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Who is doing inter- and transdisciplinary research, and why? An empirical study of motivations, attitudes, skills, and behaviours

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ABSTRACT

We witness a persistent tension between established ways of knowledge production through disciplines, and the urgent need to widen and change, both the production of knowledge and its organization, not least, in order to be able to understand and address the future and its challenges. Witnessing a growing call for inter- and transdisciplinarity (ITD), we set our goal to learn more about scholars who engage in this kind of research by asking these questions: What characterizes inter- and transdisciplinary researchers (ITDRs)? To what extent do these characteristics help ITDRs deal with the challenges of an academic career path? We address both questions by comparing the findings from the relevant literature and semi-structured interviews with ITDRs at different stages in their careers. Our results bring the ITDR personality a step further in taking a form. ITDR personalities can be characterized by a particular mix of motivations, attitudes, skills, and behaviors. However, the academic environment and its career paths do not seem prepared and adapted for such ITDR personalities. Furthermore and in contrast to the literature, the T-shaped training (first, disciplinary depth and then, ITDR) is considered one possible career path, with the other one being a specialization in facilitating knowledge integration and in developing theories, methods, and tools for ITD. Our analysis concludes by exploring the future of ITD if formal training and learning would be available and if the contextual conditions would be more conducive to undertaking this type of research.

1. Introduction

"*We cannot resolve any of the big challenges we face in the future with just people who have sat in silos coming together. We need young professionals who have come up in this way… to see the interconnections*" (interdisciplinary doctoral supervisor, 2009, cited in Lyall, 2019).

The search for innovation in the scientific understanding of complex problems characterized by rising levels of uncertainty, the focus on societal challenges and sustainable solutions, and the demands of the knowledge society have all contributed to the

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increasing call for inter- and transdisciplinary research (Hirsch Hadorn et al., 2008). Pohl and Hirsch Hadorn et al. (2008) define interdisciplinary research as a form of coordinated and integration-oriented collaboration among researchers from different disciplines. Regarding transdisciplinarity, Pohl (2011) defines it by the specific aims that transdisciplinary knowledge production tries to achieve. Accordingly, transdisciplinary research frames, analyzes, and processes an issue so that (1) the issue's complexity is grasped, (2) the diverse perspectives on the issue are taken into account, (3) abstract and case-specific knowledge are linked, and (4) common good-oriented descriptive, normative, and practical types of knowledge to address the issue are developed. In a transdisciplinary research project, representatives of different disciplines, of the private and the public sectors, as well as of civil society, co-produce knowledge on an issue, trying to match items (1)–(4).

The use of the concepts of inter- and transdisciplinarity (ITD) has spread among several scientific communities and a range of research topics (Klein, 2004; Pohl, 2011). These communities are diverse and not paradigmatically disciplined on theoretical and methodological levels; however, they share epistemological values and a common interest in the analysis and the understanding of teaching and research practices beyond disciplinary limits (Darbellay, 2015).

ITD does not comprise consensual conceptions, and the definitions used depend on the scientific community that applies each concept (von Wehrden et al., 2019). In the present study, we have opted for an aggregated reference to these concepts. The same rationale is used by Darbellay (2015) and found on Network for Transdisciplinary Research website (www.transdisciplinarity.ch). Contrary to the common approach that strives to define and distinguish the features of ITD, we seek to identify ITD's common ideas around the opening or transgressing of disciplinary boundaries (Darbellay, 2015; Hirsch Hadorn et al., 2008). Therefore, in focusing on the characteristics and the career paths of researchers working beyond individual disciplines, we use an aggregated reference for ITD research.

The current structure of academia is based on disciplines (Connell, 2019); as Hirsch Hadorn et al. (2008, 27) explain:

> Disciplines shape scientific research by forming the primary institutional and cognitive units in academia, on which the internal differentiation of science into specialized curricula, professions, and research is done. Members of a discipline communicate within their community, share basic assumptions and examples about meaningful problems, and set standards for reliable and valid methods, as well as establish what is considered a good solution to a problem. What modern science gains and preserves is based to a large extent on disciplinary structures.

Disciplines have often been found to be essential yet insufficient in addressing 21st-century challenges, particularly in shaping sustainable futures (ICSU & ISSC, 2015). As Gilbert (2016, 192) points out, "[e]verything is now … deeply entangled, inter-connected, unpredictable and open …. 'Reality' is incomprehensible via the traditional disciplines, which rely on reducing the system to a selection of discrete units, inevitably leaving out key aspects." This means that continuing to build universities according to disciplinary divides may be unwise or—following Sardar's definition of "post-normal times"—even unhelpful in dealing with the multiple "ignorance" of our time that "[u]nlike ordinary ignorance, which is a void to be filled by research and knowledge, … requires radically new ways of thinking" (2010, 440). Significant reflections on the knowledge needed to shape futures also come from institutions concerned with the role of innovation and technology. The Organisation for Economic Cooperation and Development (OECD, 2016) finds that significant features of technology development require cross-disciplinary institutional spaces, and while many OECD-member countries increasingly support such spaces, more efforts should be made to overcome long-established mono-disciplinary institutional and organizational arrangements for funding and undertaking research and development that inhibit cross-disciplinary initiatives.

A review of major European research universities' attitude toward interdisciplinarity (Wernli & Darbellay, 2016) reveals the persistent tension between the historically established ways of knowledge production through disciplines and the urgent need to broaden and often change both the production of knowledge and its organization. Not the least, to be able to understand and address the future and its challenges, "[the League of European Research Universities (LERU)] believes many of the most pressing societal and scientific challenges, as well as exciting avenues for research and innovation, are situated at the juncture of academic disciplines" (Wernli & Darbellay, 2016, 8). There is equal recognition that future challenges require the collaboration and the contribution of perspectives other than academic (EEA, 2016), as illustrated by the latest report on biodiversity loss by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.[1] Moreover, future studies and futures literacy—tasked with the role of helping to engage with, anticipate, and use possible or probable futures—have long depended on ITD practices and capabilities. The *futures field* is an interdisciplinary domain of inquiry, involved in complexity, contradictions, uncertainty, and richly interconnected themes (Gilbert, 2016; Sardar, 2010; Slaughter, 1995); problem oriented and epistemologically diverse in its practice (Inayatullah, 2008; Voros, 2001); and deeply engaged with actors and thinkers outside academia (Urry, 2016). Many of these scholars agree that the current universities are not fit for the intended purpose as they are called to "play a critical role in building capacity to design responses to the challenges characterising this century" (Slaughter, 2012, 123), and ITD is a critical dimension in bridging the gap.

This situation explains the wide and rising interest in ITD research, both within and outside universities, yet today, embarking on ITD research requires significant courage and entails risks, as well as opportunities, for a scholar's career advancement. This research aims to explore a specific and (we argue) prescient question. If disciplines still form the basis of academic endeavor and organization, how do individuals become inter- and transdisciplinary researchers (ITDRs)? We hope that the answer will help contribute both to more ITD research that is essential for sustainable futures and to the ongoing reflections on the future of universities as important

[1] https://www.ipbes.net/news/ipbes-global-assessment-preview.

players in the production of knowledge and ideas that shape the future (UNESCO, 2014). Our two research questions are as follows:

1) What characterizes ITDRs?
2) To what extent do inter- and transdisciplinary characteristics help ITDRs deal with the challenges of an academic career path?

To answer these questions, we interviewed some researchers who call themselves ITDRs and compared the results of this empirