself or with partners. That would allow to identify certain patterns, certain trends and deduce some knowledge, some understanding, some meaning out of it. Which then would be shared with wider experts and within the teams I've been in, but also very much based on findings from science (a lot of literature review). Then I would usually put that knowledge into reports. That's been a lot of reporting writing or tools that would allow writing reports, like indicators and data sets. I've always been operating in the science-policy interface. More from the science world first and then from the policy world – so the perspective has been changing a bit, but always within this interface." (I.02)

Experts in this science-policy interface, not only perceive a value-add in the knowledge they create, as they embrace it and engage in such a work in a rather affectionate way: "… what I like about it is that it touches all of different layers... transformations... it looks at the practice of researchers, but also practitioners and policy-makers..." (I.12)

A new question thus emerging from this research is whether actors in the boundary organisations create a specific sort of relationship with the knowledge they produce – which would have implications in their capacity to keep equidistance from various sources of knowledge.

In this line, experts in boundary organisations generally value the knowledge work they do in opposition to "just" science. "(...) in my experience, what we often get from academia is intellectually interesting, but extremely difficult to hit clearly the point to say, 'ok this is how I can make a difference'". (I.08)

Such perspective, while empowering from the perception of experts' capacity to generate "relevant" knowledge, runs into a risk acknowledged within organisations researched – that of antagonising both actors within scientific and political milieus alike. The risk is to stereotype functions rather than seek complementarities ("… it is very hard to get this type of knowledge from researchers because they get their merits not from this type of things; they get their merits, their recognition, from traditional publishing articles in journals, not from working in groups..." (I.16)). When the need or opportunity comes to enhance co-creation, stereotypes or prejudices at play will not help (as will be seen later in this chapter).

From the other perspective, an example of a workshop organised by the EEA Scientific Committee brought to evidence how institutional attempts to induce innovation in knowledge practice (in this case, seeking to reinforce open knowledge systems in a context of sustainability transitions) generated quite strong controversy from within academic experts and scientists. The approaches used by institutional stakeholders being "politically loaded" or "strongly biased", "not transparent" in their ultimate purposes. (C16)

In a similar line, as seen by the experts themselves, the value attributed to knowledge produced in 'boundary organisations' is often related to its capacity to be highly contextual in nature. This comes often, once again, in contrast with the perception of knowledge produced with academic, scientific institutions. To some of the actors engaged in this empirical work, the perception was clearly that in what knowledge produced in boundary organisations is concerned, "the context becomes much more important that it has been, say, in a more traditional laboratory type of experiment where one creates an artificial setting." (I.09) Their perception of role and responsibility generating a type of knowledge for policy that is highly context-dependent triggers epistemological reflections such as: "…It's more about understanding us as humans: who are we and how do we face, how do we understand this knowledge and how do we act when we get this information, in what kind of context are we when we think about this and trying to make decisions out of it. (I.02)

This perspective has been strongly explored through work done by 'boundary organisations' into so-called *integrated environmental assessments (IEA).* This work is done at both European and National level and IEA reports often crystalize the state-of-art in what knowledge for policy is concerned.

Given the central role of the EEA knowledge practice in this research, it appeared relevant to dig into the EEA's approach to the thinking and work on *Integrated Environmental Assessments (IEA)*. It was found that a particular definition of *Integrated Environmental Assessments* often used recurrently in workshops and seminars on the topic, has been shaping much of the thinking of experts in this regard. In a nutshell, it compares the type of *assessments* produced within boundary organisations and *scientific reviews* or *research* projects. It says:

> "An assessment is the entire analytical process for undertaking a critical objective evaluation and analysis of data and information designed to meet user needs and support decision-making. It applies the judgement of experts to existing knowledge to provide scientifically credible answers to policy relevant questions, quantifying where possible the level of confidence. […] An assessment is not a research project, review paper, or advocacy piece."

This piece of text is often followed in presentations by a table synthesising the key differences between such an assessment and, for example, a scientific review exercise:

Table 5 – Scientific Reviews vs Assessments

	SCIENTIFIC REVIEW	**ASSESSMENT**
AUDIENCES	Scientists / Experts	Decision-makers
DONE BY	One or few	Large and varied group
TOPIC	Simple and narrow	Broad and complex
IDENTIFIES GAPS IN	Research	Policy
UNCERTAINTY	Not required	Essential
JUDGEMENT	Hidden	Required, explicit
COVERAGE	Exhaustive	Sufficient
SYNTHESIS	Not required	Essential

(Source: David Stanners presentation Winter School on IEA)

This distinction between an "assessment" – as a good proxy of knowledge-for-policy generated within 'boundary organisations' – and a "scientific review", while perhaps simplistic in this table, represents to a large extent the understanding of actors in the field regarding the type of knowledge created at the science policy interface, and its intrinsic value when compared to academic research.

Data collected is not clear-cut in this proposition, but it does indicate that practitioners in the field can only conceive required innovations in knowledge practice to be effective, if managed through 'boundary organisations'' knowledge practice field; implicitly implicating academic and scientific institutions alone will not be able to succeed, given their specific characteristics, purposes and knowledge instruments at stake.

Examples as the above on the *EEA Integrated Environmental Assessments* – alike other integrated environmental assessments produced at national level – are generally perceived by practitioners as an improved piece of knowledge-for-policy as compared to knowledge emanated directly from academic institutions. As explained above, the intentionality (for policy), the production context (boundary organisations), the interdisciplinary approach (combined work of experts by workstreams, not in direct connection with disciplinary arenas) and the apparent room for co-creation, reflexivity and interpretation, make such type of assessments often being taken as the-single-good-response to the needs for a new type of knowledge.

While it may be questionable whether that is the institutional positioning of entities like the European Commission, the European Environment Agency or National Environmental Agencies, this thesis will demonstrate through its empirical work that experts in the field, practitioners within 'boundary organisations', do have a different opinion. As they acknowledge the importance of the work they do and the value added in comparison with academic knowledge, they are also very much aware that is not sufficient.

From their perspectives, the type of innovations in knowledge practice at stake are needed precisely within the remit of their work and in connection with, for example, the crafting of integrated environmental assessments.

With this in mind, in the following sections we will look more closely into how experts in the sustainability science-policy interface make sense of and interpret each of the required innovations in knowledge practice described in chapter 2 above.

5.3 Perspectives of practitioners in boundary organisations on needed innovations in knowledge practice

Through the empirical research, focus-groups and experts interviewed were presented the five key needs behind the claimed innovations in knowledge practice, as exposed in chapter 2 of this thesis. Their views and interpretations were complemented with direct observations in their field of operation. The following sections give an account of the key findings, item by item.

Co-creation

Co-creation is by far the feature informing innovations in knowledge practice most mentioned in the field. It appears in many different contexts and under a wide variety of meanings, being very often perceived by experts as being "exhausted" and "abused" as a concept.

The terms *co-creation*, *co-design* and *co-production* are often used interchangeably to represent a similar idea. In most of the practices observed the term is actually used without necessarily a thorough understanding of the concept. When questioned about the difference between, for example, *co-creation* and *consultation* processes, experts are often uncapable to produce an immediate response and at times find themselves struggling to discern the difference.

In other words, co-creation is popularly used in the field to generically refer to processes through which different actors are involved in shaping a final knowledge outcome. The level of engagement, commitment, contribution and ownership are not considered in first instance though.

Such an ambiguity appears to lead to observed organisational or institutional crossroads. As an example – very present in discourses – leadership in researched organisations would publicly commit to more "co-created knowledge" with seemingly no awareness that such 'co-creation' will require commonly owned outcomes by all stakeholders involved – which is, in turn, incompatible with the necessary independency and equidistance such organisations are meant to represent.

Another example, leaders in observed organisations would claim for more co-created processes, within wider stakeholder spectrums, with no questioning on whether the organisation has – or should have – established relationships with such stakeholder groups – without which co-creation is simply impossible.

In collaboration with its Scientific Committee and the European Commission Research Unit (RTD), the EEA organised a workshop on "Knowledge for a sustainable XXIst Century", in the frame of the process towards the SOER2020. The workshop brought together a mixed group of scientists, civil servants and experts within the science-policy arena. In a session on "how should knowledge be developed and used in the science-policy interface", the following questions were raised:

- Which (institutional) **barriers** / **boundaries** need to be broken down in order to allow wider co-creation within a given knowledge arena?
- Do we have standing **relationships** with the different **stakeholders** that need to be involved? How do we strengthen those?
- What can help **co-owning** the **outcomes** of knowledge generation? Is it possible at all? What would that mean in reality?
- What **open** knowledge systems need to be used / created to facilitate co-creation?

The answers to these questions – discussed in smaller groups – were not straight forward. In most cases, participants indicated how difficult it was to address them in the institutional context they were operating, and how much more they needed to be explored.

This said, through interviews and focus-groups, it was undoubtedly visible the expressed need for enhanced co-creation. The understanding of co-creation in the field researched comes associated with as different notions as the ones of, for example: *partnerships*, *citizens science*, *working together*, *participation*, *common mind maps*, *iterative processes*, *shared knowledge* or *stakeholder engagement*.

The following excerpts give a good account of such different type of approaches to the notion of co-creation. They also blend in a critical awareness on how difficult co-creation is – or can be – in the organisational context these expert's work. Both accounts derive from experts working at the very core of producing environmental assessments and report, right at the interface between science and policy.

> "Co-created knowledge: I definitely see it as an important component. For example, vis-a-vis our key stakeholders... if we'd done it alone we wouldn't know about changing priorities and needs. The importance of getting the end-user perspective into the knowledge generation. You'd then be much more aware of the sensitivities, but also about where the key things to focus on." (I.14)

> "…you spoke of co-creation and immediately I had the image of citizens science. (…) if you have some of the non-experts involved in the collection of (even if it is of scientific) data, I think it changes a lot the perspective of both the scientists and the people, because there is some kind of ownership and people understand: "oh... that's what they're talking about...". So that's what... this co-creation triggers in me..." (I.01)

These inputs underline two important issues raised at various stages through the empirical work: (1) the need to integrate knowledge from "non-experts" and the extent to what that is possible in such institutional contexts; (2) the sense of ownership generated through co-creation processes.

To the first one, what almost all experts in the field emphasise is the need to engage in knowledge creation processes actors – such as farmers or car manufacturers, to give an example – that are normally positioned outside the scope of commonly taken stakeholders. The *usual* stakeholders mentioned by practitioners are normally those directly engaged in policy-making dynamics (institutional or governments representatives, for example) or the so-called *specialists, technical experts or scientific advisors*.

This last group of people often function as proxies to the *other* stakeholders – those that are not directly involved in consultation processes. The following excerpt, coming from a former "country representative" in developing European integrated environmental assessments, speaks to this exactly:

> “As we see it now, we co-create with people with more or less the same background as us. People that work for environmental agencies in the countries, ministries, specialists in environmental topics - be it large topics or small topics. We are not going to practitioners’ groups with certain interest, like farmers, car manufacturers. Maybe we will end up there, but that will be through the Eionet system, through specialists. That’s the idea. While co-creation, as it is described here, includes also (…) participation. Through participation you involve stakeholders earlier in the process to understand what their view means to problems and solutions are to certain problems. What I will probably be doing is more focus on going and reach out to experts, and not necessarily to other stakeholders in the policies.” (I.03)

Adding to these challenges, comes the realisation that, to a large extent, such boundary organisations – let alone policy or scientific institutions – appear to lack established relationships with wider groups of stakeholders. The following account is provided by an expert at national level:

> “The interesting thing now, for example, is that we are looking for other partner / stakeholders, but we don’t have relationships with them. (...) It’s about finding new routes for us to find out and establish new positions in new settings; and I think that’s the way we have to break with the institutional setting that we are stuck into.” (I.10)

This perception of “being conditioned” by a limiting institutional system was overly present throughout all of the empirical work. To a large extent, experts in the field manifested how the institutional setting they operated within (or close to) prevented them to develop the processes and the relationship to induce wider and deeper knowledge co-creation dynamics. Two other examples are exposed below:

> “What I witness is the interaction with [our partners] to whom we communicate this will to co-create; we generate expectations, but then we don’t have answers for their questions and also not the right conditions to have this process work. So what I witness is declarations of interest (we are well oriented) but then, when we realise what it implies, there is a reaction to come back to what we are comfortable in doing, which is in fact not co-creation. We want to go there, but we don’t know how.” (I.05)

> “Now... sometimes there is an intention - for example for co-created knowledge - but to get there is not

> that easy because of organisational boundaries, rules in place,... Even shifting those boundaries would probably just create new boundaries... it's simply a realisation... co-created knowledge requires a very conscious effort to break down those boundaries." (I.08)

The second input above comes from an official at the European Commission. Triangulated with other inputs, the concern raised is strongly related to the sense of *ownership* associated with the notion of co-creation. Much of the inputs collected from actors in the field emphasize how central the sense of ownership is to co-creation:

> "This is also what me and [colleague at the EEA] tried to do. We had an idea of what the objective and the direction was, more or less. But we didn't... we put in the building blocks, but it is just the starting point of a conversation. What we want is to tap into the brains of the experts, to their knowledge and to their experience, and their networks, etc. Just start to shape the structure of the report in a way that is meaningful to all of us given our different experiences. So it is not just (…) kind of consultancy work. It is supposed to be a partnership where your brains are coming together. […] Well... basically to reach a common way forward. A common... I don't know if consensus... but at least like commonly agreed... "ok, let's try this, this seems reasonable..." or... "no no, we cannot go that way because...". (I.02)

> "well... engaging with stakeholders or members of the network, meaning: gathering together, running workshops, expressing opinions, trying to build a collective shared vision on how things work in reality; a sort of a common mind map. That's the way I see it. Co-creation to me is a sort of iterative process which in the end leads to a sort of common mind map: we understand, we agree that there are these connections and linkages and we share the definitions and the anthology of what we describe. So, it is fundamental in that sense." (I.04)

> "An example... [stakeholder] has required working with member states, universities, NGOs and business manufacturers, retailers, media, citizens... so... that is the co-creation because we all work together on this common kind of systemic goal... and it's really across disciplines... sometimes there has been areas where everyone is working on their own areas, but then we need solutions for which you need to get in between them, you need to be willing to step outside your comfort zone, and start building something in between." (I.13)

Once again, the expression of how co-creation is understood by practitioners, clashes with the realisation of institutional conditioning factors that raise concerns about how co-created such type of knowledge can actually be:

> "I don't think we generate new knowledge as such... we simply identify the issues across that were important... (...) I don't think we engage in really co-creation... (...) [on the ownership aspect] ..." (I.14)

> "I think it's like a continuous line between consultation and co-creation. Co-creation is more like by involving you de-facto change the direction of the project... in the first example though, we don't do much of co-creation... it's maybe more like consultation... or stakeholder engagement towards policy uptake..." (I.14)

> "… the type of interactions was basically a workshop presenting the EEA work on global mega trends and trying to scope what these trends could bring about in the country. With some of them was possible to engage more and more practical, challenging and questioning some of the assumptions behind the global mega trends; for others it was more trying to extract, trying to force their thinking in the paradigm designed by this process. In that sense I'm not so sure this is about co-creation. It really depends on the audience you have..." (I.04)

These inputs from actors in the field reinforced the relevance of exploring in greater depth the limitations imposed by the institutional frameworks experts operate within.

Transdisciplinarity

Transdisciplinarity is not a term used as frequently in observed organisations as is, for example, co-creation. The term 'inter-disciplinarity' is far predominant. It was not clear during the empirical work whether the terms were used interchangeably or whether the actors truly meant to refer to the different terms distinctly – in most cases pointing to interdisciplinarity as such. For example:

> "(...) can I talk about transdisciplinarity? It requires openness, willingness to leave your comfort zone and be able to listen to others in different disciplinary languages." (I.16)

During the empirical work, transdisciplinarity was often suggested to name the type of dynamics being described by experts in the field, rather than used by the experts themselves as a deliberate concept. The following excerpts are a good illustration of that:

> “I had a chance to meet and work with people we called them "naturalists". They were not really experts on anything, they knew a lot about nature and the species. […] So there was a kind of a cultural dimension that was incorporated in the knowledge of nature and natural sciences.” (I.01)

> “… sometimes there has been cases where everyone is working on their own areas, but then we need solutions for which you need to get in between them.” (I.13)

It is a possible interpretation in this research that, by mentioning “not really experts” or “a cultural dimension” into knowledge of nature, or looking for “solutions in-between”, interviewees are describing transdisciplinary dynamics. However, the term as such is not used upfront.

In whatever the case, the perception was that, even when the term was used, the understanding of transdisciplinarity was probably not fully acquired. Just as in the case of co-creation, the term was sometimes used by organisational leaders in ways that raised doubts on whether there was a clear understanding of the intrinsic meaning of it and the implications for knowledge produced within the institutional context at stake.

In the workshop previously mentioned, bringing together institutional leaders and experts alongside with scientific advisors, the following questions surrounding the notion of transdisciplinary were raised by the researcher of this thesis (though in a different role, as coordinator of the EEAcademy):

- Are we willing to **accept** relevant knowledge coming from non-scientific sources?
- How do we resolve the tension between **transdisciplinary** knowledge and the need for **legitimacy** and **credibility** of knowledge coming from your institutions?

- What can help address inter-disciplinary **divides** and promote greater transdisciplinarity within specific areas of knowledge practice? How would that translate concretely in organisation workflows and management processes?

Confronted with these questions, institutional leaders and experts alike, would in most cases have no straightforward responses to them – and in many cases would seem to be reflecting on those for the first time. Such a finding reinforces the perception above that while the term "transdisciplinarity" is increasingly used in the field, there is actually little understanding of what it actually means from a knowledge practice approach; of what needs to actually change in order to generate more transdisciplinary knowledge.

In other cases, experts demonstrate to understand the concept and actually use it to describe the need for different approaches to knowledge practice in the sustainability science-policy interface. Through their own words, they depict many of the pointers in the notion of transdisciplinarity as described in chapter 2 of this thesis. As examples:

> "That was my experience (…) at a conference, where we had different arenas of scientific knowledge, from different disciplines really... understanding this was a novel field coming up... that it was transdisciplinary by nature and that they really wanted to make sure it was not highjacked, boxed into something else and then you'd lose this space of no-boundaries basically (the in-between is a no-boundary)." (I.02)

> "Transdisciplinarity relates to different perspectives... they shine light on different parts of the problem... the challenge is to get the academics to disconnect from the arguments, and leave aside their academic animosities..." (I.06)

> "Transdisciplinary will only increase. [in this conversation] we have been mostly focused on the human dimension of it. What might be missing there is the effect that new technology (algorithms for example) will play in transdisciplinarity." (I.08)

> "… in my reading of transdisciplinary... it's exactly what we do [in my organisation]… we talk about transdisciplinary as involving different actors beyond science..." (I.12)

The understanding of the concept comes hand-in-hand with the awareness of how difficult it is to implement it within the institutional contexts these actors are operating. What has recurrently emerged was not only the sense of “animosities” between disciplinary territories or the reluctance to accept as valid knowledge that from outside scientific domains (as seen in excerpts above); it was also the recognition that knowledge production in this field has largely focused on intense specialisation – that seen as detrimental to enhance transdisciplinarity: “I think the level of specialisation has made even more difficult to have this transdisciplinarity.” (I.01)

As explained in chapter 2, the notion of transdisciplinarity often appears coupled with that of co-creation. The findings out of the empirical work do confirm that. In most cases it appears to be difficult for the actors in play to disentangle those two terms when thinking of their own practice application.

While expectable, from an operative perspective some actors recognise it would be important to distinguish these two knowledge innovation features, as they point to different organisational capabilities and individual competencies.

Systems Thinking

As explored in the earlier chapters of this thesis, inducing systemic approaches into knowledge practice is not the same as understanding or knowing about systems. This said, while the use of the term “systems thinking” is abundant in boundary organisations researched, empirical data evidenced confusion between those two notions through practitioners’ discourses. The following excerpts are representative of a much wider sample collected at various stages of the research:

> “… (…) *systemic knowledge* is more how you describe the system that we study as an environmental agency. (…) [co-creation, transdisciplinarity and reflexivity] are more or less about the process; *systemics* is about content.” (I.03)

> “I think you have to have the knowledge of the different systems so you can connect them. If I don’t know the other system, its existence, how can I connect to it? (I.11)

> “These problems that have a large scale, a long-time horizon and relate to many different parts of a system,

> with several levels of impact, with multiple inter-linkages in the systems, not linear, many interdependencies; it is hard to visualise them...” (I.16)

> “Resource Nexus, global mega-trends, understanding properties of social ecological systems, translate into something that is meaningful for policies and compelling in terms of trade-offs and synergies. “(I.04)

The excerpts above expose how, for many actors in the field, the reference to “systemic approaches” used in relation to knowledge practice is actually understood as a better understanding of systems – not necessarily a systemic approach to knowledge practice. In their perspective, a better understanding of systems doesn’t necessarily require a different way of thinking – as per the notion of systems thinking.

Another example comes out of an EEA meeting aimed at setting-up a Community of Practice on “Systems Thinking”. While the initiative in itself suggests an explicit interest and perceived value in this arena, the notion of “systems” was in that meeting defined in very broad terms, encompassing all sort of perspectives (from ecosystems, to IT and networking). As an outcome of the meeting, the following was indicated in the minutes as part of the expected community methodological development: *“How do we do systems assessment and deal with complexity? What tools can we use?”* (C9) The idea transmitted is that of *doing* systems’ assessments rather than applying systems thinking to assessments work.

The idea that a systemic approach to knowledge practice requires a (somehow radically) different mindset, behaviour, set of values and motivations embedded in the practice of knowledge creation, transfer and use – this was expressed by a small minority of practitioners encountered through this research.

Adding to the above, often practitioners were found to be talking about two very distinct things while assuming they were talking about one and only approach to knowledge. In some cases, the term ‘systemic’ was also found to be confused with the term ‘systematic’:

> “In what the *systemic* is concerned... this is interesting... for me, systemic comes as part of the prioritisation of work... I am very organised...” (I.11)

In the workshop[29] on "Systems Thinking and Assessments", organised at the EEA for experts working on integrated environmental assessments, Martin Reynolds dedicated a good amount of time working on such distinctions between *understanding systems*, *systems thinking* and *systematic approaches*. Out of that workshop, the analysis of the feedback / evaluation forms brought to the surface that participants generally found it "confusing".

Similar feedback had already been received out of a one-day workshop with Stephen Busby on "Systems Thinking and Complexity". This workshop, organised for a wider and more heterogeneous groups of participants within the EEA, intended to look more deeply into the idea of mobilizing systemic perspectives into knowledge generation practices – not just systems *thinking*, but all the way up to systems *being*. Both the ideas exposed and the methods used were generally perceived as inadequate to the specific working context of the participants. Some referred to it as an interesting exploration on a personal journey – but not in relation to work. (C7)

As discerned through this research process, the ambiguity in the meaning and use of the term "systemic" is possibly very much instilled by the current narrative present in the sustainability governance arena. Reports and discourses point to *transitions of systems of production and consumption*, to *greater understanding of systems dynamics* and *systemic risks*, to *shifts from sectorial approaches to systems' governance*. All this induces in practitioners a perception of systemic approaches to knowledge practice as *simply* a better understanding of systems.

There are other cases though where experts demonstrate to – intuitively, in their own perspective – grasp the need for more systemic approaches, if not a good understanding of the concept of systems thinking as such. The following excerpts from two EEA technical experts illustrate such perception:

> "The system in itself is very much scale dependent – it depends on which lenses are you looking from. And

[29] Workshop organized at the EEA as a follow-up of the Winter School on "Integrated Environmental Assessments"

there are things that clearly you can do at one scale but cannot do at another scale. Nature conservation things are a very good example of that. Normally you have very big successes on local scale (…) but that's not the major driving force that is causing the loss of biodiversity on a global scale. The problems are of another dimension." (I.01)

"I think it is really about this being able to navigate... is not just having this wider perspective, we still need to find ways to really map and understand how individual and local actions do have a systemic impact and the other way around, right? I think that's also an emerging field. For sure we need tools to be able to connect those different levels of systems, otherwise people will get lost. (I.02)

The excerpts above, while apparently referring to the usual "understanding of systems" approach, actually point to the individual, to the knowledge broker as such: "it depends on which lenses you are looking from" or "we need tools to be able to connect those different levels of systems". There is a sense of the role of the expert in trying to think systemically.

As for these particular actors – those more closely related to the theoretical approach to systems thinking – the struggle seems to be not as much in the understanding of it, but rather on its application in their specific working context.

At the EEA, in a meeting with three key experts deeply engaged in the drafting of the SOER2020, some aspects were highlighted as needed in order to better implement system thinking in such a process: (1) the need to know more about system dynamics and governance implications to policy, (2) the need to be better capable to map systems' dynamics, synthesise findings, communicate them in an understandable way (make them not alien to others) and visualise concepts and approaches used, (3) the need to be more "indifferent" to the extent of achievement, understanding, to whatever the outcome is, to be more "superficial" in a way, less concerned with analytical robustness, but also more structured in approaching different types of questions and perspectives. (C10)

Overall, what was shared by these three experts – and many others – during this empirical enquiry, was their concern on "how far can we really engage into this type of knowledge". The understanding of what it takes to apply systems thinking in environmental assessment work, is often accompanied with a sense of scepticism on its actual feasibility under their current working context. As with previous items in this chapter, this will be further explored in chapter 7 below.

Reflexivity

For the sake of this research, the notion of 'reflexivity' was synthesised in chapter 2 in relation to *knowledge being generated through constant reflexive learning loops, through which values, beliefs, mental models, and worldviews of the knowledge broker (or institution) are questioned and made explicit.*

'Reflexivity' as such is a term rarely used in the daily practice of experts in the science-policy interface. Terms like 'transparency', 'quality of evidence' or 'explicit assumptions' are largely more used. Reflexivity in knowledge practice is also often confused with 'time to reflect' or 'making sense of'.

However, the clear majority of experts interviewed or observed, would relate to the notion of 'reflexivity' in terms rather close to what has been described in chapter 2 of this thesis. The extracts below are a good illustration of that – they demonstrate how the notion of reflexivity is understood (and often embeeded) in experts' practice, despite the term not always being used as such.

The following excerpt speaks to how practitioners in the field can actually perceive themselves as part of the reality (problem) they're trying to address, through their own knowledge practice.

> "... reflexivity is about the fact that once you understand the issue, you're part of the system... when you understand the topic and then you act to it, you change the nature of the problem. It's a kind of a systemic understanding of knowledge and action." (I.06)

The excerpt highlights the relationship established between their knowledge practice (and implications of it) and the shaping of the problem itself.

Practitioners also acknowledge the perspectives their share on the knowledge reality they are working on, is just one out of many different possible perspectives. By rendering this assumption explicit, they contribute to higher levels of reflexivity, exposing the mental models underlying their knowledge practice:

> "I think it didn't end up in the introductory text, but I really tried to make it explicit that it was the perspective of the [organisation] only, working in the science policy interface,... you know... just to really show that this is one single perspective... especially because it was new knowledge... people are just now talking about sustainability in the food system (as about any other systems) so, it is not right or wrong it is just one perspective, trying to be far reaching... very collaborative, very co-creative... but just one." […] At the end it is making your mental model explicit." (I.02)

> "... in a way you need the courage to put a real quality of information disclaimer on nearly every bit you publish. You need to be clear about what is the source of this, to what degree is this based on a mental model or belief system that is not consistent with the belief system used in the previous chapter. How do these things fit together?..." (I.09)

In the same line, practitioners are capable of acknowledging their own biases, despite all methodological mechanisms to secure objectivity and impartiality:

> "… whatever we do, we are part of the system we are trying to assess, and we are not neutral objective observants, we live in some social-technical imaginaries, each of us, and it is very important to be aware of this, that our view on things is biased. This is something I'd like to bring as reflections to the [organisation] because they are very relevant for understanding for instance where policies have been successful or not, why and whether assessments are considered solid or not. First of all, it's about been self-reflective about what we do - in terms of tools and how this belongs to our school of thought." (I.04)

> "… I come to this Agency with a certain agenda, with a specific purpose... (...) that can make me biased... (...) I have that reflection when it comes to writing an assessment... (...) We are not a scientist organisation; we are not communicating science, we are communicating knowledge to policy makers. We have interpretation and stuff like that, which influences part of the validation process. In that sense I'm not sure we should be bound by the same type of criteria or concerns that science validation has." (I.14)

The excerpts above are overall a good representation of the empirical evidence collected across organisations and actors, as they seek to make sense of the notion of *reflexivity* based on their own experience.

However, the combination of these same interviews with other pieces of empirical data, bring to the surface a more complex understanding of what it means to "put reflexivity in practice".

As with previous factors implied in knowledge innovation, practitioners tend to rather emphasise the organisational or institutional barriers preventing *being more reflexive* in their knowledge practices. To start off with, reflexivity is often referred to by the "lack of", something "missing" or "very difficult" – and rarely as an existing, predominant practice:

> "… [reflexivity] is something largely missing. Quite often we tend to produce information and reports that are very assertive: this is the knowledge we have and how things are. Without leaving such possibly that even with the same information, different people in a different context might come up with a different conclusion." (I.02)

> "The whole process of [report] prototyping. Very difficult. It would have been much easier if we were able to structure the process on the basis of [a common] understanding. The report is many things (from data analysis to systemic thinking) and we are going through the process without any reflexivity, without having the competencies for doing this type of reflexive analysis at least. We are managing the process behind because we lack reflexivity, we lack this type of mediation, openness,..." (I.04)

These are just some examples of what appeared to be a largely shared set of concerns regarding the institutional capacity (or lack of) to "put reflexivity in practice". Such concerns boiled up to a set of synthesis questions, as discerned in this research through the combined set of interviews, focus-groups and in numerous conversations in a context of participatory observation: *How aware are we of our own assumptions, values, beliefs, world-views, mental models as individuals and as an institution?... Why is it so difficult (what is at risk when) exposing own assumptions, values and mental models? Is there room for full institutional transparency in knowledge* practice *in particular knowledge arenas? What is realistic for specific areas of knowledge? What routines can help embed higher reflexivity in our knowledge processes?*

These questions were then re-introduced in the empirical work, in interaction with practitioners in the field and in various occasions, in an action-research frame, through participatory observation. In that process, no evidence was found that these questions were otherwise being explicitly asked and addressed in a dedicated organisational or institutional context.

This cannot mean they were not present in practitioners' discourse – and those of organisational leaders. While not openly, explicitly addressed, these questions were implicitly present in significant activities carried by some of the organisations investigated – often under different labels or concepts.

To this account, an important example is that of the process leading to the SOER2020 drafting, at the EEA. As part of that process, a consultancy sub-contracted work run under the title of "Quality of evidence in post-truth world". The scoping process for this project was managed by an EEA expert working in the Integrated Assessments unit. Initial drafts included questions (and tentative responses to) such as: Why do we need qualified evidence, and what can we do about that? Why and how can the EEA SOER2020 be affected by the disconnect between belief of society in predictability and the known uncertainty in this field? Why should we worry? What tools are there to cope with uncertainty and quality assessments? (C12)

Seeking to address some of these questions, the EEA organised later on a workshop on "Critical appraisal of knowledge", where the notions of "quality of evidence", "reflexivity" and "transparency" appeared combined in a series of presentations, from both EEA staff and academic experts alike. Key findings out of this workshop were later included in a set process to induce more reflexivity in the process leading to the drafting of SOER2020. A later presentation by the SOER2020 coordinator on the process to date already alluded to "how we internalised the 'quality of evidence / reflexivity' dimension". (C23)

Similar examples could be found through the empirical research both at national level – with emphasis put on the work done by the environmental agency in the Netherlands – and at the European Commission and European Parliament – with work carried by units such as RTD, JRC or

STOA, as examples.

Overall, data collected through the empirical work indicates, in what reflexivity is concerned, a state of "being in transition", from one mode of producing knowledge to a new one. Based on observation of practices in boundary organisations, the work appears tentative, calling for continuous experimentation towards effective implementation of required innovations.

On this, some of the interviewees expressed concerns rather than optimism though. The issue of institutional constraints and the lack of competencies are amongst those most mentioned:

> "So, I understand that it is very difficult and very sensitive being reflexive because you unveil a lot of things. Especially when you move from the data driven issues to the more systemic dimension. […] reflexivity is very much important because it is a mean of making things more democratic per se, and is more informative and socially robust, at different levels, and.... I think it is a duty, honestly; as a civil servant. […] Maybe embedded in the notion of "reflexive": the idea of transparency and accountability." (I.04)

> "... we are not good at making our assumptions explicit, but we are also not good in taking other perspectives into account... if we'd take other perspectives into account, we'd probably not need to be that explicit regarding our own assumptions. (I.14)

With all this, empirical research indicates that, while the *understanding* of reflexivity is well developed in the thinking of actors researched, the *practice* of reflexivity in a more systematic way is conditioned by organisational and institutional constrains. Empirical data suggests the existence of underlying institutional barriers – based on existing organisational cultures, sets of values, belief systems and political dynamics – that engender the implementation of reflexivity far more difficult than the understanding of its value and deep meaning by practitioners.

Generative knowledge practice

For the sake of this thesis, the notion of a *generative knowledge practice*, is associated to the need *for more action-oriented knowledge, created, from the outset of the process, in view of generating possible responses to challenges at stake, be transformative, point to action, and* *promote change.*

As with some of the previous notions, the expression "generative type of knowledge" did not resonate immediately with experts in interviews and focus-groups. While the idea of it – when clarified – appeared relevant, the term as such was for the most of it not present in the observed field.

As found through the empirical research, the notion of a "generative type of knowledge" was rather engendered through academic milieus, rather than in 'boundary organisations' as such. And yet, a significant amount of practice and discourse researched was in essence directly related to it.

An important contribution to this finding comes from experts working in the fields of *forward looking*, *horizon scanning*, *scenarios* or *foresight*. There, the notion of "generative knowledge" was clearly associated with the idea of *transformation*, in the long term.

> "I'd probably include the "long-term" characteristic of knowledge... in a transformation perspective... future-oriented... probably similar to what it's meant by 'generative'... where we want to go, our vision, foreseen impact,... to emphasise the radical perspective of change and the need for that..." (I.12)

As expressed by the experts in these fields, such an approach emphasised not just knowledge as an outcome of a process, but knowledge as a practice geared to generate transformation. A good illustration of this, are methodological exercises that seek to project experts into possible desirable futures through a set of given techniques (like *back-casting, or scenarios, for example*) in order to shape the realities shaped by their own knowledge practice outcomes.

For other actors, the idea of generative knowledge comes associated with that of *experimentation*. This approach was found more often within those working closely with the arena of *sustainability transitions* – from socio-technical innovations to governance. Broadly put practitioners in this arena argue there needs to be an application of knowledge engenered (through their knowledge practice) so that subsequent learning can leverage scale from niches of innovation to *regime* layers.

From the perspective of these experts, there is a thin line in the field leaping from this idea to the need for possible governance “responses / solutions” for sustainability challenges. In other words, through the eyes of practitioners, *knowledge-to-action* requires a cycle of application, experimentation, learning and scaling. Experimentation is, in this context, a suitable proxy to “action”:. The following excerpts speak to this type of approach:

> “… [it is like] the design-thinking approach to this because it is about prototype-reiterate, prototype-reiterate all along.” (I.02)

> “By being involved in these processes, businesses have already started trying out new things, find alternatives. Sometimes helped by the ministries. They try things out - some work, some don’t - and then from that they learn and other companies use that knowledge. New questions arise: does that provide the function that we wanted? Is it really necessary? (...) so there’s a bit of generative knowledge, and of shifting expectations and values along the way... as well as products.” (I.13)

A third group of practitioners – those more closely engaged in reflection and work of the science-policy interface as such – would immediately associate the term “generative knowledge” with the idea of “knowledge that is generated purposely to be applied”. Such an approach stresses *intentionality towards action* in knowledge practice as the key to what needs to change, to where innovation is needed.

The following excerpts are good illustrations of the above through practitioners’ own words:

> “… there’s a difference between knowledge that furthers you understanding things in abstract, and knowledge that is generated purposely to be applied - and the application element.” (I.09)

> “… "generative"... in design [thinking] this is about the use, the purpose. (...) It represents a shift from a traditional academic way of looking at knowledge. It should focus on what do we want the knowledge to be used for. That’s at least what I try to think of when I’m engaged with this type of processes. Trying not to apply a methodology just for the sake of it; but to identify the need from a user and then propose

knowledge for that purpose (design, customise,...). (I.05)

"It's not only a question of having somewhere the knowledge... but being able to grab this knowledge to a level that is actually applied to solutions strategy and not to the abstract understanding that there would be a better solution." (I.09)

From these practitioners' perspective, it is one thing to apply knowledge independently generated, it is another to generate knowledge with a clear intention to make it usable, actionable. In their account, this is one of the keys to more clearly distinguish academic knowledge from, for example, the type of knowledge practice within 'boundary organisations'.

"The difficulty is not getting the knowledge - is applying the knowledge. There is no shortage of research these days, or think-tank endeavours that try to embrace many of these characteristics. But once you come to the policy-making arena, you are in the realm of many different established interests. At that level, knowledge and understanding is only one of the many factors that determine the outcome of policy processes or decisions." (I.09)

Overall, experts in the field also emphasised the perspective that, for knowledge to be intentionally crafted to be applied, experimented, and generate learning insights from such an exercise, it cannot be prescriptive, or normative.

"In 'generative' I see it is 'non-predictive', which I agree very much, but also I think it would be important to reflect on the fact that it shouldn't be 'prescriptive'." (I.04)

As seen above, this idea is strongly embedded on the notion of integrated environmental assessments and may well shape the thinking of many of the practitioners in the field.

This positioning by many of the experts researched brings significant debate and controversy. In observation, it actually configures one of the hardest characteristics to accept towards innovations in knowledge practice. The tension between "indisputable facts" and "tentative responses", although potentially constructive, is most likely to generate aversion and defensiveness to foreseen innovations in knowledge practice.

One of the critical questions raised by practitioners was precisely whether current knowledge practice can actually be disrupted to allow room for experimentation. Not just that, as much of these processes require resources and institutional conditions that were found to be unfeasible through the eyes of experts in 'boundary organisations' researched. The following input from a European Commission official is a good illustration of such scepticism:

> "Generative... it is an iterative process... again, does it really happens?... do you really learn at each stage?... How do you actually induce such iteration?... is it a design process? out of the blue? erratically?... If it is about making knowledge actionable, how can you make it actionable?... (I.08)
>
> "The same with forward looking: it is very human (which I like), but there maybe be new types of knowledge generated we are so unfamiliar with, that we are not able to deal with them. And we need first of all to be able to handle that type of knowledge." (I.08)

The concerns expressed above do not prevent interviewed experts and others involved in focus-groups from emphasising the need for more generative experimentation in knowledge practice. It is the actual feasibility of experiment in real context, adapting existing workflows to incorporate pilot experiences, induce design thinking and prototyping, that raises the greatest scepticism – would that really be possible in the given institutional setting?

A significant piece of data in that regard emanates from conversations with three of the EEA senior managers. When enquired about their thinking on the idea of "generative knowledge" as exposed above, the three pointed to significantly different directions: (1) one emphasised its value in response to the need of more solutions-oriented knowledge (rather than problem-focused knowledge), (2) another stressed the opportunity of constantly generated action loops while in the knowledge-creation process, and (3) the other one welcomed the idea of going beyond the "purely technical policy framework".

While these three different responses are obviously subject to multiple interpretations, they bring to the surface how innovations in knowledge practice under the umbrella of more “generative knowledge” can be taken very differently from an organisational leadership perspective.

5.4 Chapter conclusions and discussion

This chapter has exposed the views of practitioners in what the need for a new type of knowledge in the sustainability science-policy interface is concerned. Based on the empirical data collected, it has demonstrated that there is a significant acknowledgment from experts in the field of the need for changes in how knowledge is crafted in this arena.

In that regard, the interaction with practitioners through the empirical work has revealed a lesser interest in defining how knowledge as an output should look like, and much greater concern on how such knowledge ought to be generated, as a process – the knowledge practice as such. Section 5.2 of this chapter provides a good account of practitioners’ considerations on ‘how differently’ knowledge needed to be produced and, in doing so, how practitioners in boundary-organisations perceived their own somehow special role in driving generating such changes. Through exploration of discourses, presentations and interviews, it is exposed how such a sense of “uniqueness” by experts in boundary organisations is at times positioned antagonistically vis-à-vis academic institutions or policy-making institutions alike.

This chapter also reflects in greater detail the views of practitioners on the five key characteristics informing innovations in knowledge practice, as synthesised in chapter 2 above. While empirical data demonstrates a broad acknowledgement of innovations based on those five features as being necessary and welcome, it also presents a seeming ambiguity in what those type of innovations would exactly mean in experts’ specific work context.

Overall, section 5.3 in this chapter demonstrates, articulating data reporting and interpretation, an ambivalent perspective from practitioners between the need for such type of innovations, and their concerns of feasibility given the institutional context they operate.

On one hand, part of those concerns relates to distinct understandings of what “co-creation”, “transdisciplinarity”, “systems thinking” or “reflexivity” would actually mean, in practice. The absence of common references on these notions in their own working milieu leads to a perception of “confusion” and “disorientation”.

On the other hand, as practitioners gain greater awareness of the wider scope of meaning and implications of these type of innovations – through the research interviews as such, for example – they become sceptical about the feasibility of implementation of such changes in knowledge practice within their given institutional context.

Further discussion and personal interpretations of these findings are offered in the conclusions chapter 8, below.

6. THE ROLE OF INDIVIDUAL COMPETENCE FOR INNOVATIVE KNOWLEDGE PRACTIVE IN BOUNDARY ORGANISATIONS

As presented in earlier chapters of this thesis, inherent to claims for innovations in sustainability knowledge practice, is the concern about how capable are 'boundary organisations' – and actors therein – to help induce such type of innovative approaches.

In Chapter 3 above, a competence-based approach was presented to address the issue of capability. Conceptual and operative frameworks were also provided to help better understand and apply the notion of competence in the context of this research.

Based on the literature reviewed, section 3.3.3 proposed a list of competencies deemed critical to induce innovative knowledge practices at the sustainability science-policy interface.

As explained at that stage of the thesis, these ten key competencies were identified and selected based on a systematic literature pointers and on an assessment of the type of competencies not so commonly present in mainstreamed institutional competency frameworks.

The proposed list of ten key competencies for innovative knowledge practice is therefore a synthesis and a selection used for the sake of this research, in particular for the empirical work now presented in this chapter.

The current chapter therefore focuses on three main aspects of the empirical research associated with second key research question:

a) Firstly, based on access to organisational materials and documentary evidence, it presents findings on the extent to which the type of competencies required for innovative knowledge practice are present in existing competency frameworks surrounding sustainability 'boundary organisations'. In doing so, it seeks to infer how boundary organisations treat the type of competencies at stake (as described in chapter 3 above).

b) Secondly, based on empirical research methods chosen – mostly interviews and focus groups – it presents how do individuals relate to the notion of competence in general and to competence-based approaches in relation to the institutional capability to induce innovations in knowledge practice. This section therefore also seeks to explore how do practitioners in the field reflect about their own competencies – or perceived lack of – to induce innovations in knowledge practice and how do they equate in their own workflow the need for continuous competence development.

c) Finally, this chapter addresses more directly research question #4 on *how do practitioners in the field relate to the need for different types of competencies other than those existing institutional competency frameworks?* In this regard, this section uses the interaction with practitioners in the field to help make sense, in context, of the type of competencies listed in section 3.3.3 above. *How are those perceived in context? How suited do they seem from the perspective of practitioners? Are there examples that can illustrate the value and use of such competencies? In their practice, are behaviours that demonstrate the application of such competencies – or the lack of? What challenges do practitioners feel when trying to mobilise such competencies?*

6.1 How do boundary organisations frame required competencies for knowledge practice – an overview of existing institutional competency frameworks

As explained in chapter 3 of this thesis, a list of ten key competencies was identified and selected based on a systematic analysis of literature pointers and on an assessment of the type of competencies not so commonly present in mainstreamed institutional competency frameworks.

Such an exercise originated a set of competencies that is therefore different – both in nature and language – from those normally used and known within ‘boundary organisations’. As explained before, while mainstreamed competency frameworks tend to privilege rather ‘transactional’ type of competency descriptors – focusing primarily on dimensions of knowledge and skills – the type of competencies required for innovative knowledge practice tend to emphasise dimensions of attitudes, values and purpose.

One important component of the empirical research was therefore to verify to what extent were these type of competencies for innovation in knowledge practice present in existing competency frameworks – especially those within the scope of operation of sustainability 'boundary organisations'.

The need for such an exercise was also reinforced by empirical data analysed that brought to evidence that practitioners lacked adequate institutional / organisational references on competencies for innovative knowledge practice – which will be further presented in section 6.2 below.

The empirical research therefore looked into existing competency frameworks – or similar instruments – within the scope of work of practitioners in sustainability 'boundary organisations'. Some of those are presented as "competency frameworks" as such. Others though were deemed as equivalent documents, instruments, or guidelines that, having been crafted within the broad scope of work of these boundary organisations, had been mentioned or used by any of the actors in the field. In simple terms, this analysis considered all those found references that could be at reach to support practitioners on what competences to develop in order to innovate their knowledge practice.

As for that sake, the following documents were analysed:

- The *EEA Competency Framework*
- A set of *European Commission* institutional competency frameworks or equivalent initiatives / instruments: EPSO and Joint Research Centre
- The OECD Competency Framework and the OECD report on "Skills for public sector innovation"

- The *Dutch Knowledge network on System Innovations (KSI)* tools and competencies framework
- The *EIT Climate Knowledge and Innovation Community (Climate-KIC)* Competency Framework
- The UK Civil Service Competency Framework

Overall, it is clear from the analysis of all those documentary pieces, that with few overlapping exceptions, the type of competencies at stake in such frameworks is for the most of it different from the type of competences explored through this thesis.

The EEA Competency Framework covers both *core competencies (applicable to all EEA staff)* and *technical competencies* (applicable by specific job areas). As for the former, the framework refers to competencies such as "Communicating effectively" or "Developing self and others", "Solving problems" or "Embracing change". Respective competency descriptors point to capabilities such as "helping create an inclusive environment", "facilitating wider exchanges between colleagues, stakeholders and partners", "listening and asking questions to ensure understanding" or "taking time to share and learn from experience", as examples.

While these are deemed valuable to foster a certain organisational culture, descriptors do not tackle, for example, what *attitudes* and *values* are expected to innovate the practice of relationships with stakeholders (moving from *sharing* to *integrating* new knowledge). They also fall short in describing the ability to develop self-awareness or to mediate and translate mutually incomprehensible concepts – both being fundamental to undertake reflexivity or co-creation, for example. While they describe important attitudes vis-à-vis problem solving and change, those are based on classic paradigms of engineering and planning, and less on systems thinking or principles of design thinking, which in turn call for dimensions of values and purpose, as seen in section 2.3.3 of this thesis.

The *EEA Technical Competency Framework* does address explicitly required skills in areas such "systems thinking", "cultural awareness" and "forward looking" – all of which are important competencies described in previous sections of these thesis. As seen, these competences are found to be, also from the perspective of practitioners, relevant to respond to knowledge innovation needs in terms of *systemic* approaches, *reflexivity* and *generative* dynamics. Yet, once more, such type of competencies are described primarily through the lenses of knowledge and skills, and less by exploring dimensions of values, purpose and attitudes.

The European Commission EPSO Competency Framework is the general framework used for recruitment, learning, performance and career management across its various units. As generic as it is meant to be, the framework does not provide relevant pointers to what competencies are required for knowledge creation, let alone innovations in knowledge practice.

The *Joint Research Centre* (JRC) is the European Commission's science and knowledge service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy. Through the JRC domain of practice, it is possible to approximate the remit of work targeted in this research project, focused on sustainability 'boundary organisations'.

The JRC has developed a *"Skills for evidence-informed policy making: continuous professional development framework"*, which points to the importance of competencies such as: "Understanding Policy & Science", "Interpersonal Skills", "Synthesising Research", "Managing Collaborative Expert Communities", "Communicating Scientific Knowledge", "Advising Policymakers", "Engaging with Citizens & Stakeholders" and "Monitoring & Evaluation".

While this skillset is not devised to support innovations in knowledge practice as such, it does provide relevant insights in what type of competencies sustain the adequate production of evidence within the institution. In that regard, aspects of 'anticipatory skills' or 'building trust', along with the need to engage with a wider scope of stakeholders / citizens, as examples, appear closer to some of the competencies listed in section 3.3.3 of this thesis.

In a similar line, the work developed by the JRC under the *Policy Lab* project, brings in important support in terms of *foresight*, *behavioural insights* and ***d**esign for policy*. Through these lenses, the project focuses on providing room for *testing*, *experimenting* and *co-designing*, by using tailor-made frameworks with a *strong visual focus*. All of this is strongly connected with the competencies explored in above sections of this thesis.

Finally, also important to note are the suggestions implied in the *Enlightenment 2.0* program, also under the scope of the European Commission JRC. This project follows the essence of a published report on "*Understanding our political nature: how to put knowledge and reason at the heart of political decision-making"* and seeks to address, in its specific institutional context, issues such as: *Misperception and Disinformation*, *Collective Intelligence*, *Emotions*, *Values and Identities*, *Framing*, *Metaphor and Narrative*, *Trust and Openness* and *Evidence-informed policymaking*.

The report dedicates a section specifically on the set of skills that are relevant for both policymakers and scientists operating within 'policy organisations' to engender evidence informed policies. This list of skills includes references to terms like "making sense", "ethical way", "transparent", "values behind research" and "build trust" – which connect very closely with competencies relevant for this thesis.

The report also explains that 'it is unrealistic to expect that all policymakers or scientists will ever master all these skills'. Instead, the authors advocate the need to build teams of policymakers and scientists that, altogether, gather these skills. They refer to this as an "ecosystem" and emphasise the need for 'boundary organisations acting as honest brokers".

The *Organisation for Economic Co-operation and Development (OECD)* sets defines part of its work as "drawing on facts and real-life experience, to recommend policies designed to improve the quality of people's lives." – this makes the OECD, for the sake of this thesis, a valid reference as organisation positioned within the science-policy interface.

The OECD has published a report on "Skills for public sector innovation" drawn from the 2014 conference on "Innovating the Public Sector: From Ideas to Impact". The remarkable value of this report in the context of this thesis is that it focuses precisely on innovation within public sector organisations. In this context, the report suggests 6 key skills to induce such innovation from within the civil service: (1) iteration, (2) data literacy, (3) user centricity, (4) curiosity, (5) storytelling and (6) insurgency.

The report is rich in detailing descriptors and expected associated with these skills, and to a large extent, it does correspond – almost directly – to some of the competencies explored in this thesis.

Looking at civil service competencies, the *UK Civil Service Competency Framework 2012-2017* was also analysed, given it was often mentioned by participants at the UK focus-group during the empirical research. Given its broad, generic scope, this framework didn't offer much support regarding the type of competencies required to induce knowledge innovations in the science-policy interface.

Finally, the research looked into two other initiatives that, given their particular focus on the content area implied in this thesis – the sustainability science-policy interface – could possibly offer some relevant pointers on existing competency frameworks practitioners could refer to. These were: (1) the *EIT Climate Knowledge and Innovation Community (Climate-KIC)*, working to accelerate the transition to a zero-carbon economy and (2) the *Dutch Knowledge network on System Innovations (KSI)* competency toolkit.

While these are not competency frameworks as such, the two initiatives offer some quite good pointers to required competencies to enhance innovations in the sustainability arena. They are not focused on knowledge practice though, but both would refer to competencies such as demonstrating systems thinking", "visioning", "sense making", "experimenting" and "accepting and dealing with uncertainty" – which are quite connected to the type of competencies explored through this thesis.

Overall, the empirical research reveals that, while some of the competencies described in section 3.3.3 above appear present in these frameworks, they are in most cases described based on their dimensions of knowledge and skills – and not those of values and attitudes. As seen above, in order to induce innovations in knowledge practice, the latter are more critically relevant.

This nevertheless does not undermine the role such frameworks can play in serving as references for further competence development. Contrary to perceptions of practitioners in the field, such frameworks exist and the competences at stake are explored to a certain extent. In the next section this latter finding will be explored in further detail.

6.2 From institutional capability to individual competence – a lack of repertoire, references and institutional frameworks?

The analysis of the empirical data collected, brings to evidence one key striking finding: if not *asked about* or stimulated to *think of* it, practitioners in the field do not mention the term "competency" when reflecting about the need to innovative their own knowledge practice at the sustainability science-policy interface.

When posed the question "what would need to change to enable innovations in knowledge practice", practitioners very rarely responded to the question using any reference to *individual competence*.

At early stages of the engagement with practitioners – be it in interviews or focus-groups – the question about required capabilities to induce innovations in knowledge practice is normally answered through views on the domains of institutional or organisational capability, such as, for example, governance settings, organisational management, political boundaries and policy cycles, time and budgets, or inter-personal relationships. Very rarely the domain of individual competence was mentioned upfront.

It is only when explicitly asked about "competencies" specifically, that actors in the field seem to start reflecting on such domain of capability. In most cases, at such a stage, data shows a rather difficult engagement with the concept.

At an EEA Workshop in 2017, an exercise invited participants to draw a 'rich picture' of an integrated assessment situation (knowledge practice). The exercise conducted participants to reflect about "do's and dont's" in their practice, collaterally and tacitly leading the discussion to the domain of individual competence. Some of the outcomes are relevant to this research, as participants came out with outputs such as: (1) *Don't impose a structure; (2) Represent the situation, not the problem; (3) Use a visual brainstorm; (4) Allow for mess and complexity; (5) Use words sparingly; (6) Allow for metaphors; (7) Include feelings/emotions; (8) Put yourself in the picture; (9) Use colour (preferably).*

As the empirical data in this research is analysed though, the example above appears to be rather an exception. When inquired generally about the type of individual competencies required to induce innovations in knowledge practice, actors in the science-policy interface would in most cases name some of the usual, known types of competencies. For example: the need to be *open-minded*, the capacity to *think out-of-the-box*, to be able to *communicate* different types of messages to different audiences or to communicate complex concepts in simple terms, the ability to *articulate theory and practice*, the capacity to *learn from each-other*, *networking* and *stakeholder management* skills, etc. – to name a few found in the data collected. While of significant relevance in the practice context of experts in 'boundary organisations', these are not close to the type of competencies discussed in Chapter 3 of this thesis.

The analysis of the data collected – especially in focus-groups – indicates professionals in the field would easily attune to the meaning and understand the value of more familiar types of competencies as the examples mentioned in the previous paragraph. Such "common" type of competencies, appear obvious and important in their specific institutional context. However, as expressed by practitioners, they point to acknowledged factors that determine current perceived success, rather than to what individuals need to *do differently* in order to innovate their own practice.

Another relevant observation out of the data analysed is that, in most cases, competencies are named assuming each individual's understanding of its meaning – not necessarily an expression of an organisational or collective recognition of what it means in their particular organisational context. For example, a given expert would have one (his/her own) understanding of what “thinking out-of-the-box” means, which was – as discovered through the empirical work – not the same as what a close colleague would mean.

A third critical observation out of the empirical work is that competencies are normally described by practitioners at a very generic level. When teased to dig-deeper into the substance of a specific competence – in terms of knowledge, skills and attitudes – practitioners investigated would normally struggle.

As an example, practitioners did often refer to a competence like “being able to build trust”. When asked about “how do you do that – how do you build trust?”, interviewees would in most cases hesitate, tentatively seek possible responses and ultimately articulate the words ‘I don’t really know…’. As put by one of the interviewees:

> “It's hard for me to actually pinpoint competencies... I probably need to sit down and look at the competency framework... that is quite useful in listing these skills because I never think about competencies... so I think if I had that in front of me it would probably be easier to point to what is needed.” (I.14)

This recurrent feedback from the empirical work does suggest the notion of individual competence to be a rather unfamiliar conceptual territory for most of the practitioners in boundary organisations.

As will be demonstrated in the next section of this chapter, the above doesn’t mean the type of competencies required to innovate knowledge practice are not present in ‘boundary organisation’. On the contrary, data brought to evidence that many of the competences described in chapter 3 are actually present in their thinking and – in some cases – in their practice.

However, practitioners do generally miss the support of organisational competency frameworks that could help them think through and develop required competencies to support innovative in knowledge practice, in a more structured and oriented manner.

Also at a broader level, the issue of individual competence – or *skills*, in a more popular proxy term – appears rather absent in internal documents, events or presentations on whatever topic related to knowledge innovation.

What could at first seem vague and distant from the reality of knowledge practice in 'boundary organisations', was nevertheless found to be highly present and valued when going deeper into the empirical research data. As extracted from the discussion in the UK focus-group: "… without such type of competencies we will not be able to reflexively consider and question the analysis or knowledge generation throughout the entire process."(FG3)

As presented in the next section, the type of competencies explored through this research are actually fairly connected to individuals' struggles and perspectives on required changes to their own knowledge practice.

6.2 Practitioners' perspectives on required competencies for innovation in knowledge practice

Through the empirical research, practitioners in the field – mostly interviewees and participants in focus-groups – were presented the list of competencies described in chapter 3 (section 3.3.3) above.

As previously explained, the list of competencies deemed critical to induce innovations in knowledge practice, was developed for the sake of this research. It has been distilled combining the literature reviewed and the experience of the researcher in this field. In that process, a list of *a different type of competencies* was curated assuming professionals would need to mobilise a *different* type of competencies, to perform *differently* in order to innovate approaches to their knowledge practice.

As also referred in chapter 3, the set of competencies chosen is therefore – and for the most of it – not necessarily the set of competencies expected to be present in common institutional competency frameworks. The set of competencies at stake in this empirical work were therefore selected with a focus on what could possibly be different from familiar territories of institutional practice and, at the same time, be coherent with the literature pointers to what competencies would be relevant to induce greater co-creation, transdisciplinarity, systems thinking, reflexivity and generative action loops in knowledge practices.

The empirical work then explored to what extent would this different type of competencies be significant in the practice domain of experts in field, in view of enhancing further innovations in their knowledge practice.

This current section of the thesis therefore presents the findings of that empirical work, directly associated with research question #2 on *how do practitioners in the field relate to the need for different types of competencies other than those existing institutional competency frameworks*?

With this in mind, interactions with practitioners – especially in focus-groups and interviews – sought to gather their perspectives on each of these named competencies, one-by-one. *How do practitioners make sense of them? Do practitioners perceive these competences as present or rather missing? Which behaviours would possibly best demonstrate these competencies? Are there examples that can illustrate their pertinence and / or applicability? Do they consider for themselves holding such competencies? Etc.*

In the below paragraphs a presentation is done on how data collected helps better understand, interpret and qualify that series of individual competencies, deemed to be important to enhance innovation in knowledge practice within 'boundary organisations'.

6.2.1 Translating and mediating knowledge

In summary, this competence can be described as:

The capacity to share knowledge and learning (rather than imposing knowledge), promoting distinct forms of communication among potential collaborators who have no history of talking with one another; possibly involving translation or mediation of mutually incomprehensible concepts, sets of assumptions, norms or values.

In much of the data analysed, the capacity to *share knowledge*, *communicate in different ways* and *adapt the language to different audiences* was very much present.

From the surveys run, this competency – described as "the need to share and mediate knowledge" – was in all cases amongst the highest rated on importance by practitioners. In other words, when asked "how important does this list of 10 competencies seem to you, in your particular working context", *communication* always came on top.

As perceived by experts in the field, in a context of knowledge co-creation, the interaction with a wider variety of stakeholders will necessarily give room to different perspectives looking at the same reality. While this is part of the richness of such dynamics, it also comes along with additional challenges. Different stakeholders do not necessarily use the same language, the same codes, the same concepts and descriptors to share ideas on a given subject or question.

Participants in the UK focus-group synthesised these concerns into the following needs:

- To communicate with diverse groups and understand how they use language in many different ways;
- To communicate across completely different words and ways of saying what is meant in a message. – *how to do that?*
- To frame questions such that they can be answered (especially within a scientific context; if you ask the wrong question, you don't get an answer that is meaningful).

Practitioners shared some examples of concepts or approaches that do require a careful mediation of different understandings amongst stakeholders. One of the interviewees referred to the notion of a ‘systemic’ approach, as an example, being often understood by others as a ‘systematic’ approach.

Another example mentioned more than once was around the notion of [environmental] assessments as such. While most actors in the field would commonly refer to environmental assessments as part of their work, some of the practitioners interviewed flagged what appears to be a risky misconception of what an ‘assessment’ is. Existing even within expert colleagues, the awareness of such a risk triggered at the EEA the need to conduct further training on the notion and practice of integrated environmental assessments in the frame of the SOER2020 drafting process.

The same type of anecdotal misconceptions was found around notions of ‘nature’, ‘biodiversity’, ‘evidence’ or ‘uncertainty’ – just to name a few more.

Below are two synthetic examples of how practitioners illustrate this competence – and its inherent importance – in their real-work context:

> *For example, sometimes someone makes a proposal and, in the comments, I sense the message didn’t get across as - I believe - the person intended it. In such cases, quite often I ask the person making the proposal to paraphrase it. Or, instead, I take it myself and try to phrase it in different words, trying to translate it... "Is this what you mean...? Because I think what mister X understood is that... what do you think?...". These types of situations happen a lot, particularly when you work in multicultural contexts; what one says may be understood in a completely different way by others. (I.01)*

> *For instance, ’sharing, translating and mediating’: we have had very few discussions in the group about ’transitions’; and in those we had, none of these terms were part of the analysis. When moving from working with countries like Germany or France and moving to West Balkans for example, we know we are dealing with a totally different set of values, assumptions and world views... and then [because we don’t address these issues] there is a risk to have an unsuccessful process. And there is also the risk that the EEA as a body sticks to some perspectives (without recognising that) and loses credibility because hasn’t been able to address this (translating and mediating). (I.04)*

In a different perspective, this need for constant translation and mediation of knowledge is also perceived by practitioners when communicating to non-experts (incl. policy / decision-makers). The challenge in this case lies normally in the translation of rather complex and interdependent concepts into understandable messages, using concepts and ideas closer to the reality of interlocutors.

As exemplified by one of the interviewees:

> *In the interaction with stakeholders we are still bringing issues that are very difficult for some of them to understand, that doesn't speak something real to them. (...) we are bringing elements which are very kind-of intellectual constructs, very difficult, which are not - for some of the stakeholders - connected to their reality. (I.04)*

> *[translating and mediating knowledge]: This is the most difficult part: you read a lot about the topic and then you need to put yourself in the shoes of those who are going to read it and don't know what you're talking about – how are you going to generate responses that will help the reader understand it, so that they can also do something with it. (I.11)*

The following example is particularly relevant as it points directly to the articulation between science and policy and speaks to the capacity to understand different realities that don't necessarily have a tradition to communicate between them:

> *[for example: academics and decision makers]: How often do they get together? How often do they communicate with each other in a way that they mutually understand each other? (…) If you want as an academic to make a concrete impact in decision making, you need to understand the language; and the other way around, the decision maker needs to take time to understand some of the complexities. Time that is not often available in day-to-day decision making. (I.08)*

Yet another perspective on this competency comes from the perception by some practitioners that co-creation is a *process*. In such case, co-creation requires from those co-creating to engage in processes with continuous interpersonal relations, iterations and feedback loops. In doing so, actors involved in co-creation will develop a common understanding of certain problems, approaches, and possible solutions, but also of background worldviews, assumptions, emotional reactions, change of perspectives, dynamic positioning, etc. While in itself this represents a great achievement in what the outcome of such processes are – the co-created knowledge – it does raise a different challenge though: it makes it very difficult to communicate such outcomes to 'third parties' not involved in the process:

> *The biggest challenge is to translate something that is multidimensional (…) into something that can be understood by others that didn't take part in the process, in a two-dimensional format, which is typically a technical report (what we are used to publish in this Agency). Concerns are raised by colleagues on bridging these two realities: the complexity of the output of these processes and the over-simplification we get through a report. There is challenge there and I still didn't figure out how to translate that. (I.4)*

As noted at the UK focus-group, such dynamics is different from *reaching consensus* – in the sense of "reaching consensus when there are conflicting views / interests (especially in a context of negotiation)".

Or, as mentioned by one of the participants, it is also not about *negotiation*. This competence does require a genuine willingness to integrate new (unknown) knowledge, and value it in its potential to find adequate responses to rather complex problems. That is not necessarily about negotiating power positions sitting on different perspectives of established knowledge: "…if we try to go upstream, we need to think differently, we have to think across silos and that requires a different... we really have to consider what is the alternative to the way we do it..." (I.13)

In one of the internal workshops run at the EEA for experts engaged in the SOER2020 drafting process, a slide has been presented, synthesising the "new" key skills needed for an integrated environmental assessment:

- *"Communication* – active, iterative, and inclusive communication between experts and decision makers proves crucial to systems that mobilise knowledge that is seen as salient, credible and legitimate in the world of action.
- Translation – linking knowledge to action requires open channels of communication between experts and decision makers, but also requires that participants in the resulting conversation understand each-other; mutual understanding between experts and

decision makers is often hindered by jargon, language, experiences, and presumptions about what constitutes persuasive argument.

- Mediation – the trade-offs among salience, credibility and legitimacy are fundamental; conflicts among efforts to attain them cannot always, or even often, be resolved merely by improving understanding; the process often requires active mediation of those conflicts; mediation enhances the legitimacy of the process through increasing transparency, bringing all perspectives to the table, providing rules of conduct, and establishing criteria for decision making."

As a follow-up of this, one of the interviewees later shared: "…to be able to translate and communicate this differently for different people. So it's not only one structure that I had. The kind of things the director needs to be told are different than the kind of things another manager needed to be told. Be able to translate the ideas we had for this workshop into the specific realities of each person." (I.09)

6.2.2 Humility, curiosity and appreciation for the unknown, coping with vulnerability

In summary, this competence can be described as:
The capacity to recognise, with humility, the limitations of one's own knowledge and perspectives in dealing with complex issues; being able to expose unknowns, doubts, weaknesses; coping with vulnerability. Developing a vibrant curiosity, actively and openly inquiring toward other systems of thought, disciplines and worldviews and other sources of knowledge and learning, both formal and informal. Nurturing an appreciation for the unknown, recognising the invisible / unseen behind the material, looking after own blind-spots.

Taken the data collected, this is found to be a highly controversial competence as perceived for actors engaged in the sustainability science-policy interface. As put by two of the interviewees: "*humility... in principle I agree, it is extremely important, but of course... when there's two people meeting and there's politics into play, it may not be the right strategy". (I.08) Or: "*... I think there's a lack of humility, especially when it comes to politics". (I.11).

As shared by some of the practitioners, exposing vulnerability, unknows and doubts is at the antipodes of what most of these experts are expected to provide, of what is meant to be credible, reliable evidence to inform policy. And yet, such type of competence is deemed critical to support transdisciplinary and reflexive processes, as can be demonstrated by the following excerpts:

> *We struggle a lot because of lack of holistic worldview, humility and appreciation of the unknown. (I.04)*
>
> *In terms of what we should do... the solution-oriented knowledge... we don't have the answers... we don't have any good examples for a big transition in society... we have small cases... (...) I think we need much more humility in terms of what we can say... (I.14)*
>
> *(…) when we go to this new type of knowledge and we need to go to this more solution-oriented knowledge, to the more systemic way of seeing things, we need to be humble. Nobody has the solution. I can provide a part of the puzzle but I need to rely on other people to help complete it – and not everybody has that kind of understanding. In first instance you need to choose the people that have that kind of openness, of humility. (I.14)*
>
> *(…) it's also about respecting people's knowledge, what they bring to the table... they might know nothing about it (me being the expert) but they might know about other things that I don't. (I.13)*

The same issue was observed in one of the focus-groups:

> *[for transdisciplinary research to work well]* we need "the capacity to appreciate that one's opinion is not the only one in the room (openness); to appreciate that we're all fallible; the capacity to understand what is informing one's qualified opinion (our own included) and how it relates to other in the room." (FG3)

According to this group, it is also important to "value and utilise disciplines other than our own; not just understanding that they're there but making the most out of those people; knowing whom to go to". (FG3)

Such ideas of exposing unknows, expressing vulnerability is often perceived by actors in the field as a weakness, both at an individual level, but also from an institutional / management perspective. As expressed by practitioners interviewed, it requires a certain dose of "courage", "nerve", "assertiveness" and "entrepreneurship" to express such unknows and look for responses and knowledge elsewhere.

That doesn't seem to suit everyone. It requires, as said by one of the interviewees, 'to get out of our comfort zone':

> *Sometimes there has been situations where everyone is working on their own areas, but then we need solutions for which you need to get in between them, you need to be willing to step outside of your comfort zone and start building something in between. (I.13)*

Or, as explained by another interviewee, some people are just more *confident that their knowledge is superior and they have righter answers than others", and what is needed here is "people that are willing to engage in an open, reflexive process, and it is not everybody […] that is able to do that and achieve a good outcome. A good outcome in this context can be they change themselves out of being part of the journey, but not necessarily in terms of the content out of it. That is probably one of the lessons learnt." (I.14)*

While not fully expressive, data analysed indicates the perception of actors in the field that, in contexts of political negotiation, *humility* is intimately related to the perception *vulnerability* and ultimately to that of *power*. As a good illustration of this:

> *The experience with my research group with a facilitator: the deep dive down – the group works much better now because we've all kind of revealed our worst fears to each other. […] It was a little bit bold to me as a leader and I felt a little bit vulnerable ('I could get in a lot of trouble). (I.07)*

As observed through this empirical work, accepting, embracing and coping with vulnerability is far from being a valued competence at work.

6.2.3 Self-awareness and introspection

> **In summary**, this competence can be described as:
> The capacity to acknowledging oneself as part of the system, recognising and accepting inherent partiality and bias; detecting and examining own mental models, describing own assumptions, meanings, preconceived ideas, values and beliefs, inquiring inwardly towards oneself, perceiving, recognise and map own emotions.

As seen in chapters 2 and 3, very connected to the notion of “reflexivity” is the idea of self-awareness. In other words, the capacity for introspection and the capacity to develop a consciousness of connection with our inner self and the world around us.

While classic paradigms of science and engineering tend to place researchers and other knowledge brokers ‘outside’ of the problem to be solved, the broad indication from data analysed is that practitioners in the field perceive it differently:

> *(…) reflexivity is about the fact that once you understand the issue, you’re part of the system... when you understand the topic and then you act to it, you change the nature of the problem. (I.06)*

In April 2017 the EEA organised a workshop precisely on “Co-creation and Reflexivity”. This workshop targeted staff members involved in the crafting Environmental Assessments to support policies both at European and National levels. Karen Obrien, one of the workshop facilitators, presented at some point the following approach to reflexivity:

> “Reflexivity is generally accepted as an important ingredient of transdisciplinary research, but has often been critiqued for not sufficiently having been explained.... A transdisciplinary research process that is not restricted to acquiring social legitimacy in the process of knowledge production requires a transformational type of reflexivity to acknowledge that researchers’ own understandings are value-laden. These should be made explicit and deliberated on.” (Buizer et al. 2016)

This approach was found to largely resonate through the subsequent discussions with participants. A strong line of thinking coming out of it was that making explicit the perspective from which knowledge is produced will actually leave room for other perspectives to blend in, in complementarity. This will contribute to further understand that same reality – which is inherently complex – from adopting different perspectives each time.

Practitioners were also aware that, for this to occur, it is instrumental that the knowledge broker is capable of describing his/her standpoint, from a variety of dimensions: mental models, assumptions, emotions, beliefs, etc.

Many examples of this were provided by practitioners, in their own words and in connection with their own working context, as the excerpts below can illustrate:

> *(…) there is not a 'real world', there's only our perspective on it. So you need to make it explicit to be able to bring in different ones and co-create this new perspective, more embracing, that accommodates us all. (I.02)*

> *(…) whatever we do, we are part of the system we are trying to assess, and we are not neutral objective observants, we live in some social-technical imaginaries, each of us, and it is very important to be aware of this, that our view on things is biased. (I.04)*

> *For me one of the things that has helped me is my own knowledge of myself. (…) I have learned to step back of situation and trying to look at them with different eyes and points of view. (I.01)*

> *[in a knowledge co-creation context] do they [participants] feel bad about the people that are affected? ... somehow is as if there should be more than just words... whether there is any reflexivity... it's about their beliefs and mental models... do they have an overarching thing on top of 'this is just work'?... (I.14)*

While this acknowledgment appears rather firm, the capacity to introspect and to acknowledge oneself as part of the system, recognising and accepting inherent partiality and bias within the science-policy interface, is perceived by practitioners as difficult to align with the institutional promises of rigor, equidistance, impartiality. Once again, introspecting into and exposing own biases or belief systems is found to require an attitude close to an 'act of courage', as it can easily be perceived as an infringement, an explicit or tacit disrespect for the set norms of credibility and ultimately guarantors of institutional reputation. As exposed by two of the interviewed officials in the European Commission:

The pedigree of the knowledge becomes important; and that requires someone to make judgment calls, to make an assessment – and that is very difficult in a context of co-creation. […] In a way you need the courage to put a real quality of information disclaimer on nearly every bit you publish. You need to be clear about what is the source of this, to what degree is this based on a mental model or belief system that is not consistent with the belief system used in the previous chapter. How do these things fit together?... I think for purely process-wise is difficult, for those reasons mentioned above. (...) You will be left alone if you will need a subsequent validation of such report. (...) wouldn't know how to do it!... (I.09)

(…) oneself as part of the system', yes-but, I personally have a more institutionalist view that despite individual views, the institution is pretty much shaping what is coming of a certain system... (I.08)

Yet another example, from an official of national environmental agency:

(…) it is sometimes hard working in this complex interdisciplinary contexts... you need to explain several times... and often you bring your own personal views... many people will agree and share your views, but others will despise it as not appropriate for an (institutional) staff member... (I.16)

As shared by one of the interviewees, the ability to recognise and accept inherent partiality and bias requires "bringing to light all those things that are keeping our blind spots in the dark – a bunch of belief syndromes that are reinforced through society, that are implanted through society (in many cases cultural things that are just like the baggage we're carrying for being in society, or in a family or in an organisation)." (I.07)

A perception largely shared by practitioners is that, doing so requires time and energy organisations are not always capable of offering: "this whole thing of self-awareness... when time allows, you might be able to mobilise this type of competencies, but when time pressures, many times you fall back to whom you really are. Or maybe not what you really are... but what you're competent at, let's put it like that." (I.02)

In December 2015, a group of 5 staff members of the EEA – including the author of this thesis – engaged in a very exploratory workshop trying to practice some of the approaches deemed to be critical to engage in generating a new type of knowledge. Such workshop included exercises of self-awareness and sharing about own values, beliefs and mental models. In some of the documented subsequent reflections following this workshop, we can find reflections from participants such as:

> *Today, I re-learned the importance of self-awareness before setting out to engage with others in novel or exploratory activities that aim to harness their knowledge (as in expertise) and/or experiences. Being able and open to identify the main layers that make up my (perceived) identity allowed me to better understand what might be at stake for me when going through a process that can challenge my world view (i.e. perspective on the world).* [Participant 4]

> *[…] we need to go beyond engaging with our regular stakeholders through the normal consultation exercises. The exercises focused on ourselves helped explore our different interpretations and expectations, while also making us think about the challenges that we and other participants will have to engage with to do this.* [Participant 3]

These pieces of data are simply representative of a wider set of indications collected from the field on the importance of self-awareness and introspection as key competences to induce innovations in how knowledge is created within boundary organisations. Broadly they also speak to how difficult practitioners deemed it to be applied in the institutional context they work in.

6.2.4 Tolerating ambiguity, uncertainty and unpredictability

In summary, this competence can be described as:
The capacity to tolerate ambiguity, engaging in a "both/and" rather than "either/or" type of thinking. Dealing with uncertainty and unpredictability as part of a natural heuristic journey towards new knowledge. Capacity to integrate feedback loops.

As previous ones, this competency is surrounded by both a convergent sense of its relevance and need and, at the same time, a significant controversy on its adequacy in the institutional context interviewed practitioners operate.

Experts in the field do underline the importance of definiteness, certainty and predictability in their working contexts. Associated with this comes the perceived organisational culture that is one "bound by the need to measure and quantify".

The currently reality of their work, however, often clashes with such an approach. Specific works domains or projects necessarily call for an acceptance of a significant level of ambiguity and uncertainty.

A good example of it is the work being done in the domain of knowledge for systemic transitions. As explained by one of the interviewees:

> *"… we approach this without knowing what it takes in terms of mindsets that require to be comfortable accepting that all your thinking based on indicators is not enough, it requires to understand that this view covers just 10 or 20% of what needs to provide robust knowledge. For some this is a big challenge, but they take it. For others they need to be reassured - hence the need to develop competencies." (I.05)*

While this is found to be largely acknowledged by practitioners, data analysed also shows that "tolerating ambiguity, uncertainty and unpredictability" is also charged with a sense of 'wrong direction':

> *(…) ambiguity, uncertainty,... yes but again it is not... on that basis, the moment I bring that to play in my day-to-day work is not going to help whatever case I'm trying to make. (I.08)*

With this, the remainder of the data analysed doesn't add much to the understanding and interpretation of this competence beyond what has already been depicted from previous ones. The broad line of feedback received from practitioners is that while they see the pertinence of it, they lack references to translate such type of competence into observable behaviours.

To a large extent, responding to this has been found an area of priority in many of the organisations researched – some of which has been exposed in chapter 5.3 above. What is still to be explored within boundary organisations is the individual competence, the inner development by practitioners to *embrace* – not *mitigate* or *tame* – uncertainty and ambiguity as an “essential” part of their professional attitudes in generating robust knowledge for policy. Data collected is rather vague in this regard.

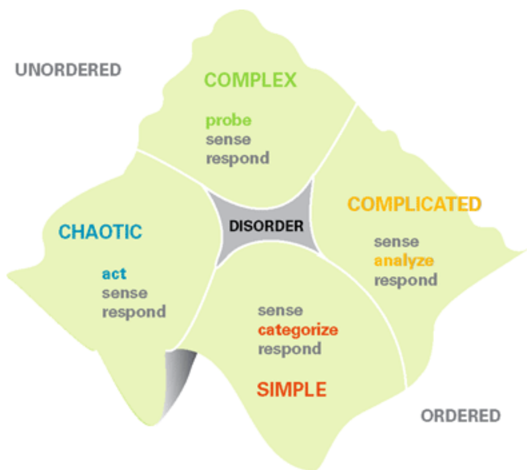
6.2.5 Thinking systemically, beyond analytical approaches

In summary, this competence can be described as:

The capacity to hold a holistic worldview, describing systems dynamics, made up of interdependent parts, understood in their relationship to the whole. Be able to identify and map distinct entities in a system, multiple relationships amongst them, as perceived from a variety of different perspectives.

At the EEA Workshop on “Co-creation and Reflexivity” (already mentioned above), Anne Caspari[30] presented the *Cynefin Framework*. This framework was developed in the early 2000s to support decision makers finding the adequate mode of response under four different contexts of operation: *simple*, *chaotic*, *complex* and *complicated*.

Figure 7 – The Cynefin Framework



Source: (Snowden & Boone, 2007)

[30] Workshop facilitator

While some of the participants would know the framework and found it useful for talking about the types of knowledge relevant to an issue and the appropriate processes to use to explore an issue further, the framework itself was not widely known by the participants in the workshop. The subsequent discussions provided a growing level of awareness in participants on the type of competencies required to operate in different contexts. The broad idea coming out of this discussion was that, in a complicated system there is at least one right answer, as it is possible to identify casual relationships, even if these are not initially visible. However, trying to understand and operate in expert-driven domains that are increasingly complex – and not just complicated – the mental bias produced by knowing what the right answers should be (seeing systems as complicated and not complex) can produce adverse effects.

One additional observation in the context of this thesis – later synthesized by a CECAN[31] member – was that as one works through the spectrum from simple, complicated, complex, chaotic traditional knowledge become less important and quality of process become more important: one needs to collect data, reflect, learn and adapt on the go, and depending on the nature of the problem build this in to the appropriate degree.

At this stage of the workshop, participants seemed to realise and acknowledge they were for the most of it using analytical approaches in contexts where they should be using systemic, adaptive approaches instead. It then came to evidence such type of approach would require a different type of competence, even if it was not yet clear what exactly that meant in terms of their specific working context.

The essence of this discussion as extracted out of the mentioned workshops was cross-checked with other data inputs and appeared to be representative of the thinking of some of the practitioners in the field – not all though.

[31] UK-based The Centre for the Evaluation of Complexity Across the Nexus

Data collected from the interviews actually stressed some of the challenges – rather than the competencies – inherent to applying a more systemic approach to their work (in context of growing complexity). In a way, the acknowledgment of the need comes accompanied by a realisation of the difficulty to mobilise such competencies in their specific institutional working context:

> *There is a certain institutional sensitivity and fear on whether you're doing the right thing. It really requires from leaders and those taking decision that they have a more holistic perspective and can see this is something that get beyond... (I.13)*

> *It depends on situations... sometimes the issue of complexity - and maybe because of my way of reasoning - I tend to look very strategically, but then I try to cut everything into pieces and tend to try to get pieces into place. Sometimes in this work of seeing the broad picture and translating that into small pieces, I may lose the whole, the complexity. (I.01)*

In a similar vein, experts keep struggling between the importance of holding an holistic view and the need to break observed realities into smaller pieces so it can be more easily "analysed", or "digested", or even "simpler" for policy purposes. This struggle can be clearly demonstrated in the interview excerpt below:

> *Also, for example, regarding the holistic world view. If you turn it around, if somebody has a simplistic specialist view, in a way that may sometimes be very useful. (...) In that sense making a very generic statement is a bit risky. I'd always prefer to inquire in relation to the issue at stake. (I.08)*

In general, the lack of systematic, applicable tools to help induce systemic approaches and navigate systems thinking in the practitioners' work context was much mentioned. A good example of it:

> *For sure we need tools to be able to connect those different levels of systems, otherwise people will get lost. From my experience - as you know I was also writing a report - it was really difficult to find these tools to help. Otherwise it's all in your head and then many people cannot track that and cannot communicate so you really need to have those tools to help you do this kind of journey. (I.02)*

6.2.6 Embracing complexity and disruption

In summary, this competence can be described as:

The capacity to embrace – not 'tame' or 'mitigate' – complexity, non-linear dynamics and disruption as informative components of (instrumental sources of knowledge about) adaptive systems.

Observing practitioners in action, the challenge behind the idea of embracing complexity and disruption was found to come rather with the attitude of *embracing*, not the knowledge about *complexity* or the acknowledgement of *disruption* as such.

To a large extent, the empirical work reinforced the idea described in earlier chapters of this thesis that the by-default mindset of practitioners in the sustainability knowledge arena is to deal analytically with complexity and disruption, not to embrace it.

One of the interviewees describes this in a very candid way. When posed the question 'how do you embrace complexity', the interviewee answered: "(…) we break it into smaller pieces and work from there". (I.11) In saying this, there was no acknowledgement this would possibly be not compatible with the nature of complexity and how to handle it.

As understood through this empirical journey, embracing complexity – instead of avoiding or taming it – is generally not favoured within the organisational context practitioners operate. As one interviewee exposed it:

> *"In my experience I have seen that it is very hard for people to understand complex problems, complex analysis and also complex recommendations. (...) at some point I developed a monitoring system to become more precautionary (...) but when we tried to implement it, nobody understood that; we completely failed; it was put to the shelf, because it was going far beyond individual silo responsibility; it was not broken down enough into understandable bits." (I.16)*

Various practitioners highlighted this same perspective. Embracing complexity is too complicated because it implies working beyond own area of responsibility, which comes as an organisational *barrier.*

The same was found when it comes to the idea of 'embracing disruption'. On one hand, knowledge actors in boundary organisations do recognise the value and pertinence of disruption into their knowledge practice:

> *"Exactly!... […] sometimes what's happening is that you are in a group, ten people discussing, and after one hour you are at the beginning of the discussion and here we go again... and so forth... turning in circles, not getting out of there. Sometimes disruption can break this circle, this continuity. Sometimes it works, some other times it doesn't." (I.01)*
>
> *I don't mind putting forward a proposal that I know is going to be "killed"... but in a way it will trigger maybe more focused criticism that will help us extract some pieces that will finally go to a proposal that will fly. (I.01)*

On the other hand, though, once again, the institutional framework in which they operate was found to be little conducive of such practices:

> *"From an organisational perspective, how can you try to encourage disruption?... my impression is that there isn't much disruption going on... there's been a certain timidity about move people around..." (I.06)*
>
> *"One thing I miss is the capacity to leave things on canvas instead of starting sorting things immediately (what is right and wrong); accept change; persistent, not stubborn (…), we don't have such freedom to think out of the box here, for example to hire a designer; design thinking, we need to design our own assessments." (I.15)*

6.2.7 Nurturing empathy, compassion and trust

In summary, this competence can be described as:
The capacity to nurture empathy and compassion, integrating mind and heart, opening and holding spaces of interconnectedness and shared purpose; being able to connect to one's deepest source of will and intention.

This competency is perceived as the most disconnected from “real science” and “credible evidence” by many actors in boundary organisations. As one of officials at the European Commission manifested about the need for empathy and compassion, with a real work example:

> *…’empathy’... not entirely sure I understand how this is linked to the competency to the knowledge... these are important human values, but to knowledge it is not entirely clear for me what is the link here... It does make sense in a way, but I’m still not so sure... like the disruption... with empathy you may go a certain way but sometimes empathy is not enough... take a concrete example: mining regions that are changing completely and people have to acquire new skills... of course you may have empathy and you try to soften such transition... but it is still a disruptive change... is empathy and compassion always the right choice in such a context of disruptive change? (I.08)*

This said, the need to mobilise empathy and compassion does not seem disconnected at all from their own practice. The following excerpts provide a good illustration of how these notions manifest in the real work context of practitioners:

> *“… the issue of "empathy"... gets more into the sphere of human relations and it happened to me in some meetings that I so much dislike somebody that I have to do a huge effort to listen to the person, and sometimes I notice myself (itching) and say ’cool down, be quiet and listen’. And sometimes this interpersonal relations... sometimes even just a person you met for 10 minutes... there is something there that... you don’t have this empathy... physical, chemical, whatever... it may interfere in the communication... that’s also something that I may lack. All this depends very much on the context or the time, the subject you’re dealing with... sometimes it will be more present, some other times more lacking.” (I.01)*

> *“(…) "nurturing empathy" (…) it speaks to how I am... when you like to do things properly, and you’re used to be able to deliver things... of course there’s a certain effort you need to put into it... but when you’re really stretched many times and then you feel a bit lost and then you don’t really have anyone to reach out to in your work setting,… (…) then there’s a bit of self-judgment... like... ‘oh I won’t be able to do this’... and sometimes you’re so much into it but you don’t stop and go like... it’s ok... so I think there’s something about the personal side of things going into this that is really key.” (I.02)*

> *“(…) We needed to have people feel comfortable with the process. Be able to translate the ideas we had for this workshop into the specific realities of each person. That includes making sure they are not worried with any potential damage there might be. The ability to project myself into the reality of the other person. (…) applying some of these things… (…) there’s a lot of empathy needed...” (I.09)*

> *"Something else: I feel it is very important to bring these people that may be a bit more idealistic together, and avoid knowledge islands. I think it is very important to protect and avoid the sense of feeling lonely and appreciate each other." (I.13)*

The same type of competence was expressed at one of the focus-groups, using a different concept – the one of *care* – "The capacity to care (about the place, people, our prospects) – are you in this to make a difference?"

Linked with the idea of empathy and compassion came through the empirical work the notion of 'trust'. The capacity to develop trustful relationship appeared as instrumental to navigate processes of co-creation and reflexivity. Such a notion was not that present in the literature reviewed as a competency required to generate processes of knowledge innovation. And yet, much has been shared in that regard through interviews, focus-groups and participatory observation.

The examples below illustrate not only the reference to "trust-based relationships" that practitioners find relevant in their domain of work, they also provide a good account on what "trust" means in that context.

> "So I was given that operating space, right? I think that helped. It gave me a lot of freedom to just go about it. There was a lot of trust as well, I think - built trust." (I.02)

> "(...) the most important currency in getting it done was a level of trust that I would attempt to do it well and that I would stick to what I promised we would be doing at the beginning. (...) these things often work because there are individuals that are able to convey a confidence that this is not a trap. (...) at the end of the day the success of these processes depend on the confidence you have (or may not have) on the individuals portraying it - and the willingness to pick them up from where they are... and they will only do it if you they have some faith on what you do. And that needs to be built over time." (I.09)

> "First of all we have to trust what the stakeholders are telling us... that is not always about 'peer-reviewed' articles, sometimes they tell us about things they have seen in their workplace... and yet, their inputs are also important to us." (I.11)

"One thing that I don't see here: 'trust'. If you're asking people to go on deep waters, and to something where there could be a backlash, disrupting their values,... people have to trust each-other. (…) You do that by spending time with people. It's actually difficult, in a learning setting. That's why I think going to meetings (despite Skype), having dinners, talking to people... that creates trust over time. All social things at work or outside of it. (...) If you have the same values and clear guidelines, people feel safer." (I.13)

The following excerpt is a powerful illustration of this competency in action, as described by one of the interviewees:

"'How to build trust in this context?' – I think it's about being very transparent about what you do and what your motivations are and share information. It's also about what's going out at the organisation - so that they can understand the context in which this takes place. And also provide guided access to my own work situation. And then all the basics: listen to people, respect their opinions and follow-up to what you promised to deliver. Part of it is also sharing this informal knowledge, the culture, the working situation. (...) so you really feel you are on a shared mission all across, a shared purpose. (…) of course it takes content knowledge, but it's also about personality: willingness to listen, trying to absorb other ideas, ask if you don't understand, respect other people's opinions... part of that is this 'building trust'..." (I.02)

An interesting observation out of the empirical work is that, contrary to other competencies listed, practitioners were less inclined to point out the institutional challenges and barriers when it came to the idea of "building trust" as a needed competency to innovate in knowledge practice.

6.2.8 Visualising possible futures and Design Thinking

In summary, this competence can be described as:
The capacity to mobilise forward looking, scanning horizons, building scenarios and possible futures; engaging in tentative efforts of visualisation, imagination and design thinking. Being capable of ideating, prototyping and testing.

As discovered through the empirical research (and better explained in chapter 5 above), many practitioners in the field understand a generative type of knowledge innovation as one that triggers constant sparks of action – mostly towards experimentation and prototyping. As the same actors also see it, such a generative exercise requires an initial capacity of visualising various possible futures and then design pathways towards some of those.

In the science-policy sustainability arena this type of work is very present in exercises of foresight, horizon scanning and scenarios. Organisations like the European Commission JRC Policy Lab, the Dutch Environmental Agency or the European Environment Agency or the Portuguese Environmental Agency have developed significant work in this domain.

Through the empirical work, it was also observed that the concept of "design thinking" has become more and more popular, making it hard to distinguish – competency-wise – the borders between *foresight* work and *design thinking*. Both appear mutually and complementarily influenced. Hence being treated together in this section.

The following excerpts from interviews are good examples of the need for such type of competence. They also translate that need into specific applications within their real work contexts:

> *"We are locked in past obligations. Of course we have to respect those, but we should also find space to more visionary thinking." (I.13)*

> *"This competence is much more important than I used to think. Especially with different backgrounds, with different understandings. If you have that shared vision it is much easier." (I.14)*

> *"The forward looking... should follow naturally from the other competences... you do this when you need to look into the future, but there are many different ways of doing it." (I.04)*

> *"I'm a bit divergent sometimes... and you need to be competent at this art of dancing between convergence and divergence... that's something I think design thinking brings, and that's cool. That's one of the things I was missing." (I.02)*

> *"…it helps if we'd have an idea of what we'd rather have instead... understanding what it takes to instil commitment and buy-in… what is the knowledge that you lack." (I.13)*

In one of the focus-groups, these ideas were clearly synthesised in two key points: the capacity to "(1) imagine and advise and prepare for the long term and (2) utilise foresight, insight and hindsight.

The same focus-group left a question in this regard that may be worth retaking as part of further reflection in these domains: "How much should policy be about solving past problems and how much of it should be preparing for the future; moving from knowing what we know towards what we don't know, the future?"

6.2.9 Entrepreneurial and resilience capacity

> **In summary**, this competence can be described as:
> The capacity *to deeply commit with transformative approaches, accepting risks, keeping the drive, energy, focus, sense of purpose and motivation in contexts of continuous barriers and constant personal and institutional opposition.*

This competency came to the list following through the empirical work – it didn't immediately emerge through the preliminary literature review. While talking to and observing various actors operating in the science-policy interface, it came to evidence that innovations in this field would, rather than being instilled "from the top" (i.e., from institutional management), depend on (often) individual initiatives, involving at times reproaching feedback from managers, as well as reputational risks and even career setbacks associated with the fact that these actors wouldn't be perceived at fully dedicating to the "core business" and priority deliverables at the organisation.

On the other hand, as explained by practitioners interviewed, due to the lack of institutional support, instilling this type of innovations requires from actors a level of energy and dedication that is either not compatible with other (priority) tasks at stake or simply not humanly sustainable in the long term – or both. In many cases, such efforts end up not being organisationally recognised and therefore solely depend on individual's deep motivations, beliefs and sense of purpose.

> *"If you're not motivated from you heart and gut, you're just going to drop it." (I.02)*

The following excerpt is yet another illustration of how practitioners in the field perceive the successful capacity to innovative their practice as a factor of their own resistance and resilience:

> *"Basically this is a process that is usually very high demanding in terms of energy. (…) There's always this back and forth that is very exhausting every time you touch on it. (…) It's very demanding energy wise to mobilise all of this." (I.02)*

> *"(…) some people do not have the energy, and you need a lot of energy to do this." (I.15)*

Referring to their efforts to innovate their own approaches to knowledge practice, practitioners often expressed the sense of frustration and exhaustion that comes with constantly struggling with uncertainty, ambiguity:

> *"It is easy to get overwhelmed when you're confronted with all this uncertainty, not knowing where you're get to." (I.06)*

On a different note, the need for entrepreneurial capacity and higher levels of resiliency is also associated with the resistance and opposition of others in the process of innovation in knowledge practice.

> *"In that respect, there is maybe a competency missing here. The capacity to deal with opposition. Despite not imposing knowledge, you should be able to get your point through." (I.08)*

> *"... in a way you need the courage to put a real quality of information disclaimer on nearly every bit you publish." (I.09)*

There is also an element of risk – and risk taking – associated with this type of competence. When seeking innovations in their knowledge practice, practitioners are aware of a certain "status-quo" they may be disrupting. To many interviewed that risks reputational and career consequences, many of experts are not willing to undertake.

"I find that a lot of the relevant work that I do on this, I need to do it without asking for permission.(…) I find that once you want to move beyond the boundaries, there is not a space for it, there is not a lot of acknowledgement, of trust. (…) It takes some guts, because I have to be willing to accept that I can be criticised for various reasons because I'm stepping on a new ground." (I.13)

"(...) very often people avoid such innovative processes. Why?... because it is frightening to leave your safe ground, to accept the unknown, or to nurture empathy and compassion... for some people this is a threat, depending on personalities." (I.16)

Taken altogether, the examples above provide a good account of practitioners' perceived need of a certain capacity to resiliently trigger and endure innovation processes, which involves risks often related to their own careers or personal credibility. Such type of challenge is later addressed in chapter 7 below.

6.2.10 Mobilising intuition and sensing

In summary, this competence can be described as:
The capacity to appreciate, trust and mobilise own intuition involving decisions related to discerning "relevant" data and knowledge. Mobilising domains of 'feeling' and 'sensing' beyond factual, intellectual or logic criteria for decision-making.

Empirical data suggests that *mobilising intuition* as a professional competency can be extremely controversial when it comes to the perception of the "right" knowledge – or evidence – to inform policy within boundary organisations.

This said, data often reveals practitioners' expressions such as "I felt this was the right approach" or "I sensed there was something fishy in the data", or even "I had a gut feeling we were missing the essential perspective on it". To a large extent, and despite expected debate in this domain, it was notable such type of competence is already present in some actors' practices within boundary organisations.

In interviews, when asked about how they dealt with certain dilemmas or choices in knowledge creation processes, some experts went straight into the role *intuition* played in their assessments:

> *"Oh... that's very intuitive. It's not mathematical. It's body language. (…) most of times is intuitive, it's not coming that clear that I hear an argument." (I.01)*

In other cases, while the term 'intuition' is not explicitly used, practitioners refer to the role of 'sensing', 'emotion' and a certain type of 'feeling' that account to decisions and assessments in their knowledge practice:

> *"(…) it's something you sense about... (…) It is very fast when you talk to people and analyse what they say, what they focus on... whether you feel they are really concerned about an issue. Is there also some kind of emotion? (…) somehow is as if there is more than just words..." (I.13)*

Also, some practitioners refer to 'other types of knowledge' to assess aspects in their knowledge practice such as finding "*the right moment, the right context and who are the right people to get involved." They refer that: "…there isn't a check list to go through. I'll probably get it wrong as much as I get it right (maybe more often wrong). (...) in a way it is an experience - not a solution or a recipe." (I.09)*

An important observation out of the empirical work though, is that such type of competence, despite its presence, had not been mentioned by practitioners before being questioned about it. In other words, it suggests, again, that the absence of a usable competency framework on such type of competence – beyond the ordinary ones – would most likely help practitioners make better sense of their own practice towards knowledge innovation.

6.4 Chapter conclusions and discussion

This chapter presents perspectives of actors in 'boundary organisations', on the type of competences required to innovate their knowledge practice, as presented in chapter 3 above. It gives an account of (1) the extent to which such type of competencies are present in relatable competency frameworks, (2) it explores how experts in the field engage in reflection and discussion about individual competencies as part of organisational capability to innovate and (3) responds to research question #2 on *how do practitioners in the field relate to the need for different types of competencies other than those existing institutional competency frameworks?*

Section 6.1 provides an account of the analysis of existing competency frameworks. It finds that, although not always explicitly, some of the type of competencies deemed critical to innovative knowledge practice are present in existing organisational references, frameworks and guidelines. Is such cases though, competence descriptors tend to privilege dimensions of knowledge and skills, rather than attitudes, values and purpose.

Section 6.2 in this chapter starts by exposing a certain unfamiliarity by practitioners with reflection and discussion about competence in general, especially their own individual competence to carry out their work. Such a finding does not question the existing of competencies required for innovation in the knowledge practice, per se. However, it does point to a lack of organisational references and guidelines to support and orient practitioners in discussion about required competencies.

Under section 6.3, this chapter provides a more detailed account on practitioners' views on each of the 10 different type of competencies required for innovations in knowledge practice, as synthesised in chapter 3 above.

The feedback from practitioners on the type of competencies required to innovate their own approaches to knowledge practice is ambiguous. On one hand, practitioners acknowledge, agree with and identify examples for when the mobilisation of such type of competencies was critical to innovate their knowledge practice. Such inputs make it reassuring that the type of competencies listed in this thesis are indeed pertinent for actors in the field. On the other hand though, as practitioners explore a more generalised development and application of these competencies, they raise concerns on institutional feasibility. They indicate how difficult it is to institutionalise such type of competence towards knowledge innovation, revealing a significant level of scepticism.

Further considerations and conclusions are presented in chapter 8 on a seeming "disconnect" between institutional efforts to provide usable frameworks on competencies for innovation in knowledge practice, and the perception by experts of such frameworks to be inexistent. In a similar line, empirical findings presented in this chapter indicate practitioners' awareness on the type of competencies required to innovate their own knowledge practice is greater than their capacity to discuss about those in a structured and oriented manner.

7. LEARNING APPROACHES FOR COMPETENCE DEVELOPMENT TOWARDS INNOVATIVE KNOWLEDGE PRACTICE

Chapters 5 and 6 above revealed, amongst other, three important findings out of this empirical research so far:

a) while practitioners in sustainability boundary organisations found it critical to induce innovations their knowledge practice, they manifest concern about individual and organisations' capacity to do so;
b) also, to their views, developing further individual competence for innovations in knowledge practice requires different competence frameworks, adapted to include the type of competencies presented in chapters 3 and 6 above;
c) the latter, as seen in previous chapter, should be accompanied by a set of intentional, structured and oriented learning strategies to help develop such competencies – the type of learning approaches that are perceived as absent in practitioner's' working contexts.

This chapter is focused to address the last item above, which corresponds to research question #5 on *how can professionals working in the science-policy interface most effectively learn and acquire such new set of competences, given their specific organisational / institutional contexts*.

It is safe to state that findings through the empirical research indicate many of the competencies described in previous chapters are not just perceived as *needed* as they are *already present* in much of the work done by professionals operating within the science-policy interface. Associated behaviours are pointed as examples of "what seems to work well". Often that same idea is noted by interviewees, asserting they feel competent in many of those areas and / or recognise such type of competencies in people or teams around them.

This adds additional disorientation to the already complex and ambiguous reality practitioners operate within. On one hand, they believe more intentional and structured competence development strategies are needed, especially attending to the different type of competencies required to innovate their knowledge practice. On the other hand organisational leaders interviewed express the view that maybe such type competencies can be (and will only be) developed organically, through ongoing "practice" and "reflection", applied throughout "many years of experience" – not something management can push into the organisation.

This seeming organisational inertia is perceived by interviewed practitioners as a problematic factor, not responding to their questions (and concerns) on *how to steer, accelerate and scale-up the development of such type of competencies*.

As observed through empirical work, practitioners in 'boundary organisations' do not believe the development of such competencies is simply a factor of time. While *time* and *critical reflection* on *own practice*, and therefore organic development through experience may be important, experts in the field share this may however not be compatible with (1) the necessary steering and structure supporting governance approaches and with (2) the urgency imposed on knowledge innovations to support sustainability transitions.

Experts in boundary organisations (as well as policymakers) do acknowledge the field cannot afford waiting for upcoming generations of sustainability professionals and new generations of academic curricula to organically transform the way they learn, work and contribute to generate innovations in knowledge for policy. These need to be steered, accelerated and scaled-up.

Amidst apparent leadership disorientation, lack of suitable (known) institutional frameworks and the perceived absence of good, feasible practices to develop required competencies, practitioners in the field do claim for pointers that can help – experts and leaders alike – find adequate responses to help accelerate innovations in knowledge practice in the sustainability science policy interface.

As explained in chapter 3 above, developing the type of competencies required for innovative knowledge practice requires the combination of a variety of learning theories and approaches, in an integrated manner.

Knowing little – or nothing – about what such type of learning programmes may actually entail, most of the experts researched share a concern that such processes might become overwhelming to many of those in boundary organisations, having professionals freeze in face of complexity, outside their 'comfort zones', shutting down their motivation for learning:

> "… very often people avoid such learning processes. Why?... because it is frightening to leave your safe ground, to accept the unknown, or to nurture empathy and compassion... for some people this is a threat, depending on personalities." (I.16)

As expressed by a few of the actors interviewed, the organisational aptitude to foster and put in place such type of learning strategies, needs to be accompanied with the capacity to explain *what* competencies are being developed, *why* and *how* exactly to support that:

> "On the flip side, there is people struggling with this stuff – those are grateful when they see some of these concepts clarified. The same would be true on the competency discussion. If they are battling with these concepts and they are not sure how to handle it, then an offer of support in developing particular competencies would be great. But it has to seem relevant to them – as response to a need." (I.06)

As previously mentioned, this research has found that there is an organisational tension in developing competence: On one hand, although apparently timid, there is a growing awareness that such (new) type of competencies is important to stimulate innovations in knowledge practice in the sustainability science-policy interface. On the other hand, actors in boundary organisations appear to lack relevant references for learning strategies that can help develop such competencies in a structured and oriented manner.

In that regard, this research process looked for existing learning programmes, organisations or curricula that shed some light into these reflections, and identify, from those experiences, which learning approaches, methodological choices and pedagogical principles are deemed adequate to develop competencies required to innovate knowledge practice.

The empirical research sought to identify programmes located within and beyond the usual networks of boundary organisations. This was to balance both the relevance of approaches in the field of action at stake, and the potential for innovative insights.

Organisations and experiences were searched in knowledge and learning practice territories that were not too far from practitioners' immediate working realities, so it could allow making sense of them within the scope of this research work. Also, such programmes were identified not only from within the acknowledged spectrum of training programmes and academic curricula used by practitioners in these organisations, so the research findings could build on what is already known (and perceived as insufficient) by practitioners in the field.[32]

In common, the type of learning programmes and organisations surveyed have a declared (or perceived) intention to articulate some of the learning requirements and features needed to develop the type of competencies described in section 3.4 above. Moreover, they relate to the content arenas or the innovations in knowledge practice described in chapter 5 above. Finally, some of these experiences were analysed given their intersection to (or having been referenced through) the work carried by some of the actors researched.

With this, out of all organisations, learning programmes, training or academic curricula surveyed, the following were deemed relevant for this research:

- The *EEAcademy Winter School on 'Integrated Environment Assessments'* – developed within the EEA as an attempt to explore 'new learning approaches' to leveraging competencies to address complex, systemic sustainability challenges, particularly at the science-policy interface.

[32] In the particular case of the EEA / EEAcademy, it is important to note my double role as the author of this thesis and, simultaneously, the coordinator of the EEAcademy. Issues of transparency, reflexivity, research validity and credibility have been addressed as described in chapter 4.

- The *School for System Change* – set up and managed within the Forum for the Future initiative, seeking to serve the field of systems change, as a vehicle for connecting and amplifying spheres of learning and practice.
- *DRIFT Transitions Academy* – developing and sharing transformative knowledge to support people, cities, sectors and organisations to engage proactively with [sustainability] transitions.
- *cChange* – an organisation invested in offering knowledge and experiential tools to help people understand the potential for transformation as a deliberate response to complex challenges.
- *Climate-KIC Toolkits* – developed to support those involved in learning programmes design and implement specific methodologies to develop competencies within their respective remits of action
- *The U.Lab* program – managed by the *Presencing Institute* and based on the *Theory U* change framework, is a platform that blends new tech tools, social change processes, and multi-local community building efforts.
- The *THNK School of Creative Leadership* – offering different learning strategies towards creative leadership and innovation especially within the sustainability arena.
- The *Academy for Systems Change* – a non-profit organization focused on advancing the field of awareness-based systemic change in order to accelerate ecological, social, and economic well-being.
- The *Unlocking the Immunity to Change* program – developed by Professors Robert Kegan and Lisa Lahey, Developmental Psychologists at the Harvard Graduate School of Education, seeking to provide a method to unlock the potential for change in individuals and organisations.

A tabulation in *Appendix 6* provides an overview of each of these programmes organised by: (1) a brief description of its main goals, context and overall features, (2) the targeted groups of potential learners, (3) the main program formats (whether time-bound workshops or longer processes, online or face-to-face programmes, group or individual coaching, etc.), (4) the most relevant methodological / pedagogical features or principles, (5) the key competences addressed through these programmes and (6) any particular key learning approaches and instruments associated with the program at stake.

The section below will provide a synthesis of the main aspects – methodological features and principles – found to be effective in accelerating competence development for innovations in knowledge practice.

7.1 Effective approaches and critical principles to accelerate competence development for innovations in knowledge practice

An in-depth analysis of the programmes listed above has been conducted. A summary overview of those programmes is tabulated in *Appendix 6*.

The synthesis below is based on critical analysis of the data obtained through the materials reviewed (incl. online information, readers and syllabuses, but also resources sent directly by the organisations contacted), as well as through ad-hoc input and feedback collected from actors directly involved in such programmes.

Rather than an exhaustive reflection on all features and approaches that define each of the programmes at stake, the analysis below seeks to highlight aspects in these programmes that:

a) differ from traditional training / education modes known to practitioners in boundary organisations researched, and
b) focus on learning approaches, principles and methods that relate to the development of the type of competencies described in chapters 3 and 6 above.

None of the learning programmes investigated was necessarily designed from the outset to respond, as such, to the need to develop competencies innovations in the sustainability knowledge practice. All of them have nevertheless been found to correspond to "what seems to work" in that regard – and therefore deemed relevant to provide useful pointers to this research.

Likewise, in isolation, each of these programmes alone does not offer empirical evidence on single learning strategies that are effective to develop competencies required to innovate knowledge practice. However, taken altogether, they do provide valuable pointers of what organisational options, approaches and principles contribute successfully to develop the type of competencies at stake.

The synthesis below therefore also takes into account inputs received through the empirical research journey, holistically, combining participants' feedback to these programmes, observation of practices and a few excerpts from interviews and interpretations based on my own professional experience in the field.

Such complementary research resources help better interpret (qualify, value) which of the characteristics of learning programmes investigated are critical for the specific context of 'boundary organisations' researched.

In combination, this section offers actionable insights subject to be used when considering adequate learning strategies to develop competencies for innovation in knowledge practices.

7.1.1 Language and explicit naming of competencies do matter

A significant finding in this empirical research is that learning programmes investigated do name and make explicit the type of competencies to be addressed through the programmes.

For example, competencies such as "holding the space of listening", "observing", "sensing", "presencing", "visioning", "scaling", "love and care", "building community", "thoughtfulness", "whole system visioning", "crystallising", "prototyping", "co-evolving", "transcendence and transformation", "sufficiency" and "unpacking hidden assumptions" are explicitly mentioned.

This raises two important conclusions: (1) the programmes do emphasize the role of "developing competence" (or "capacity") beyond just knowledge itself; (2) *different types* of competencies – similar to those described in chapter 3 above – are verbalised.

These competencies – the way they are named and defined – are indeed significantly different from mainstreamed competencies known to practitioners in boundary organisations researched. They are, however, very close in their substance to the type of competencies described in chapters 3 and 6 above (even if some of those practitioners deemed many of such competencies to fall outside of the scope of professional competencies as such).

The above indicates that explicitly addressing and naming *differently* a *different* type of competencies to be developed, is central to effectively develop a set of competencies for innovations in knowledge practice – as those described in chapters 3 and 6 above.

Another important finding is that investigated programmes do address explicitly competence domains and capacity beyond *knowledge* itself.

In the case of the EEAcademy Winter School, the programme is explicitly presented from the outset as intended to develop competences and build capacity – not just to *transfer knowledge*. The intention to *build competencies* rather than just *transfer knowledge*, is carried through the school programme in regular reflection loops about what competencies are being addressed at any stage and what competencies will participants need to further develop in the future.

The same with the 'School for System Change'. The programme is designed focused on "developing the capabilities that will be suitable to participants in their specific context, rather than 'teaching' them how to 'do' system change". These include: *systemic diagnosis*, *strategy design*, *innovation for impact*, *collaboration and engagement* and *leadership and learning*.

The learning programme, normally a six-month journey, combines a wide variety of methodologies to build such a set of competencies, such as practicing looking at challenges in a holistic way, systems thinking and mapping, future inquiries, synthesising insights, iteration and experimentation, design thinking and interventions design, drawing and visualising, prototyping, communities of practice, deep democracy, collaborative action inquiry, action networks, etc.

All the above appears particularly important for 'boundary organisations' as, on a daily working context, the way many of the competencies above are worded, does not populate usual practitioners' discourses. Such type of expressions and respective notions can actually seem awkward denominations for something intangible, hard to understand. Given most experts in the sustainability field are not necessarily versed in adult learning theories or development psychology, the terms like 'transformative learning' are hard to grasp from a conceptual point of view. They are not therefore something actors in this arena would know what it means or know what to do with it.

7.1.2 Emphasis on *process* vs *content* requires time and robust pedagogical expertise

Another important finding – perhaps the most striking one – in the analysis of these programmes is that, overall, they attach far more value and attention to the *process* of learning rather than to the *content* as such.

While most of these organisations have a strong anchoring in academic milieus, with extensive research and scientific knowledge behind, their focus in these programmes is almost entirely devoted not to the dissemination of knowledge itself but, instead, to creating the adequate conditions for participants' learning and unique competencies' development.

Such a focus on the *process of learning* alongside with the *content of learning* is, in most cases, made explicit. It is also followed methodologically with time dedicated to setting-the-scene for "how we want to learn in this school"[33] and time for participants' reflection on their own learning across the programme. This dynamic was evaluated as especially relevant by participants at the end of the programme.

Practitioners in the field reinforce this perspective: "A good outcome in this context can be they change themselves out of being part of the journey, but not necessarily in terms of the content

[33] Example from the EEAcademy Winter School.

out of it. That is probably one of the lessons learnt.” (I.14)

Indeed, about half of the programmes analysed refer to their learning approaches and practices as being part of broader “transformative” learning strategies. Using different expressions, most of the programmes investigated share that common denominator, one that sets their pedagogical options as part of designed processes to transform the way participants “perceive their reality”, “question their own assumptions”, “relate to self and to others”, “deal with their own ambiguities and vulnerabilities and those of others”, “cope with uncertainty and disruption”, etc.

As mentioned before, such type of pedagogical approaches require addressing participants’ (individual and collective) deep rooted belief systems, values and mental models. As it puts the emphasis on the “*process* of learning” rather than on the “*content* of learning”, this type of approaches renders the learning strategies more complex. Traditional conceptions of training and education methods – largely predominant in ‘boundary organisations’ researched – are not compatible with the innovative learning features found in learning programmes investigated.

Within boundary organisations researched, the unfamiliarity with notions of alternative learning methods and facilitation techniques makes it a challenge. The quest for practical means and guidelines is significant. From wider institutional settings (like the European Commission) to EEAcademy activities or small practices within expert seminars, the concern is the same: What techniques to use? How to enhance and facilitate such processes? Where to find additional support?

Working within the science-policy interface though, these organisations are often shaped by either traditional academic work and learning settings, or by institutional formal weight and complexity. For most of the tried methodological learning innovations, the sense of “not being adequate” is quite present. From a perception of “childish” settings to the discomfort of exposure to areas of intelligence other than intellectual, experts in the field resist to learning outside their comfort zone.

The set of learning programmes investigated have in common a wealth of research and robust pedagogical engineering behind. Activities proposed in their curricula are for the most of it heavily tested and reviewed in advance – moving from piloting experiences to scale. Programmes devise alongside a significant battery of feedback and evaluation mechanisms to enable ongoing learning loops and course-correction.

What may be perceived by practitioners in the field as a nice set of activities bundled together to “help break the ice”, or “socialize”, or even “have fun before we get to the real stuff”, are actually in most cases surgically distilled exercises to enhance the development of very specific competencies – for the most of it those that are at stake in this research.

The careful analysis of those learning programmes indicates this dimension of professionalism and expertise cannot be underestimated. Developing the type of competencies required for innovation in knowledge practice requires professional, expert support to set-up this type of learning strategies.

It also requires broad time frames. In none of the programmes investigated the learning response was accomplished with a one-single intervention in a short period of time. Instead, focus on process, a combination of pedagogical features and a longer period of time were instrumental in their methodological options.

This is largely in line with views of practitioners in the field, for whom this type of learning must be rather seen as a *process* – a long term process, a “journey” – rather than a collection of isolated training inputs. In many reported cases, such processes are not even mentioned as explicit learning processes. Instead, they are portrayed as *working processes through which learning occurs* – the idea of learning embedded in the workflow.

7.1.3 Effective learning strategies require diverse pedagogical methods

In line with the above, another important finding out of the analysis of respective materials is that these programmes make use of a wide combination of pedagogical features and methodologies that can range from *case clinics*, to *sensing journeys*, *guided journaling* or *4D mapping*.

The repertoire is vast and each of the methods used appears to be finely tailored to develop particular dimensions of competence. For example, the *U.Lab* “20-minute-dance” is used to further develop a ‘sensing’ capacity, practicing a non-judgmental attention to the what’s happening ‘here-and-now’, including one’s body consciousness, feeling it, without thinking about it or judging it.

The approach of THNK is in this regard quite illustrative. They understand this methodological combination as a central part of their work: “to create is to combine existing bits of insight or ideas into new material and new interpretations of the world. Einstein called this Combinatorial Play. Steve Jobs said "creativity is just connecting things". (THNK School of Creative Leadership)

While such type of learning approaches would be described by interviewed practitioners in boundary organisations as “maybe not adequate to their professional context”, these programmes are known to emanate from institutions – such as Harvard or MIT – acknowledged by their indisputable (scientific and academic) reputation and credibility. They were, moreover, in some instances indicated by actors in the sustainability science-policy interface themselves.

In that regard, organisations and programmes researched do succeed in their learning outcomes as they diversify the pedagogical methods used, in order to adjust to a variety of learner’s profiles.

As an example, the *EEAcademy Winter School on ‘Integrated Environmental Assessments’* attempts to distinguish different types of learning features, seeking to utilize different learning strategies for different types of competence development needs. This links to the findings in chapters 5 and 6 above that not all experts in the field see the value and feel the need to engage in highly transformative learning practices. By breaking their programmes down into distinguishable, flexible, and manageable learning features, the EEAcademy is opening room for a wider type of learning preferences and needs to fit. For example, while 'classic' lectures and readers would account to share knowledge on a tangible cognitive level, the role of the simulation exercises and peer coaching exercises was to experiment to the possible depth dimensions of values and attitudes in generating integrated environment assessments.

The approach of the *School for System Change* is also illustrative in this regard:

> "We do not think there is one particular methodology or approach that is the "right" way to do this work. This is why we are interested in, firstly, convening accomplished practitioners to learn together; and secondly, supporting people to navigate this emerging field of system change, developing the capabilities that will be suitable to them in their specific context, rather than "teaching" them how to "do" system change. (…) We draw from numerous fields and disciplines that we see coming together in the emerging field of system change. These fields set out their own processes, language and ways of knowing and in the School we seek to hold and facilitate these multiple lenses." (School of System Change)

The same quest for methodological diversity is found in programmes under the "Climate Knowledge and Innovation Community (Climate-KIC)". One of them is the "Visual toolbox for system innovation". The particular value of this *toolbox* – for the sake of this thesis – is its incontestable emphasis on *visualisation* (or *visualising*) as a learning support feature to enhance systemic understanding of problems and challenges.

The second one is the "Toolkit Innovator Catalyst". Of a more conventional type, the valuable contribution of this toolkit lies in its explicit exposure of different learning styles and the need to choose learning methods that suit a variety of such learning styles. The toolkit offers a wide range of learning methods and keeps the link to the development of competencies towards innovation within the sustainability transitions framework.

As seen before, the expert blending of learning methods, styles and approaches necessary to develop the type of competencies at stake in this research is a predominant feature of learning programmes investigated.

Not all types of learning methods suit all types of learners, considering their own personalities, sets of values and motivations. It is therefore to be expected that such approaches to learning – different in essence to 'traditional' formal training and education practitioners are familiar with – are more or less successful in bringing about required competencies depending on how individuals perceive the value of respective competencies as such.

In that regard, common to many of the curricula and methodological approaches in the learning programmes analysed above is the importance and role of individual 'personalities', 'values' and 'purpose' for each of the learners involved in those programmes.

7.1.4 Learning must be personalised and respond to learners' own perception of needs

Learning programmes investigated indicate that, in tailoring effective learning strategies, individual needs, values and motivations need to be carefully taken into account. The general constructivist proposition that "knowledge cannot be forced onto learners" is strongly evident in the learning programmes analysed, as it is through the views of interviewed practitioners.

The analysis of the referred learning programmes, makes clear that learning strategies to develop the type of competencies at stake in this research are not compatible with uniformity, conformity and standardisation.

An illustration of this approach from the Academy for System Change:

> "*The fellows were brimming over with learning, reflection, community, and gratitude. Even before the first workshop, we had a lot of conversations about the personal, organizational and system dimensions of change leadership. Since these people have similar jobs in the same domain, they have a lot of experience*

from which to ask good questions to help one another get through stuck moments. The conversations at the workshop were sometimes strategic, sometimes tactical, and sometimes very personal."

This type of pedagogical approaches are distinctive from formal training as such and cannot be applied to generic groups of professionals as a whole. Such type of learning strategies need to be highly personalised, taking into account individuals' personalities, values and motivations within specific contexts.

The perspectives of practitioners in 'boundary organisations' reinforces this type of learning approaches: "… I think there is potentially a large degree of personal history or psychology that may influence such development." (I.01)

Data is abundant in this regard: it evidences some experts in boundary organisations would be better prepared to engage in more innovative learning approaches than others, which again speaks to the variety of learning styles and preferences amongst actors in 'boundary organisations'.

> "I think we cannot ignore personalities... some people are just more confident that their knowledge is superior and they have righter answers than others... (…) you need people that are willing to engage in an open, reflexive process, and it is not everybody in [here] that is able to do that and achieve a good outcome." (I.14)

As captured by one of the interviewees, also a participant in the EEAcademy School, success of this type of learning programmes strongly depends on "the people: if they are willing to do that, if they feel there is a good enough reason for it, if they are acknowledged for it." (I.13)

Linking learning strategies to perceived needs and goals that learners value themselves and are motivated to achieve, is instrumental to undergo effective learning processes in this domain. "It has to feel relevant to them." (I.06)

Practitioners in the field reinforce this approach: "What can help developing these competencies?... a recognition that there is a *need*. A minimum consensus that something needs to be done. Have the right individual, curious enough to challenge rather "static" institutions." (I.08) Or, as put by another participant: "there needs to be an intrinsic purpose and meaning and then you need acknowledge for what you do." (I.13)

7.1.5 Learning is most effective if experiential and embedded in routines

While intellectually rigorous and in all cases highly supported by robust scientific and academic research, all programmes investigated draw important attention to experience – both in terms of participants' experience and opportunities created for experimentation. Most of the learning programmes analysed above point to experiential learning – learning from experience – as one of their fundamental features.

As an example, *cChange* devised a methodological instrument named "cChallenge", which is a practical tool for individual and organisational transformation, through which participants commit to one sustainability-related change for 30 days and reflect on what it means for them, others and the bigger picture. The approach behind the *cChallenge* methodology is based on the perspective that transformative responses to contemporary challenges will have to question the assumptions that are explicit and implicit in current development pathways and practices. "This is where the *cChallenge* comes in. Through one small change experiment, it is possible to see the bigger picture, and to find new ways to approach change."

Practitioners in the field reinforce the need for such an approach to learning – the need for greater focus on experience and experimentation. Such a position comes at times expressed through the idea of "exposure" to reality – "… by being exposed to different views that incorporate such a holistic perspective." (I.01).

While this idea of exposure resonates very coherently across learning programmes analysed, experts in the field offer little pointers to what it takes to be "exposed" and, especially, what it takes to enhance exposure in their institutional settings. More commonly appears the notion of "learning by doing".

Another relevant example is provided by DRIFT. From the analysis of their programmes within the so-called “Transition Academy”, stands-out the claim to “reject the false dichotomy between thinking and doing”, suggesting that, instead, “action and reflection imply and reinforce one another”.

This perspective common across learning programmes analysed. The development of certain type of competencies can only be acquired through repetitive practice. Practitioners in the field reinforce this approach, as they mention the importance of “practice routines” to embed competencies that are more strongly focused on attitudes:

> “How do you bring this change in a gentle way that is not threatening? (...) Introducing some soft routines and reflecting about micro changes all the time; the more you can reflect on questions, the more you can take it from being subject to being object to it.” (I.07)

> “…for some of these competencies to emerge, we need to talk less about curricula, but more about routines... (…) What I’ve described is quite practice-oriented. (...) by running this transition-management processes, this boosts reflexivity... (I.12)

From the programmes analysed, an illustrative example can be provided from the U.Lab programme. Methods such as the “guided journaling”, or regular “peer coaching” in several other programmes, are pragmatic pointers to the need to transfer some of the exercised experienced in designed activities to the daily routines of participants.

This type of approach naturally requires organisational cultures and leadership to welcome the application of such type of exercise into daily working routines. This has been perceived by interviewed practitioners though as particularly challenging.

7.2 Chapter conclusion and discussion

This chapter builds on practitioners manifested lack of guiding references to support them develop the type of competencies needed, to present research findings of out of the exploration and analysis of existing learning programmes in organisations acknowledged by actors in the science-policy sustainability arena.

This chapter presents a list of learning approaches and principles that appear critical to inform effective strategies to help actors in the develop required competencies. These refer to: (1) the importance of adjusting the language used and explicitly name the different type of competencies required to innovative knowledge practice; (2) the emphasis put on process of learning rather than just the content of learning and the engagement of specialised pedagogical support, accordingly; (3) the use of diverse, complementary pedagogical methods; (4) the capacity to personalise learning strategies and respond to learner's own values and perception of needs; and (5) the role of experiential learning and embedment of learning in practice routines.

While this synthesis was primarily obtained through analysis of selected learning programmes, substance therein was also supplemented with perspectives of practitioners on these same approaches to learning and development. Their views are in this regard double folded. On one hand, they reinforce the validity of such type of learning principles with examples from their own practice, on how they themselves effectively develop similar types of competencies. On the other hand, as the empirical work digs into the implication of such learning and training approaches at an institutional level, data from the field reveals that practitioners are rather sceptical about their effective organisational feasibility and institutionalisation.

This is referred and further explained in chapter 8 below, as indication of fertile matter for further research in this domain.

8. CONCLUSIONS AND FURTHER REFLECTIONS

This research project focused on new approaches to sustainability knowledge practice, especially those engendered by practitioners in 'boundary organisations', in the interface between science and policy. It synthesised a set of innovations claimed relevant towards 'a new type of knowledge" and defined a list of differentiating individual competences deemed critical to induce innovations in knowledge practice. With it, this research explored perspectives of experts in the field on the application and development of such competencies to induce innovations in their own knowledge practice.

As an overall conclusion, the thesis has found that, while the need for a 'new type of knowledge' in the sustainability science-policy interface is largely acknowledged in the field, the actual capacity to induce required innovations in knowledge practice is strongly questioned by practitioners.

Empirical data shows that both discourses and practices in the field appear ambivalent in:

a) what exact innovations in knowledge practice were required,
b) the articulation of competence-based approaches to induce such type of innovations, and
c) the need for different types of learning approaches to develop required competencies.

The sections below will present in further detail the main conclusions of this thesis for each of those domains of findings, in response to the key research questions described in chapter 1.

8.1 Key Conclusions

8.1.1 How do practitioners in the field perceive the need for and the pertinence of innovations in knowledge practice

In response to research question #1, and further explored in chapter 2 above, this thesis presented a synthesis of five key elements, claimed relevant for innovations in knowledge practice, towards a ‘new type of knowledge’ in the sustainability science-policy interface: (1) the need for more **co-created** knowledge, (2) the need for stronger inter and (especially) **transdisciplinary** approaches, (3) the need for applied **systems thinking** in knowledge practice, (4) the need for extended and deeper **reflexivity**, and (5) the need for a **generative, action-oriented** and **response-based** type of usable knowledge.

In first instance, the empirical research has found that, from the perspective of practitioners in ‘boundary organisations’, there is clearly a need for a new type of knowledge supporting sustainability policy.

Practitioners in ‘boundary organisations’ express interest in innovations that impact *how* knowledge is crafted in the science-policy interface, rather than *what* specific knowledge is expected to come out of such process. Otherwise put, experts in the field acknowledge the need for innovative approaches to their own knowledge practice. The research further reveals, in that regard, that practitioners converge on those five key elements above being essential to the type of innovations required.

Discussions with actors in ‘boundary organisations’ expose nevertheless a rather partial and inconsistent awareness of the wider frameworks and *implications* surrounding such type of innovations in knowledge practice. They also reveal important insights into specific *challenges* experts in the field face when seeking to induce such type of innovations in their knowledge practice, especially, on how feasible they are to be addressed within existing institutional cultures (see section 8.2 below).

While the need for **co-created** knowledge, involving a wider and diverse set of actors across sectors, roles, and geographies is unequivocal to experts in boundary organisations, empirical data exposes a limited awareness of institutional implications regarding (1) the shared ownership of knowledge outcomes and (2) expanded relationships with a wider and more varied range of stakeholders. In practice, the acknowledged value of expanding and reinforcing stakeholders’ engagement in knowledge practice – beyond already set formal consultative mechanisms –

collides with the institutional need to preserve independence, equidistance and credibility vis-à-vis such set of stakeholders.

Transdisciplinarity, on the other hand, is a term not commonly used by practitioners. The substance of the concept – integrating different types of knowledge(s) beyond discipline-based science – appears nevertheless implicit in many of their discourses and practices. Discussions with practitioners in the field expose however a significant resistance in their institutional milieu to acknowledge and validate knowledge originated from non-academic (non-scientific) domains. It also exposes a predominance in practice of natural science inputs as opposed to those of social sciences.

While the expression '**systems thinking**' populates many of the discourses, documents, events and conversations in 'boundary organisations', empirical data reveals a recurrent confusion between the adoption of 'more systemic approaches to knowledge practice' and a greater 'understanding or thinking about systems'. This generates, in 'boundary organisations', a disconnect in practice between (a) initiatives that seek to generate more *systemic thinking*, *systemic learning* and *systemic knowledge*, and (b) initiatives to augment the existing knowledge base on given systems. Empirical data demonstrates an explicit antagonism between practitioners in the field, in what the application of systems thinking to support knowledge practice is concerned.

Reflexivity is a term rarely used as such, although the essence of the concept is often present in practice around 'transparency' or 'quality of evidence' in knowledge for sustainability policy. Most practitioners in organisations investigated would recognise the need for greater questioning of own mental models, assumptions and biases, looking for deeper levels of (self) consciousness. Empirical findings reveal however strong resistance – both personal and institutional – to implement knowledge practices that enhance such type of introspection, transparency and exposure.

The idea of a **generative** type of knowledge practice, capable of generating continuous action loops, triggers significantly different interpretations in boundary organisations, depending on the practitioners' specific working domains. Empirical findings render it difficult to discern a preponderant perspective that could lead to institutional change or innovation in this domain.

The perspectives of practitioners on the type of innovations required in their knowledge practice are not convergent. They display a scenario of significant **ambiguity** in the field. Empirical data also indicates an apparent sense of "messiness" that goes beyond a mere lack of specific knowledge on these matters. Instead, as described by the actors themselves, it seems intrinsic to the institutional ecosystem of knowledge practice as such.

8.1.2 How do practitioners in the field relate to the notion of individual competence and need for different types of competencies to induce innovations in their own knowledge practice?

In response to research question #2, and further explored in chapter 3 above, this thesis proposes a competence-based approach to address the issue of capability in sustainability 'boundary organisations' to induce innovations in their knowledge practice.

The thesis provides an operative framework for a competence-based approach towards innovations in knowledge practice at the sustainability science-policy interface. This framework is based on a constructivist approach to the concept of competency and offers an understanding of competence as a combination of *knowledge*, *skills* and *attitudes*, *personality*, *values* and *purpose*.

The analysis of competence requirements implied in the five knowledge innovation features presented above, has led to the curation of ten key features of individual competence, deemed critical to induce innovations in knowledge practice:

a) Translating and mediating knowledge,
b) Humility, curiosity and appreciation for the unknown, coping with vulnerability,

c) Self-awareness and introspection,
d) Tolerating ambiguity, uncertainty and unpredictability,
e) Thinking systemically, beyond analytical approaches,
f) Embracing complexity and disruption,
g) Nurturing empathy, compassion and trust,
h) Visualising possible futures and design thinking,
i) Entrepreneurial and resilience capacity, and
j) Mobilising intuition and sensing.

This set of distilled competencies was used to engage in the empirical research on an analysis of existing competency frameworks and discern to what extent such different types of competencies were present therein.

Interviewed actors in boundary organisations express the lack of proper frameworks – suitable guiding documents or instruments – to help them reflect about the notion of individual competence in this context, in a more structured and oriented manner.

A deeper analysis of existing competency frameworks, found nevertheless that such type of references can be extrapolated from those frameworks, accessible within the remit of practice of 'boundary organisations'. The research therefore exposes a disconnect between the perception of individual practitioners on the existence of adequate references for competence development towards knowledge innovation, and the wider, institutional efforts carried to make those available and explicit.

Empirical data demonstrated however that reflecting on and discussing about individual competencies is a rather unchartered territory for the vast majority of practitioners involved in this research.

There is a widespread focus on discussing organisational capabilities rather than attention to individual competence development. While able to provide examples of *knowledge*, *skills* and *attitudes* required to induce innovation in knowledge practice, practitioners do not necessarily relate it to a discussion on *competence* as such.

Taken as relevant and pertinent, the type of competences listed above and discussed through the empirical work, are often perceived as personal attributes – some of them trivialised as 'obvious' – but not seen as making part of a work environment and therefore not to be confused with professional competence, subject to be developed on the job as a learned attribute.

Moreover, some of the listed competencies are still subject to discomfort, mistrust and often placed in the realm of 'esoteric' domains, not connected to day-to-day work responsibilities. Research findings reveal that not all practitioners in the field are ready and willing to engage in discussions about this type of competencies within their institutional work context, as such is perceived as inadequate.

While many of the competencies deemed critical to induce innovations in knowledge practice are observed in the field, the research found individual practitioners keep developing those in a rather intuitive and tentative ways, out of their personal drive and motivation, rather than guided or informed by organisational leadership or by existing references and frameworks. Practitioners question its worthiness and express an increasing perception of institutional inertia and maladjustment. Section 8.2 below will further present such perceptions of institutional barriers to develop and apply further this type of competences.

8.1.3 How can professionals working in the science-policy interface most effectively learn and acquire such new set of competences?

This thesis demonstrates how developing the type of competences required for innovations in knowledge practice demands significant changes in much of the usual modes of education, training, and organisational learning. In turn, given methodological and pedagogical approaches implied, changes in work *praxis* and organisational management are also required. Such combination of needed evolutions in both learning and work practices is seen by practitioners as extremely difficult to achieve within the institutional context they operate within.

This research looked for existing learning programmes, organisations or curricula able to shed some light into these considerations, and identified, from those experiences, which learning approaches, methodological choices and pedagogical principles are deemed adequate to develop competencies required to innovate knowledge practice.

While close to knowledge domains and working contexts as those of practitioners researched, these programmes display indeed a high level of innovations in pedagogical practices and learning approaches.

This research has identified a set of key learning features and principles that have been found critical to help develop the types of competencies required for innovations in knowledge practice. As described in section 7.1 above, these are strongly based on:

a) the importance of adjusting the language used and explicitly name the different type of competencies required to innovative knowledge practice
b) the emphasis put on process of learning rather than just the content of learning and the engagement of specialised pedagogical support, accordingly
c) the use of diverse, complementary pedagogical methods
d) the capacity to personalise learning strategies and respond to learner's own values and perception of needs
e) the role of experiential learning and embedment of learning in practice routines

Data collected also demonstrates that changes required in organisational, leadership and management approaches for success in these learning strategies is not always compatible with observed institutional norms and practice.

Practitioners in boundary organisations, recurrently point to obstacles that condition the implementation of such type of learning approaches and make therefore difficult the acquisition of competencies critical to induce innovations in their own knowledge practice – see section 8.2 below.

8.2 Lessons on institutional barriers for innovations in knowledge practice

This thesis demonstrates that developing the type of competences required for innovations in knowledge practice within sustainability boundary organisations demands significant changes in much of the usual modes of education, training and organisational learning. In turn, given the methodological and pedagogical approaches required – set within the sphere of 'transformative learning' – these call for changes in the working *praxis* and institutional frameworks under which experts in the field operate within.

Through the empirical research it was notable that such requirements come across as changes in organisational, leadership and management approaches, not always compatible with observed institutional norms and practice.

Practitioners operating within boundary organisations point to barriers that prevent or slow down the acquisition of such new types of competencies. Very frequently in interviews and focus groups, the emphasis was put on the lack of institutional / organisational conditions to develop and mobilise such competencies.

It was not a central part of this thesis to explore in depth what the organisational conditions are to foster the development of such type of competencies – the focus being rather on the mechanisms that can help develop individual competencies. However, findings out of the empirical journey made it relevant to point some of those institutional conditions.

One of the greatest obstacles pointed by practitioners during this research refers to this area of knowledge practice not being an institutional priority. Without such legitimacy to experiment and innovate, efforts undertaken by individuals, more often than not, get overtaken by 'business-as-usual' type of work, priorities and objectives – suggesting perspectives on possible ways forward.

Demonstrated awareness of experts on the need to transform their own work praxis, contrasts with their perception institutional inertia. Experts feel unsupported by their hierarchies, as they see no real manifestation – in practice – of deliberate, politically anchored leadership steering such type of innovations.

Through the empirical research various cases were found of individual experts using side-tracked projects and navigating the thin borders of their annual management plans to dedicate time to "innovative" projects they deemed important to advance better knowledge practice. This is done outside the spotlight of management monitoring as practitioners find (from experience) leadership wouldn't deem it a priority as part of core business.

Several practitioners observed or interviewed claimed for these areas of innovative work to be anchored in formally recognised organisational plans. That, according to many, is the only way to get a "license to operate" and feel supported when confronting the expected resistance that comes along with these innovations.

It is clear from the empirical research that enabling conditions for transformative learning and innovation in knowledge practice does require strong organisational leadership. From the perspective of experts, developing competences towards innovations in knowledge practice within the science-policy interface requires shifting priorities in this arena of work, moving from a "nice-to-have" approach into a legitimate mandate to operate.

The point above is very much linked to the lack of incentives, as perceived by experts. Interviewees claim there is no institutional encouragement for experts to dedicate time and energy to transformative learning. There are no incentives to adjust behaviours, transform attitudes, practice new skills or explore different types of knowledge.

It is important to note that *incentives* in this context are not necessarily about *financial* incentives or rewards. Incentives in this context are rather expressed through institutional acknowledgement of value, management recognition and support, higher visibility in roles assigned to this type of work, budget allocations to working area, promotions to positions of higher responsibility, participation in key stakeholder meetings, exposure to wider networking circles, involvement in strategic consultation processes, etc.

Findings through this research would also suggest these organisations learned to keep a robust set of procedures and practices, a certain *status-quo*, that enables granting credibility and reputation over the long term, despite political cycles and volatile priorities. That is particularly valuable in contexts where knowledge, know-how and technical or scientific expertise is required to be trusted.

Throughout this empirical research though experts manifested a growing concern on a perceived overdominance of risk averse management cultures. That is, to their understanding, undermining a minimum space for transformative learning, new competence development and, ultimately, innovations in knowledge practice.

This aversion to risk as perceived by experts in the field, related less to a strategic, institutional positioning of respective boundary organisations, and more to a sort of inertia, an installed inability to deal with institutional controversy, or simply an under covered management incapacity to deal with innovation-related risk.

At the same time though, experts in boundary organisations understand they can only provide quality knowledge if they innovate their working *praxis*. That requires trying new approaches, learning and prototyping new routines, processes and procedures. Necessarily, it implies failures and consequent learning from error. Such tension is well perceived in the field, and apparently bending to be discouraging rather than constructive.

As seen above in this thesis, transformative learning and knowledge innovation are definitely not compatible with *command-and-control* leadership styles and management approaches. On the contrary, they require leaders and managers to instil curiosity and entrepreneurial attitudes, to propose stretch assignments, to value learning from mistakes, to coach and mentor based on competence and talent development, to nurture critical thinking, to build complementary-based teams, to provide genuine feedback to support critical reflection, to protect niches of experimentation, to remove or minimize operational obstacles, etc.

In organisations observed, this type of leadership is far from being predominant. On the contrary, management styles appear to privilege control over pre-defined plans and expected results, leadership success being measured in terms of tangible outputs and deliverables.

Connected to this point is the acknowledgment of methodological lock-ins. Based on robust scientific, tested and validated methods, observed boundary organisations operate within relatively rigid operative frameworks. Being different to academic institutions, boundary organisations are found, however, in this regard, to be conditioned by the same science production logic as most universities or research institutions do.

Serving political institutional work (and often set within such framework), these science-policy boundary organisations are also conditioned by the logics of governance, representativeness, transparency, compliance, and accountability as much of the known public administration in Europe.

Despite the status of independent organisations, many of the interviewees reported the lack of methodological transparency on how certain content appears to gain higher prominence than others.

The combination of these factors results in a complex operative framework under which the room for innovation in knowledge practice appears to be very limited.

Another barrier identified by practitioners in the field is the narrow scope of (what is perceived as) relatively closed knowledge networks. In fact, when referring to "wide" networks, practitioners in these boundary organisations are often referring to *their* governance networks. These are for most of cases circumscribed to member states representatives and experts in the fields associated with both academic and governance institutions. As found out through the empirical work, there is little room for networks involving, for example, civil society (like youth or neighbourhood associations for example), industry or business representatives, local farmers producers or consumers, artists or entrepreneurs, NGO's, etc.

One additional concern captured through the empirical journey, was signalled by some of the practitioners around the practice of 'outsourcing of expertise'. The distance to data sources or hands-on assessment work narrows the scope of intervention by boundary organisation experts in what systemic approaches are concerned. Part of the work – the knowledge produced – is defined by established reporting mechanisms devised under linear, compartmentalised knowledge areas.

Being unable to question and experiment over alternative forms of knowledge practice, making sense of data and information in different ways, experts in this area are prevented to engage in transformative learning and therefore develop certain type of competences for knowledge innovation.

Knowledge production in boundary organisations researched is conducted through work streams managed within relatively bounded, hierarchical and linear plans – one input conducting to another in a pyramidal setting. In this framework, sequential planning approaches are valued and clarity on expected outputs is in most cases critical. Disruption is normally expected to be minimised and workflows deviating from the set plan are often considered marginal, accessory and therefore not welcome. Individuals are rather made accountable for specific parts of the puzzle than for the whole knowledge outcome as such.

The converging perception in the field is that, for as long management strategies avoid addressing these issues as important problems as such, innovations in knowledge practice within boundary organisation will hardly occur.

Finally, there is the obstacle of time-bound assignments – or yearly planning approaches. As seen in the learning programmes analysed, transformative learning – and ultimately innovations in knowledge practice – is more likely to occur in a continuum of time and space, as emerging properties of a dynamic and open system of knowledge sharing, interactions, reflection, experimentation and prototyping. Setting time boundaries corresponds in practice to determining in advance what the outcomes of these processes should be. That is the opposite, in this context, of transformative learning and innovation.

The shared perception from the field is that, in order to support transformative learning and innovations in knowledge practice, boundary organisations will need to re-design their workflows differently from traditional engineering and planning approaches. They will need to set-up workflows that are less time-bound and through which learning and innovations in knowledge develop as an on-going practice and not as a final result, a deliverable of an end product of a project.

Overall, the paragraphs above synthesize insights throughout the empirical work that point to organisational barriers or institutional frameworks that make it difficult for actors in the field to engage in learning strategies conducive of new competencies to enhance innovation in knowledge practice.

While these are not subject to the research focus under the scope of this thesis, they represent an important corpus of collected data that may offer important hints on what could be slowing down the development of new competencies and the subsequent generation of needed innovations in knowledge practice.

Such type of obstacles are not unique to the boundary organisations researched; on contrary, they are known as systemic challenges in many large organisations, especially those under bureaucratic modes of administration. Actors in the field – especially leaders in organisations researched – seem concerned and open to pointers that can help them address such challenges.

8.3 Contributions of this thesis

This research project initiated in January 2016, and was motivated by a perceived need in "real world" sustainability science-policy arenas to discuss ways forward on the quest for a so-called 'new type of knowledge'. While there was a vivid debate amongst actors in the field (including those in institutional and academic milieus alike) on what changes would be needed, it appeared no synthesis of the various contributions brought in existed. There was no convergence on "what to do" and there was hardly a body of research or literature that could bring together the needs at stake – as claimed by the actors in the field – the necessary conditions to induce innovations (or barriers preventing those) and pointers to action. Existing knowledge didn't seem to be usable, actionable as such. In the context, the whole debate about individual competence to induce innovation in knowledge practice within the science-policy space was absent.

This research project therefore sought to balance a robust understanding of the challenges and issues at stake (including the perspectives of practitioners in the field), with a constant quest for possible keys to action, and support frameworks that could be intelligible and usable in the specific context of boundary organisations operating in the sustainability science-policy interface.

This thesis integrates contributions from diverse literatures and practice perspectives in a coherent whole, with its greatest value lying precisely on such an integrated, interdisciplinary approach – the whole being more relevant than the sum of individual contributions.

Below is a synthesis of the key contributions to knowledge made by this thesis. It has:

1. <u>Synthesised five key elements of the claimed innovations required towards a "new type of knowledge".</u>

While the claim for a "new type of knowledge" in the sustainability science-policy arena was quite present in institutional discourses and international reports, no research to date had synthesised the key characteristics informing new approaches to knowledge practice. Literature on this appeared dispersed, fragmented, not connected, and not integrated. The research for this thesis engaged in an interdisciplinary and multi-faceted methodological approach to synthesise and stabilise the following five key elements informing claimed needs in knowledge practice towards a "new type of knowledge" in the sustainability science-policy interface: (1) the need for more **co-created** knowledge, (2) the need for stronger inter and (especially) **transdisciplinary** approaches, (3) the need for applied **systems thinking** in knowledge practice, (4) the need for extended and deeper **reflexivity**, and (5) the need for a **generative, action-oriented** and **response-based** type of usable knowledge. This approach required covering a broad range of scientific disciplines and knowledge.

2. <u>Provided a competence-based approach to the debate on institutional capability to induce required innovations in knowledge practice at the sustainability science-policy interface.</u>

As explained in earlier chapters of this thesis, while there was work done on the broad domain of "competencies for sustainability", there was no previous research or existing body of literature on individual competencies required to induce innovations in knowledge practice at the science-policy arena. This thesis set the argument for a competence-based approach to the discussion on institutional capability to innovate knowledge practice, especially focusing on the role of individual competencies required by practitioners in the field. It provides an operative framework for a competence-based approach towards innovations in knowledge practice based on a constructivist approach to the concept of competency and offers an understanding of competence as a combination of *knowledge*, *skills* and *attitudes*, *personality*, *values* and *purpose*.

3. <u>Proposed a list of ten differentiating individual competencies deemed critical to enhance innovations in knowledge practice</u>.

The analysis of competence requirements implied in the five knowledge innovation elements presented above, led to the identification and synthesis of ten key features of individual competence, deemed critical to induce innovations in knowledge practice: (**a**) *Translating and mediating knowledge*, (**b**) *Humility, curiosity and appreciation for the unknown, coping with vulnerability*, (**c**) *Self-awareness and introspection*, (**d**) *Tolerating ambiguity, uncertainty and unpredictability*, (**e**) *Thinking systemically, beyond analytical approaches*, (**f**) *Embracing complexity and disruption*, (**g**) *Nurturing empathy, compassion and trust*, (**h**) *Visualising possible futures and design thinking*, (**i**) *Entrepreneurial and resilience capacity*, and (**j**) *Mobilising intuition and sensing*.

While some of these may be found in work broadly associated with "competencies for sustainability", this thesis offers a deeper analysis of the meaning and application of each of these competencies at an individual level, through the perspective of practitioners, and specifically geared to induce innovation in knowledge practice at the science-policy interface.

4. <u>Rendered visible and explicit the perspectives of practitioners in sustainability boundary organisations on the innovations in knowledge practice and competencies required towards "a new type of knowledge".</u>

The synthesis of needed innovations in knowledge practice and the identification and synthesis of differentiating, required individual competencies to induce those was considered sound from a theoretical and conceptual viewpoints. However, there was to date no evidence of what sense would practitioners in the field make of it, or whether those would be seen applicable in the particular context of sustainability boundary organisations. This thesis exposed the thinking and perspectives of actors in the sustainability science-policy arena in relation to the above, including their perceptions of institutional barriers and enabling conditions towards innovations in knowledge practice.

5. Identified and analysed learning programmes deemed successful in developing the different type of competencies at stake, enabling room for wider cross-fertilisation of experiences.

This thesis demonstrated how developing the type of competences required for innovations in knowledge practice demands significant changes in much of the usual modes of education, training, and organisational learning. Actors in the field appeared unfamiliar to the type of learning programmes and approaches that could serve as references to how best develop the type of differentiating competencies to induce innovation in knowledge practice. This thesis identified, mapped and analysed existing learning programmes that can be used by practitioners in the sustainability science-policy arena. A simplified tabulated synthesis is offered as an appendix to this thesis, which is also of direct value to practitioners in this space.

6. Developed a synthesis of key features to enhance and accelerate the development of competencies required for innovation in knowledge practice.

Based on the literature reviewed and the learning programmes analysed, this thesis proposes a curated set of learning approaches, methodological choices and pedagogical principles deemed adequate to develop competencies required to innovate knowledge practice: (a) the importance of adjusting the language used and explicitly name the different type of competencies required to innovative knowledge practice; (b) the emphasis put on process of learning rather than just the content of learning and the engagement of specialised pedagogical support, accordingly; (c) the use of diverse, complementary pedagogical methods; (d) the capacity to personalise learning strategies and respond to learner's own values and perception of needs; (e) the role of experiential learning and embedment of learning in practice routines.

8.4 Limitations of this project and opportunities for further research

Key challenges and limitations of this research project were exposed in chapter 4, along with the researcher's strategies to mitigate inherent risks. Amongst them, was the difficulty to engage in a fully-fledged action-research project. The alternative approach adopted in this research has nevertheless brought significant value – including more nuanced perspectives and insights from a wider set of actors, organisations, and initiatives.

That noted, there would also be a value in a sharper action-oriented and targeted research project. That could, for example, use the empirical research field to effectively apply notions of 'transformative competencies' and 'transformative learning' in a specific learning program. Making use of the learning features curated in this thesis, the research project could assess to what extent such organisational learning strategies would bring about the desired competencies for innovation in knowledge practice.

The usability of such a type of research approach would be considerable. Its direct application in context would certainly serve to, for example, (1) craft new competency frameworks for knowledge innovation in the sustainability science-policy interface, (2) better assess experts' capability to induce innovations in knowledge practice, (3) prototype and scale-up competence-development programmes across institutional levels and countries.

Also, as explained in section 8.2 above, there was a significant set of findings derived from the empirical work that could not be adequately explored in this thesis, given they fell out of the scope of research of this project.

Through the empirical journey, data collected evidenced a series of strong arguments from practitioners in the field questioning the institutional incapacity to adapt to required innovations in knowledge practice. There were abundant indications of critical institutional barriers – or lack of organisational enablers – that prevent further advancements in knowledge innovation.

Practitioners argue that pushing innovations in knowledge practice is not an institutional priority. Without such legitimacy to experiment and innovate, efforts undertaken by individuals clash with institutional inertia. Experts feel unsupported by their hierarchies, as they see no real manifestation – in practice – of deliberate, politically anchored leadership steering such type of innovations.

Such type of obstacles is not unique to the 'boundary organisations' researched; they are known as systemic challenges in many large organisations, especially those subject to bureaucratic modes of administration. As explained in section 8.2 above, actors in the field seem concerned and open to pointers that could help them address such challenges.

The empirical journey undergone points to an unrecognised learning opportunity space which connects bottom-up experience with top-down institutional endeavours to enhance competence development.

The wealth of data collected through this project indicates there is a fertile soil for further research in the domain just described. Adequately supported by a theoretical framework around, for example, *institution theory*, and applied to the specific field of sustainability knowledge for policy, research findings in this knowledge arena could be of great value for organisations in the sustainability science-policy interface.

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APPENDICES

Appendix 1: The concept and definition of competence

The notion of competence has been subject to a wide variety of approaches, definitions, and applications. The field of research in this domain is vast and cuts across a variety of disciplines. In this appendix an overview of several approaches to the notion of competence is organized and presented.

The following excerpt from CEDEFOP's 2006 publication on the "Typology of knowledge, skills and competences: clarification of the concept and prototype" illustrates well the myriad of approaches to the term *competence* and how such diversity has been expressed in research.

> "Snyder and Ebeling (1992) refer to competence in a functional sense, but use 'competencies' in the plural. Some authors consistently use 'competency' when referring to occupational competence (Boam and Sparrow, 1992; Hendry, Arthur and Jones, 1995; Mitrani, Dalziel and Fitt, 1992; Smith, 1993) or treat the two as synonymous (Brown, 1993; 1994; McBeath, 1990). Dale and Iles (1992) distinguish occupational skills from psycho-social characteristics, but use competence and competency to describe both in discussing their role in assessing managerial skills. Hartle (1995, p.107) argues that competency as 'a characteristic of an individual that has been shown to drive superior job performance includes both visible competencies of knowledge and skills and underlying elements of competencies, like traits and motives'. Elkin (1990) associates competences with micro-level job performance and competencies with higher management attributes and, in defining 'managerial competencies for the future', Cockerill (1989) combines output competences, like effective presentation skills, with input competencies such as self-confidence. […] The few attempts to establish coherent terminology (Boak, 1991; Tate, 1995b; Winterton and Winterton, 1999; Woodruffe, 1991) have had little impact to date. Boak (1991) argues that 'competency', in the American sense, complements competence, as used in the UK occupational standards. Burgoyne (1988a) similarly distinguishes 'being competent' (meeting the job demands) from 'having competencies' (possessing the necessary attributes to perform competently). Woodruffe (1991) offers

the clearest statement, contrasting areas of competence, defined as aspects of the job which an individual can perform, with competency referring to a person's behaviour and underpinning competent performance. Woodruffe's definition is endorsed by Tate (1995b, p. 86) who warns against confusing input competencies with output competences." (Winterton, 2006)

The concept of 'competence': table of key contributions

Authors	Discipline	Contributions	Obs.
Chomsky (1987)	Linguistics	Competency vs Performance	
Watson (1912)	Psychology	Behaviourism	Influences the concept
White, R. (1959)	Psychology	Competence, motivation and behaviour	
Piaget (1967, 1987)	Psychology	Cognitive constructivism, interactionism	Influences the concept Uses the concept (with Chomsky)
Vigotsky (1978)	Psychology	Social constructivism	Influences the concept
Maslow and Rogers (1960,1970)	Psychology	Humanism	Influences the concept
Montmollin (1998)	Ergonomics	Declarative knowledge vs procedural knowledge	
McClelland, 1973	Education sciences	Assessments based on competence, not intelligence	

Gillet, P. (1998)	Education sciences	Acknowledges different contributions; anchored in cognitive psychology	
Perrenoud, Phillippe (1997)	Education sciences	anchored in cognitive psychology	
Grant et al. (1979)	Education sciences	Case studies on competence-based (higher) education (USA)	
Stroobants (1993)	Sociology of Work	From “qualifications” to “competences"	
David McClelland (1973)	Management, Business, HR	challenges the use of traditional tests (biased) and proposes testing for competence	
Gilbert (1978)	Management, Business, HR	Competence and performance, “engineering worthy performance”	
Richard Boyatzis (1982)	Management, Business, HR	Conducts extensive research on successful managers	
Specer & Spencer (1993)	Management, Business, HR	Advocates the concept	
Reinbold and Breillot (1993)	Management, Business, HR	Competence: interface between the individual and the organisation	

Other noted references:

1982	Zemke (1982)	Advocates of the concept

1983, 1989	McLagan (1983, 1989)	Competency models
1993	Dubois (1993)	Advocates of the concept
1993	Aubret et al (1993)	Analyse the notion of competence focusing on the contribution of different disciplines
1994	Rosier (1994)	4-volumes Handbook on competency frameworks
1994, 1997	Guy Le Boterf (1994, 1997)	A systemic approach to the concept of competence
1996	Hager & Gonczi (1996)	A systemic approach to the concept of competence
1996	Levy-Leboyer (1996)	Competency in working contexts
1996	Eraut, M. (1996)	Developing professional knowledge and competence; the difference between competence and competency
1998	Legendre (1998)	Builds on the cognitive constructivism influence to the concept of competency
1998	Rey, Bernard (1998)	Competence and training / learning
1999	Rothwell and Lindholm (1999)	Reviewed the competence identification, modelling and assessment literature until late 90s.
2001	Westera (2001)	Criticism: conceptual confusion
2001	Davidoff (2001)	Analyses "concept" through the perspective of behaviourism
2004	Biemans (2004)	Later developments in competence theory
2006	Hyland (2006)	Criticism: standardisation of education

2007	Hodge (2007)	Reviewed the origins of competence-based training
2007	Mulder, Weigel and Collins (2007)	Criticisms to competence-based professional learning
2010	Wesselink (2010)	Integral meaning of competence
2008, 2010, 2013	Hartig, Klieme and Leutner (2008) Shavelson (2010) Winther (2010) Blömeke, Zlatkin-Troitschanskaia, Kuhn and Fege (2013)	Recent literature on on competence measurement and assessment

The concept of 'competence': table of reviewed definitions

Mulder, 2014	Professional competence is seen as the generic, integrated and internalized capability to deliver sustainable effective (worthy) performance (including problem solving, realizing innovation, and creating transformation) in a certain professional domain, job, role, organisational context, and task situation.
Boyatzis, 1982	Boyatzis defines competence following Klemp (1980) as '...an underlying characteristic of a persons which results in effective and/or superior performance in a job' (op cit, p. 20-21). He further describes the underlying characteristic as being a 'motive, trait, skill, aspect of one's self-image or social role, or a body of knowledge...'
White, R., 1959	As used here, competence will refer to an organism's capacity to interact effectively with its environment" (p.297)
Hager & Gonczi, 1996	Competence: "… as a possession of a series of desirable attributes including knowledge of appropriate sorts, skills and abilities such as problem solving, analysis, communication, pattern recognition, etc. and attitudes of appropriate

	kinds.”
CEDEFOP, European Parliament and Council of the European Union, 2008	Ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development). or Ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development. *Comment: competence is not limited to cognitive elements (involving the use of theory, concepts or tacit knowledge); it also encompasses functional aspects (including technical skills) as well as interpersonal attributes (e.g. social or organisational skills) and ethical values.*
CIPD, 2015	'Competence' and ‘competences’ are broader concepts that encompass demonstrable performance outputs as well as behaviour inputs, and may relate to a system or set of minimum standards required for effective performance at work. The terms 'competency' and ‘competencies’ focus on the personal attributes or inputs of an individual. They can be defined as the behaviours (and technical attributes where appropriate) that individuals must have, or must acquire, to perform effectively at work.
European Commission (EPSO), 2012	Competency: “A coherent set of skills, attitudes and knowledge that manifests itself in observable behaviour and that has a predictive value towards effective delivery of a certain performance.”
Nordhaug, 1993 and 1994)	Competence is [in this article] defined as work-related knowledge, skills and abilities.
OECD, (Rychen & Salganik, 2001)	A competency is more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilising psychosocial resources (including skills and attitudes) in a particular context.

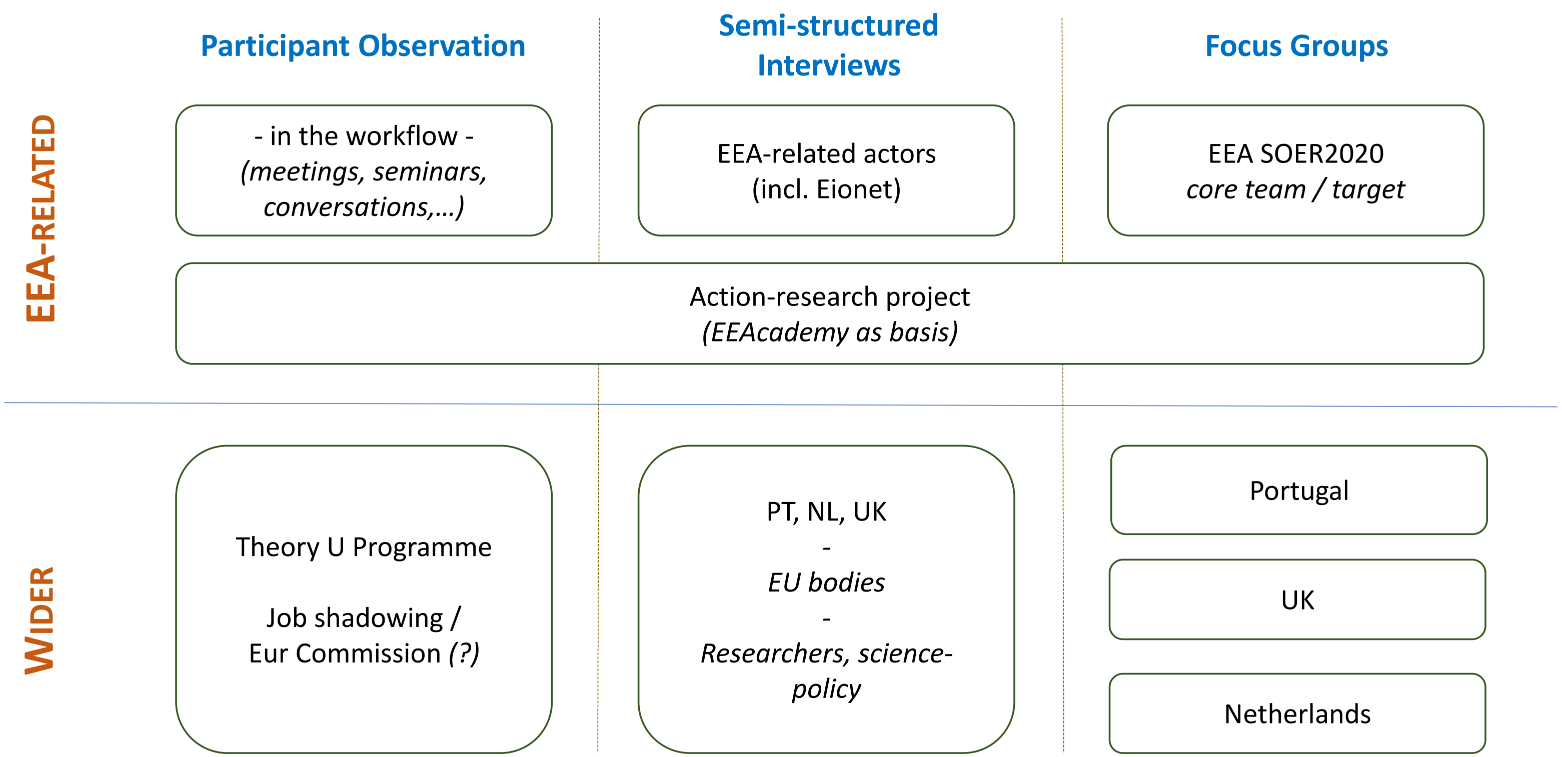
(Von Krogh & Roos, 1995)	As such, competence remains an experience-near concept which needs further conceptual clarification if it is to serve the purpose of theory building. Webster (1981) defines competence as, “The quality or state of being functionally adequate or of having sufficient knowledge, judgment, skill or strength for a particular duty”.

Additional synthesis provided by *Stoof et al. (2002)*

Mirabile, 1997	“Competency is a knowledge, skill, ability, or characteristic associated with high perfor- mance on a job, such as problem solving, analytical thinking, or leadership. Some def- initions of a competency include motives, beliefs and values.”
Parry, 1996	“A competency is: a cluster of related knowledge, skills and attitudes that affects a major part of one’s job (a role or responsibility), that correlates with performance on the job, that can be measured against well-accepted standards, and that can be improved via training and development.”
Spencer & Spencer, 1993	“A competency is an underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation. Underlying characteristic means the competency is a fairly deep and enduring part of a person’s personality and can predict behavior in a wide variety of situations and job tasks. Causally related means that a competency actually causes or predicts behavior and performance. Criterion referenced means that the competency actually predicts who does something well or poorly, as measured on a specific criterion or standard.”
Keen, 1992	“Competence [is the] ability to handle a situation (even unforeseen).” (Keen, 1992, p. 115) “Competence is a compound, made up of different parts just like the fingers of a hand [i.e., skills, knowledge, experience, contacts, values, and additionally coordina- tion which is located in the palm, and supervision, symbolized by the nervous sys- tem].”

Herling, 2000	“Human competence . . . is displayed behavior within a specialized domain in the form of consistently demonstrated actions of an individual that are both minimally efficient in their execution and effective in their results.”

Empirical research design



FEATURE	OBJECTIVE	EXPECTED OUTPUT(S)
INTERVIEWS · EEA staff · EU officials · Staff of National Environment Agencies · Sustainability researchers, consultants	The interviews seek to assess whether the propositions (5 characteristics and 10 competencies) resonate with concrete working experiences. They also aim at illustrating those concepts / ideas with examples extracted from the interviewees' specific professional contexts.	· Statements that can illustrate, substantiate the propositions · Indication of which concepts are more or less familiar / pertinent to interviewees · Indication of conditions that obstruct or enhance such type of knowledge or the development of given competencies.
FOCUS-GROUPS · Portugal · Netherlands · UK	The focus-groups aim at exploring some possible controversies around the propositions. For example whether participants agree or disagree with the relative importance of the knowledge characteristics or with the required competencies. The focus-groups also aim	· Statements that can exemplify different interpretations of the same concept or controversy around pertinence · Critical feedback on the need for such type of knowledge · List of characteristics by order or pertinence

	at digging into existing organisational / professional attempts to develop such competencies – good practices or known learning strategies.	· Indication of most relevant / needed competencies – including pointers to conditions that obstructs or enhance the development of such competencies · Indication of existing frameworks of learning strategies to develop these competencies

Participant Observation (EEA) <u>EEAcademy Winter School</u> · Team process (4+1 members) · Group of EEA participants · Group of Eionet participants · Faculty members <u>Community of Practice</u> · By design · Core group (approx. 6 members) · Full community participants <u>EEA general</u> · EEA staff members · Meetings, seminars, workshops · Ad-hoc conversations	In this context, the empirical work is mostly based on an action-research approach, the researcher being fully immersed as a subject (no declared distance, neutrality, objectivity). The objective is primarily to observe actors' behaviours and interact with them based on the framework proposed. To collect data and reflect about it under the theoretical frameworks provided. On the go, data is collected through the form of notes (observations, conversations), documents circulated, presentations run, etc. Data can be complemented with, for example:	Based on the activities described: · Systematic collection of statements and observed behaviours in context that illustrate views and meanings, aspirations and struggles, controversy,… · Set of documented evidence (such as hand-outs, presentations, recommended readings,…) that supports actors' perspectives · Interpretations by the WS team on the learning process at stake (incl. leverages and barriers) · Analysis of the replies to survey / WS evaluation emphasising the type of competencies gained (or still missed).

	· Interviews to selected pax (for example, team members) · Survey run to participants in Winter School (could be based on a simple activity ‘evaluation-form’)	

INTERVIEWEES (I)

- I.01 – EEA Expert
- I.02 – International Sustainability Consultant (former EEA staff)
- I.03 – Expert at PBL – Dutch Environment Agency
- I.04 – EEA Expert
- I.05 – EEA Expert
- I.06 – EEA Expert
- I.07 – International Researcher – Sustainability Transitions
- I.08 – European Commission Official – DG Environment
- I.09 – European Commission Official – DG Clima
- I.10 – Expert at PBL – Dutch Environment Agency
- I.11 – EEA Expert
- I.12 – International Researcher – Sustainability Transformations
- I.13 – EEA Expert
- I.14 – EEA Expert
- I.15 – EEA Expert
- I.16 – Expert at UBA – German Environment Agency

INTERVIEWS' GUIDE

Inroduction	• Introduce the scope and purpose of this PhD work. • Clarify the role of this interview in it. • Practical details: setting, duration, recording, confidentiality, etc.
Face-sheet	• State: name, gender, professional context, etc. • Would you briefly describe how do you see yourself – your role – within the "knowledge for sustainability" arena? What do you do professionally?
The broad question	• The literature points to a need for a "new type of knowledge" in what sustainability transitions / transformations are concerned. We've looked at and reviewed what researchers and main actors are saying and we found that the following core features seem to configure what that 'new type of knowledge' might be about. Knowledge that is… (1) Co-created, (2) Transdisciplinary, (3) Systemic, (4) Reflexive and (5) Generative • Do you share this perspective? How important / critical is this to your own work? In your daily work do you feel any struggle of the kind? (that the existing knowledge-base is not adequate) Could you give some examples? • Would there be any other key features that, from your own experience, seem critical to generate a new type of knowledge in the sustainability arena? • How would these features be translated into your specific working context? What would it mean, for example, to [*co-create knowledge*] or [*engage in transdisciplinary work*]?...

	• What is it that needs to change – concretely, in your daily work, in your (and your colleagues') practices – in order to achieve such a type of knowledge? • In your professional context, is there something already in place to address these? Any practical activity or process designed to generate such a type of knowledge?
The competence issue	• Within the broad community of 'knowledge players' (researchers, practitioners, policy-makers,…) there seems to be an emerging concern about '*how capable are we to generate such a new type of knowledge*'. In the frame of this research project, we have looked at it from the perspective of 'competence' – what does it take to be competent in generating such knowledge. *[display the scheme of competence = knowledge + skills + attitudes]* In our research journey, we found out that the following competencies (amongst others) appear recurrently as being critical to generate such a new type of knowledge: *[list of 10 key competencies]* • Do these competencies – or some of them – speak particularly to you in the context of your specific working environment? • What would be the most important to you, your own work in the knowledge arena? Why? • Can you give examples of concrete situations where such competencies were present / absent?

	• For most people working in the “knowledge for sustainability” arena, would you say they hold such set of competencies?
	    ○ If so, how do you believe they have built such capability? Where do such competencies come from? (school, work, exposure, innate intuition,…)
	    ○ If not, why do you believe that is? What is missing? How do people deal with it? What would people need to learn anew? What barriers are out there?
	• Do you know any reference to competency frameworks (or alike) that can help explore such a set of required competencies? Do you use any in your own professional context?

Seeking personal experiences	• Were you – yourself, in *that* context – ever confronted with a situation in which… you found it hard to… (lacking competencies) • How did you feel in such a situation? • How did you resolve the challenge?
Learning	• According to you, how could one best learn / acquire such (new) set of competencies? • What could help other people making sense of all this?
Closing	• End the interview, thank the interviewee and close it. • Re-state what will be done with the data / findings.

FOCUS-GROUPS PARTICIPANTS

Three focus-groups were organised:

- Portugal (19 participants)
- The Netherlands (7 participants)
- United Kingdom (12 participants)

In all three countries, there was a combination of profiles within the group of participants, including: (**1**) experts at respective national environment agencies, (**2**) sustainability researchers active in the sustainability science-policy interface and (**3**) sustainability consultants working for or in collaboration with national environment agencies.

FOCUS-GROUPS' METHODOLOGICAL OUTLINE

Introduction	• Introduce the scope and purpose of this PhD work. • Clarify the role of this focus-group in it. • Practical details: setting, duration, recording, confidentiality, etc.
Round of introductions	• Brief round of participants' introductions, stating name, professional occupation (if possible, specific connection with knowledge for sustainability) and motivation for this focus-group.
Brainstorm	

	• Provide key conceptual frameworks: (1) towards a new type of knowledge and (3) competencies = knowledge-skills-attitudes • In a brainstorming mode – as a "warming-up" exercise – elicit the key competencies that are required to bring about a new type of knowledge. • Note down everything. No judgement, no clustering, no filtering.
Individual work	• From your own experience / perspective, what competencies are needed to bring about such a 'new type of knowledge'? • Note down 3-5 of those in post-its. • Share with the group – stick in the board.
Collective work – the cards exercise	• Display the set of cards previously designed. • Ask participants to select the 5 most important competencies to – in their specific context – bring about a new type of knowledge. • Nurture the discussion and capture as much as possible of the different viewpoints at stake. • Contrast the results with the post-its in the board. Any relevant findings? Any competencies not considered in the cards that are critically relevant? Any additional suggestions?

Group discussion – seeking personal experiences and collective standpoints	• For most people working in the “knowledge for sustainability” arena, would you say they hold such (the adequate) competencies to bring about such a ‘new type of knowledge’?
	  ○ If so, how do you believe they have built such capability? Where do such competencies come from? (school, work, exposure, innate intuition,…)
	  ○ If not, what do you believe is missing? What would people need to learn anew?
	• Can you give examples of concrete situations where such competencies were present / absent?
	• Do you know any reference to competency frameworks (or alike) that can help explore such a set of required competencies? Do you use any in your own professional context?
	• Were you – yourself, in *that* context – ever confronted with a situation in which… you found it hard to… (lacking competencies)
	• How did you feel in such a situation?
	• How did you resolve the challenge?

Learning	• According to you, how could one best learn / acquire such (new) set of competencies? • Is your organisation striving to provide such learning possibilities? • What could help other people making sense of all this?

Closing	• End the focus-group, thank the participants and close it. • Re-state what will be done with the data / findings.

PPT Presentation at the Focus Groups

Towards a new type of knowledge for sustainability transitions / transformations – *a competence-development approach*

FOCUS-GROUP

The Hague, 10 April 2018

This focus-group is designed as part of a PhD research project at the Policy Studies Institute, University of Westminster.

ETHICS

- Your participation in this focus-group is entirely **voluntary**. You have the right to withdraw at any time without giving a reason.
- All **opinions** shared in the focus-group discussion will obviously remain **confidential** and data collected through them will be kept **anonymous**., unless explicit consent is given upon request of the researcher.
- This focus-group is going to be **recorded**. Feel free to let me know if you feel uncomfortable with it.
- You do not have to answer **particular questions** you do not wish to do so.
- Focus-group **findings** will be used for the sole purpose of this PhD project.

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AGENDA

10.00 – INTRO

10.10 – INTRODUCTION OF PARTICIPANTS

10.20 – INPUT: Towards a new type of knowledge

10.40 – Brief discussion with the group

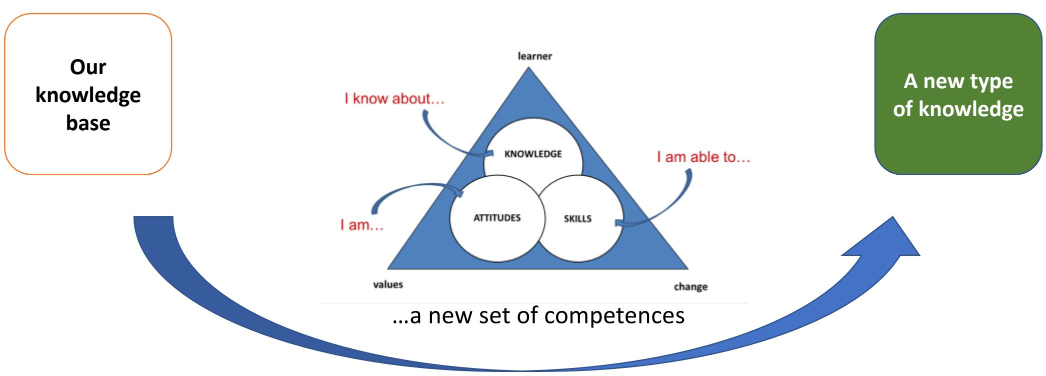
10.50 – INPUT: a competency-based approach

11.10 – INDIVIDUAL + GROUP EXERCISE

11.25 – PLENARY DISCUSSION (with guided questions)

12.00 – CLOSING

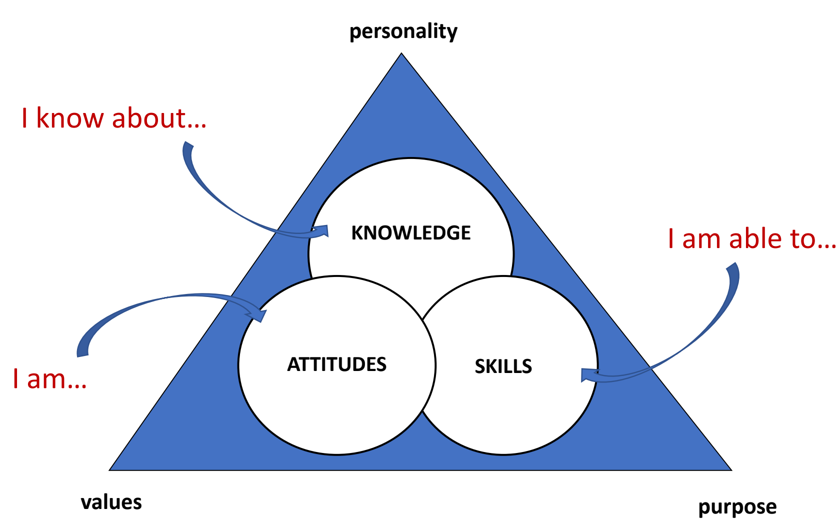
Towards a new type of knowledge



through a transformative set of learning activities

Towards a new type of knowledge

Competencies



Competencies towards a new type of knowledge

*It requires from individuals to be **capable of**…*

Name:

☐	1. **Sharing** knowledge and learn (rather than imposing knowledge), promoting distinct forms of communication among potential collaborators who have no history of talking with one another; possibly involving **translation** or **mediation** of mutually incomprehensible concepts, sets of assumptions, norms or values.
☐	2. Actively and openly **inquiring** toward other systems of thought, disciplines and worldviews and other sources of knowledge and learning, both formal and informal.
☐	3. Recognising, with **humility**, the limitations of one's own knowledge and perspectives in dealing with complex issues; being able to expose unknowns, doubts, weaknesses; coping with vulnerability.
☐	4. Nurturing an appreciation for the **unknown**, recognising the invisible / unseen behind the material, looking after own blind-spots.
☐	5. Tolerating **ambiguity**, engaging in a "both/an" rather than "either/or" type of thinking; dealing with **uncertainty** and **unpredictability** as part of a natural heuristic journey towards new knowledge.

(cont.)

☐	6. Acknowledging **oneself** as part of the system, recognising and accepting inherent partiality and bias; detecting and examining own mental models, describing own assumptions, meanings, preconceived ideas, values and beliefs, inquiring inwardly towards oneself, perceiving, recognise and map own emotions.
☐	7. Holding a **holistic worldview**, describing systems dynamics, made up of interdependent parts, understood only in their relationship to the whole.
☐	8. Embracing **complexity**, non-linear dynamics and **disruption** as informative components of (instrumental sources of knowledge about) adaptive systems.
☐	9. Nurturing **empathy** and compassion, integrating mind and heart, opening and holding spaces of interconnectedness and shared purpose; being able to connect to one's deepest source of will and intention.
☐	10. **Forward looking**, scanning horizons, building scenarios and possible futures; engaging in tentative efforts of visualisation, imagination and design thinking.

COMPETENCIES I

- Take 5 min to go through the competencies' list (both pages)

- Select the **top 5 most important competencies** to bring about this new type of knowledge in your specific working context. What are those most needed (maybe also less present)?

  Please select from 5 (most important) to 1 (least important of the top five).

COMPETENCIES II

In plenary, discuss the following questions:

- Are these competencies being tacked in your work / organisation?
- It is my perception that it is very difficult to address these type of competencies in knowledge-based organisations. Is that your perception too? If so, why is it?
- Are there any competency frameworks (you know of) addressing them?
- How do these competencies get developed? What can best help developing them?
- What programmes experiences (do you know of that) support the development of such competencies?

BEDANKT

List of EEA published documents

	Document	Date	Author(s)	Consent / Signature(s)
A1	State of Environment and Outlook Report 2015 (SOER 2015)		EEA	n.a.
A2	Multi-Annual Work Programme 2014-2018 (MAWP)		EEA	n.a.
A3	Seafood in Europe		EEA	n.a.
A4	Food in a green light – a systems approach to sustainable food		EEA	n.a.
A5	Perspectives on knowledge for sustainability transitions		EEA	n.a.
A6				
A7				

List of EEA internal documents

	Document / Activity	Document(s)	✓	Authorising Officer	Consent / Signature(s)
B1	L&D Framework 2014-2018			Søren Nielsen	
B2	EEAcademy Winter School on "IEA" (Jan 2018)	Presentation Jan Bakkes Presentation David Stanners Presentation Luis Pinto Presentation Cathy Maguire Presentation Karen O'Brien Presentation Jill Jagger Sessions handouts Background readings Evaluation synthesis		Søren Nielsen	
B3	Workshop on "Co-creation and Reflexivity" (Mar 2018)	Presentations – part1 Presentations – part 2 Sessions handouts Background readings Evaluation synthesis		Søren Nielsen	
B4	Workshop on "Systems Thinking and Assessments" (Jun 2018)	Presentation Ray Ison Sessions handouts Background readings Evaluation synthesis		Søren Nielsen	
B5	SOER Capacity-Building Workshop (Apr 2018)	Presentation Jill Jagger Sessions handouts Background readings Evaluation synthesis		Søren Nielsen	
B6	EEAcademy-ENI Summer School on "IEA" (Aug 2018)	Presentation David Stanners Presentation Luis Pinto Presentation Cathy Maguire Presentation Melchert Reudink Presentation Eva Kunseler Presentation Lars Mortensen		Søren Nielsen	

		Sessions handouts Background readings Evaluation synthesis			
B7	EEAcademy Winter School on "IEA" (Jan 2019)	Presentation Jill Jagger Presentation Luis Pinto Presentation Cathy Maguire Presentation Kees Schotten Presentation Eva Kunseler Presentation Julia Wittmayer Presentation Martin Reynolds Sessions handouts Background readings Evaluation synthesis		Søren Nielsen	
B8	EEAcademy Knowledge Innovation Lab – concept note	Concept note as presented to SMT 7th June 2019		Søren Nielsen	

List of EEA working documents

	Diary of significant events	Document(s)	✓	Author(s)	Consent / Signature(s)
C1	**2013.09.00**: EEA staff meeting. New Director (Hans B.) shares his views on sustainability transitions, systemic challenges and the need for a new type of knowledge. My question: do we have the required competencies to undertake such an enterprise?	ED presentation (PPT)	-		
C2	**2015.09.23**: Workshop on EEAcademy and L&D. First attempt to explore the competence development and L&D dimension connected to the knowledge gap.	Presentation PPT Output paper	√ √		
C3	**2015.12.15**: Follow-up work session on EEAcademy workshop in September. An attempt to trigger an "exploratory activity".	Prep Workshop – email Feedback paper Synthesis of 5 key skills Photos	√ √ - √		

C4	**2016.04.26**: Workshop on 'Foresight and Scenarios", with Ed Dammers (PBL). The difficulty to deal with uncertainty. Important note: how the work done around FLIS can be inspirational to develop some of the competencies required for a new type of knowledge. They seem to be some years ahead in what the methodological engineering is concerned.	Presentation PPT Follow-up email EEA colleague	√ √		
C5	**2016.09.13**: Conversation with EEA colleague + input to the Seafood report. First attempt to get some qualified input on the competency dimension towards a new type of knowledge.	Input to report – chap 4.1. Seafood Report	√ A.3		
C6	**2016.11.21**: Pathways workshop.	Draft Agenda + prep doc	√	Mike	
C7	**2016.11.25**: Workshop on "Systems Thinking and Complexity", with Stephen Busby. Mixed feelings: on one hand the clear perception we were tackling some of the key (deep) competencies in dealing with systemic complexity; on the other hand, the feeling we were scaring people of on the way… too much outside their 'comfort zone'.	Stephen's proposal Photos shared by EEA colleague (Attempt to Yammer)	√ √		
C8	**2017.01.12**: Come-and-Communicate. Presentation of the Seafood report from the perspective of the authors' experience.	Presentation series (PPT) Follow-up email EEA colleague	√ √		
C9	**2017.01.13**: First meeting of the Community of Practice on 'System Thinking' set-up following the workshop in Nov2016.	Luis' email setting scene Meeting report	√ √		
C10	**2017.04.11**: Conversation with EEA colleague. Extraordinary expression of struggles felt when trying to implement a more systemic approach to knowledge production. After the meeting, a K-S-A slide was drafted trying to capture some of the needs in terms of competence development.	Slides with K-S-A needs	√		
C11	**2017.05.23**: Initial meetings with new EEAcademy group - towards "winter school". Slides and Prezi are a good framing.	Prezi presentation EEAcademy slides	√ √		
C12	**2017.07.31**: Conversation with EEA colleague – first sketch of the quality of evidence proposal (incl. training).	Slide with plan	√		
	2017.08.01: Conversation with colleague - "I need to learn to deal with non-linear processes..."				

C13	**2017.08.16**: Preparation talks of the Eionet Meeting with staff of national agency. "How can we make explicit how hard it is to get this organised? How hard it is to design a programme that is innovative, participatory and that deals with people's real questions and anxieties? If only we could this frustration with them...".	Draft Programme List of pax questions	√ √		
C14	**2017.10.19**: Conversation with European Parliament staff member. The role of JRC (Policy Lab) on "Design Thinking". Also, some work around the issue of "behavioural insight". Couldn't the EEAcademy SKILL not be used a one of such projects?	JRC Toolkit (?)			
C15	**2017.11.14**: Meeting with group of EEA colleagues. The misconception on what a CoP is. Following the conversation, it seemed to germinate what could possibly be the genesis of an "exploratory activity" under the Knowledge Lab section (EEAcademy). See exchange of emails before and after.	Expl Activity slide Pursuing sustainab. (PPT) Exchange of emails	√ √ √		
C16	**2017.11.21**: "Transitions Workshop". Seeming animosity from researchers towards European Commission officer. Tendency to stick to the stereotype of the academic scientist. They feel comfortable in that conceptual habitat. The format of the session was the same as always, generating the exact same type of outputs.	WS draft programme WS Background paper Draft report – perspectives	√ √ √		
C17	**2017.11.30**: Follow-up conversation EEA colleagues. First layout of the exploratory activity (photo).	Photo	√		
C18	**2017.12.14**: Series of three meetings: WS project team, EEAcademy coordination meeting, WS steering group. Concerns from senior manager. Three key reasons: (1) too academic for the EEAcademy, (2) too close to my PhD, (3) not sure the EEA is mature enough to capture all feedback loops.	Exploratory activity: action-research project	√		
C19	**2018.01.17**: Conversation with colleague in another EU Agency. (1) introduction to the realm of OECD public sector innovation. Helps making the case for other institutional approaches to competencies, new skills, innovation, transformation, etc. (2) levels of maturity, (3) ethics and post research, (4)...	(…)			
C20	**2018.01.25**: email sent by EEA colleague to the EEAcademy faculty. Significant shift of awareness in what the (new) type of needed knowledge is concerned.	Colleague’s email	√		
C21	**2018.03.19**: conversation with EEA colleague on the new report "Perspective on knowledge for transitions to sustainability". The report mentions knowledge and	Draft report	√		

	skills, but rather looking at the outreach, not at those generating the knowledge... (As if we were detached from the whole system of transitions / transformation.)				
C22	**2018.05.28**: Workshop on "Critical appraisal of Knowledge". Important link with Reflexivity. Reflexivity goes along with transparency. Several good cases of application, incl. at the EEA. See presentation of EEA colleagues. Notes on the discussion about training and "routines".	Workshop programme Background	√ √		
C23	**2018.06.12**: NRC Industrial Pollution workshop. [Check the description sent to SBN.] To be noted: EEA colleague presentation on SOER2020. How he internalised the "quality of evidence / reflexivity" dimension. Question: who is authoring the "skills" part in the report?	Email to SBN Presentation EEA colleague	√ √		

Program / Organisation	Brief description	Main target groups	Main program formats	Relevant methodological features	Competencies addressed	Associated key learning approaches and instruments
EEAcademy Winter School on Integrated Environment Assessments / EEA	EEAcademy Schools: "(1) aim primarily at building capacity, seeking to enhance and transform the knowledge-base, through hands-on practical approaches applied to the specific working contexts or relevant content; (2) are designed as learning processes, with programmes normally conducted by joint EEA/Eionet teams, involving experts from partner institutions, academia or research communities; (3) focus on improving the know-how and professional development of knowledge actors and assessors in environmental sustainability especially those working in EEA/Eionet and EU bodies."	Primarily national administrations' and European civil servants, but consultants, students and other practitioners in the knowledge-policy sustainability arena	1-week residential program	Expert diversity in the faculty team composition, for greater transdisciplinary and systemic knowledge; Explicit balance between content robustness and a learner / learning centred approach; Competence-oriented curriculum (not uniquely based on knowledge-transfer); Combination of learning approaches during the program (from lectures, to group discussions, case-studies, exercises, simulations and networking activities); Exclusive time dedicated on Day for "how we want to learn in this program"; Intercalated, dedicated moments for 'reflection about learning and competencies' at key points in the program; Explicit, critical reflection about participants' own attitudes and interactions during the program.	Understanding the role of Integrated Environmental Assessment in the science-policy interface, methodological advancements and the challenges ahead, its principles, key features, conceptual frameworks, and assessment approaches (tools and methodologies); Complementing a 'problems' focus with a 'responses' approach – transforming the way we produce knowledge; Going from Integrated Environmental Assessment to the broader scope of Integrated Sustainability Assessment linked to the Sustainable Development Goals; Capacity to: (1) designing and framing an assessment, (2) assessing state of, trends in and prospects for the environment, (3) participatory stakeholder engagement, (4) presenting and communicating assessments, (5) seeking and including different perspectives in assessment work; Develop sense of acknowledgement and humility for the 'unknown'; Tolerance to ambiguity and uncertainty.	Presentations (PPTs); Readers; Ice-Breakers; Case-Studies; Simulation Games; Problem-Solving Exercises; Guided Self-Reflection; Group Discussion; Story Telling; Mutual Interviewing; Peer Coaching; Organised Social Gathering; Videos; Surveys and Evaluation Forms.

The School for System Change / Forum for the Future	The School of System Change seeks to serve the “emerging field of systems change, as a vehicle for connecting and amplifying spheres of learning and practice, and as a case study of an initiative grown explicitly as a system change endeavour.”	Communities of people willing to develop their skills in system change for sustainability. Participants come from a variety of backgrounds, education profiles and industries and the programme makes an efforts to breaking barriers between students and faculty, building the curriculum as a partnership between all those involved.	Programmes are normally built over a six-month learning journey, including residential seminars with field practice and online courses.	“We do not think there is one particular methodology or approach that is the “right” way to do this work. This is why we are interested in, firstly, convening accomplished practitioners to learn together; and secondly, supporting people to navigate this emerging field of system change, developing the capabilities that will be suitable to them in their specific context, rather than “teaching” them how to “do” system change. (…) We draw from numerous fields and disciplines that we see coming together in the emerging field of system change. These fields set out their own processes, language and ways of knowing and in the School we seek to hold and facilitate these multiple lenses.”	Systemic diagnosis – diagnose complex sustainability challenges using systemic approaches; Strategy design – design system change strategies and interventions; Innovation for impact – develop and realise innovative solutions that seek to create scalable and systemic impact; Collaboration and engagement – seek, initiate, build and facilitate partnerships and coalitions for change; Leadership and learning – learn and lead into complex and uncertain future.	A wide variety that includes: practicing looking at challenges in a holistic way, systems thinking and mapping, future inquiries, synthesising insights, iteration and experimentation, design thinking and interventions design, drawing and visualising, prototyping, communities of practice, deep democracy, collaborative action inquiry and action networks.
DRIFT Transitions Academy	Much of the School for System Change programmes are carried in collaboration with the DRIFT Transitions Academy. DRIFT’s relevance and approach to competence development in the arena of sustainability science-policy-society interfacing has been significant in the EU arena overall. It defines itself as a “leading research institute in the field of sustainability transitions”, developing and sharing transformative knowledge to support people, cities, sectors and organisations to engage proactively with [sustainability] transitions."	Not specific. Analysis of documentation revealed work with academic students and professionals, sustainability-related institutions, NGOs and private companies.	MA Programs; short-term or 6-month wide training courses; peer-to-peer learning programs.	The DRIFT team is an international and interdisciplinary group of researchers and advisors, with backgrounds including environmental science, innovation studies, public administration, sociology, political studies, engineering, cultural analysis and anthropology. Accorindg to DRIFT, “... our world is facing a number of persistent problems. Current approaches to solving these problems do not reach the core, but only combat symptoms. Therefore we need interdisciplinary knowledge and transdisciplinary knowledge, that is created by researchers and practitioners working together to address real-world	DRIFT doesn’t make use of a competency framework as such. However, they point to some of the learning outcomes – transformations – they’d wish to operate through participants through their learning journeys: (1) Think – deeply inquiring social change through analysing the dynamics of societal systems and actor-networks, (re)-interpreting social relations and beliefs, envisioning alternatives, co-designing strategies for active intervention and critical (self)-reflection, (2) Act – applying insights, tools and methods to real life challenges and case studies in their own context. Experimenting with solutions, establishing networks and inspiring people, (3) Change – questioning routines,	DRIFT rejects the false dichotomy between thinking and doing. "We believe that action and reflection imply and reinforce one another. In all our activities, we aim to combine deep critical reflection with applied action learning."

				problems – but we need more. (…) knowledge that is systemic, critical, generative and reflexive, with both societal and scientific impact. Transformative knowledge includes taking an integrative approach and treating systems as a whole, is supportive of the aim of grasping the complexity of current problems and critical towards the current status quo. It is generative of possible sustainable futures and related actions. Furthermore, it is reflexive in taking account of the broader context as well as our own and others' roles in knowledge co-creation processes."	challenging and altering the status quo, both in the social realm as in their own practices and perceptions.	
cChange	*cChange* is an organisation invested in offering knowledge, services and experiential tools to help people understand the potential for transformation as a deliberate response to complex challenges. cCHange goal is to empower individuals and groups with the knowledge, skills and tools to generate ethical and sustainable transformations.	Not specific. Analysis of documentation revealed work with academic students and professionals, sustainability-related institutions, NGOs and private companies.	Alongside consultancy work, talks and events, cChange promotes workshops and training courses.	Programs are conceived as "wide and open spaces for transformative learning", where participants explore "sustainability challenges and the connections between behavioural, systems, collective and individual change in a fun, positive and unforgettable way." cCHange practice clearly manifest a concern on the transformative experience of the learner, over the focus on content or knowledge transfer. It is central to their learning strategy the questioning and unveiling of own assumptions and the expansion of the so-called 'spheres of influence' through individual and collective social modelling.	Capacity to question the assumptions, habits and loyalties; Capacity to see the bigger picture and embrace different perspectives.	The unique feature developed by cChange though is the "cChallenge". cChallenge is a practical tool for individual and organisational transformation, through which participants commit to one sustainability-related change for 30 days and reflect on what it means for them, others and the bigger picture. The approach behind the cChallenge methodology is based on the perspective that transformative responses to contemporary challenges will have to question the assumptions that are explicit and implicit in current development pathways and practices.

The U.Lab / MIT, Presencing Institute	The Presencing Institute was founded in 2006 by MIT Sloan School of Management Senior Lecturer Otto Scharmer and colleagues in order to create an action research platform at the intersection of science, consciousness, and profound social and organizational change. Over the past two decades, they developed Theory U as a change framework, led cross-sector leadership, change and innovation initiatives worldwide, and created an innovation platform called U.lab. As put by its creators, "today's challenges call for profound innovation across all societal sectors; rethinking, reinventing and evolving the way we operate in our society requires a profound shift in how we think, engage and act (activating the intelligence of the head, heart, and hand)."	Governmental officials, social actvitists, researchers and community workers, entrepeneurs, corporate leaders.	U.lab is a platform that blends new tech tools, social change processes, and multi-local community building efforts. Programs tipically combine local and global initiatives and last for a period of a few months each edition - mostly online, though occasionaly with in-person muti-day residential workshops. Programs also combine a collective learning process with individual practices embedded in the daily workflow, set as routines betwen joint sessions.	The gist of the U.Lab / Theory U development framework lies of the following proposition: the quality of results produced by any system depends on the quality of awareness from which people in the system operate. The formula for a successful change process is not "form follows function," but "form follows consciousness." The structure of awareness and attention determines the pathway along which a situation unfolds.	The seven key competencies this MIT-nested programme finds essential for transformative leadership: (1) Holding the Space of Listening – the foundational capacity of transformative leadership is listening. Listening to others. Listening to oneself. And listening to what emerges from the collective. Effective listening requires the creation of open space in which others can contribute to the whole; (2) Observing – The capacity to suspend the "voice of judgment" is key to moving from projection to focused and peripheral observation. (3) Sensing – Seeing the system from the edges; (4) Presencing – The capacity to connect to the deepest sources of self—to go to the inner place of stillness where knowing comes to surface; (5) Crystallizing – When a small group of change makers commit to a shared purpose, the power of their intention creates an energy field that attracts people, opportunities, and resources that make things happen; (6) Prototyping – Moving down the left side of the U requires the group to open up and deal with the resistance of thought, emotion, and will; moving up the right side requires the integration of thinking, feeling, and will in the context of practical applications and learning by doing; (7) Co-Evolving – the need to perform at a macro level: capacity to convene the right sets of players in order to help co-sensing and co-create at the scale of the whole.	Listening; Case clinics; Dialogue interviews; Guided journaling; Prototyping; Sensing Journeys; Shadowing; Stakeholder interview; The 20-minute Dance; The Stuck Exercise; 4D mapping.

School of Creative Leadership / THNK	As self-defined, THNK is a 'school of practice' and a 'school of thought'. It was set-up to "design and facilitate transformational in-person learning experiences, to train and support global intrapreneurs and entrepreneurs in developing the mindsets, skillsets, and toolsets needed to scale their impact on the world's biggest challenges. (...) Taking the "I" out of THINK gives us the humility and freedom to innovate without ego."	Entrepreneurs, scientists, corporate executives, politicians, activists—the more diverse, the better. "We are a circle of future-builders."	Not specific. Ranging from 4-months executive leadership blended programs, to 6 or 10-weeks online programs, to 1:1 personalized coaching.	In applying their ambition towards transformative learning experiences, THNK facilitators make use of a wide variety of tools, methods and techniques . They understand this methodological combination as a central part of their work. Or, as put by THNK, "to create is to combine existing bits of insight or ideas into new material and new interpretations of the world. Einstein called this 'Combinatorial Play'." THNK positions learning towards innovation as a non-linear journey, mostly inductive in nature and with uncertain expected outputs. Acknowledging there are many insights, pointers, and tools that can help people along the way towards innovation, THNK clustered those around the four phases of the Creation Flow: (1) the Sensing phase consists of divergent and exploratory thinking, in order to get a broad and different perspective on the initial problem - it requires an explorative mindset, and works best when the natural urge to formulate a judgement, a hypothesis, or an answer is delayed as long as possible; (2) the Visioning phase paints a solution space and provides a vision, a concept, and concrete ideas to make it come alive - it consists of emergent creativity and shows a vision of 'what could be'. It allows for dreaming and designing; individual and team creativity; spontaneous ideas and slowly ripening ideas; (3) the	Not specific. Noted through analysis of their materials and conversations with some of THNK's key actors, come across competencies like: creative and design thinking, ideating, prototyping, sensing, visioning and enterpreneurial capacity.	Each of the methodological phases is filled with a series of working tools and methods that can range from reframing tools to 360º feedback, from the 'idea jackpot game' to the so-called neue kombinationen – a tool to look for innovative ideas based on new combinations. The THNK School of Creative Leadership runs heavily based on the idea of gaming as an essential part of transformative learning. They produce a significant amount of (also pedagogical) materials and resources to support their learning strategies. A good example of it is the "Eye Openers" practical guide, which collects a curated series of experiential learning games: "the games are derived from teaching tools for improvisational theatre, which trains its players to be resilient, present, and co-creative while connecting with each other and embracing uncertainty and failure."

				Prototyping phase starts with a concept and consists of ‘thinking with the hands’, a series of rapid trial and error cycles that are aimed at experimenting, leaning, and improving concepts - it encourages playfulness, falling often and cheaply, redundancy (testing different concept versions in parallel), evolution and selection; (4) the Scaling phase is still a design phase in which we ask questions: How can a “positive revolution” be inspired, triggered, and enabled? How do ideas spread and lead to acceleration at scale? How is this acceleration different from linear gradual scaling?		

Academy for Systems Change	Inspired by the work of Donella Meadows, the Academy for Systems Change is a non-profit organization focused on advancing the field of awareness-based systemic change in order to accelerate ecological, social, and economic well-being. Established as a network of individuals, organizations and other networks, the Academy focuses on cultivating thriving systems in education, marine ecosystems, business, sustainable communities, finance, and more.	Given the multi-disciplinary nature of social change, the scope of the Academy is broad and varied, cutting across multiple thematic areas and geographical boundaries, and involving individuals, teams and organizations from corporate, non-profit, government, academic and research sectors.	Not specific. Ranging from 3-year fellowship programs to intensitve, short-term workshops and webinars, to the "Learning Hives" - an interactive online video learning model, which introduces participants to tools and practices that can accelerate system transformation.	In the words of Hal Hamilton (Food Lab Co-Director and Academy Co-Founder) in relation to one of the Academy's workshops: "The fellows were brimming over with learning, reflection, community, and gratitude. Even before the first workshop, we had a lot of conversations about the personal, organizational and system dimensions of change leadership. Since these people have similar jobs in the same domain, they have a lot of experience from which to ask good questions to help one another get through stuck moments. The conversations at the workshop were sometimes strategic, sometimes tactical, and sometimes very personal."	Rather than referring to competencies as such, the program names a set of key values and principles that align their learning strategies: (1) Love and care: nurturing values that encompass self-respect, inclusiveness, tolerance, responsibility and equality; (2) Collaboration: acknowledging we can't be transformative by acting alone, we must work across geographical and functional boundaries to create more just and sustainable communities and organizations across the world; (3) Community: reaching out to communities to develop the synergies created when individuals work together; (4) Thoughtfulness: being open to new ideas and sensing our impacts on the wider system as a means of bridging to a more sustainable future; (5) Whole System Vision: learning to see, and helping others to see, the continually emerging, inter-connected nature of living systems; (6) Leadership: developing a network of Systems Leaders who can balance the personal, intellectual, emotional and social aspects of leading; (7) Thriving: imagining systems – communities, nations and ecosystems – that can regenerate and prosper in spirit and physical wellbeing; (8) Transcendence/transformation: fostering hope, which is the doorway to new action; (9) Sufficiency: challenging the myth of material growth as the answer to all problems and demonstrating the benefits that accrue when we live and work in harmony with each other and Nature.	As an example of the application of these principles into a specific learning programme comes the fellowship programme on Sustainable Food. This leadership programme was set-up including: three workshops, two multi-day learning journeys, monthly peer group calls, and one-on-one mentoring. It was designed "in a way that enables each fellow to articulate his or her specific goals, and receive support tailored to their needs." Kicking off with a "fun facts bingo game", participants got to know each other beyond their professional roles." The workshop used a combination of awareness-based systems change tools and methods, including: (1) a video on personal mastery, with a Peter Senge introducing the purpose embodied in a Stradivarius violin; (2) an inspiring story from Academy President, Darcy Winslow, who used her own experience at Nike to walk through the many leadership competencies needed to influence different types of players in a system; (3) an exercise on sustainable sourcing of agricultural products, using the US Corn Belt and Mexican barley as case examples; (4) open space sessions for participants to support one another with all sorts of challenges and ideas; (5) peer coaching groups during which fellows practiced the case clinic method.

Unlocking the Immunity to Change / Harvard School of Education	Acquiring new types of competencies requires, from a developmental perspective, significant change in behaviour. Many of the usual training methodologies fail in bringing about such type of competencies precisely because they are uncapable to overcome individuals' resistances to change. As part of their learning strategies, many expert professionals therefore seek to include methods that directly address individuals predisposition for change, so that then the acquisition of new competencies becomes at all possible. Following many years of research in the field, Professors Robert Kegan and Lisa Lahey, Developmental Psychologists at the Harvard Graduate School of Education, launched in 2009 the book "Immunity to change: how to overcome it and unlock the potential in yourself and your organisation". This book, and the methodological approaches offered, have since been serving numerous learning programs processes seeking to enhance predisposition to change towards targetter action or acquisition of new competencies.	Not specific. As observed, virtually any individual or group of people invested in enhancing pre-disposition for change.	Not specific. Can range from individual coaching to 3 hours sessions or months-long programs, depending on depth of learning, scope of expected outcomes or size og targetterd group.	The proposal of the authors includes a methodical, step-by-step approach to (1) define a given commitment to change (improvement goal), (2) describe responsive behaviours (what are we doing / not doing instead), (3) unpack hidden competing commitments and (4) discern what big assumptions underly competing commitments.	This program is mostly geared to uncover big assumptions hold by experts working in any field, which enables room for greater reflexivity towards knowledge innovation.	"Immunity Map Worksheet"; Inputs and guided reflection; Individual application; Peer coaching.

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<td>Climate-KIC Toolkits 1 / EIT</td>
<td rowspan="2">Under the EIT Climate-KIC umbrella, two toolkits have been developed to support those involved in learning programmes design and implement specific methodologies to develop competencies within their respective remits of action.</td>
<td rowspan="2">Sustainability professionals; Civil servants; Students.</td>
<td rowspan="2">Not applicable.</td>
<td>The “Visual toolbox for system innovation” (De Vicente Lopez, 2016) is in essence a booklet and a a collection of ready-to-implement tools to support innovation-related processes in the context of sustainability transitions. The toolbox aims for a systemic understanding of problems and challenges. Therefore learners “can expect this type of conceptualisation underlying every tool instead of linear process or reasoning.”</td>
<td>Visualizing possible futures.</td>
<td>The particular value of this toolbox – for the sake of this thesis – is its incontestable emphasis on visualisation (or visualising) as a learning support feature. As explained in the publication, “most of the tools have been designed as visual devices to spark creativity, systemic and lateral thinking. (...) It may take you time to feel comfortable with the visual metaphors proposed, but these techniques will help your non-linear and creative thinking (you just might need to practice a bit).”</td>
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<td>Climate-KIC Toolkits 2 / EIT</td>
<td>The “Toolkit Innovator Catalyst”, by Lydia Sterrenberg and José Andringa: of a more conventional type, the valuable contribution if this toolkit lies its explicit exposure of different learning styles and the need to chose learning methods that suit a variety of such learning styles.</td>
<td>(1) Recognising patterns: integrated thinking, questioning with an open mind, analytical thinking, conceptual thinking; (2) Reorientation: visionary and inspirational, possessing courage and the will to change, creative; historical sense; (3) Experimentation: mobilising skills, organisational talent, second-order learning; (4) Anchoring: anticipatory skills, entrepreneurial skills, powers of persuasion, networking and lobbying; (5) Monitoring: observational skills, reflective skills, self-aware and independent; (6) Transition management: systems thinking, insight, helicopter view and a sense of timing, ability to balance substance, process and results.</td>
<td>The toolkit offers a wide range of learning methods and keeps the link to the development of competencies towards innovation within the sustainability transitions framework.</td>
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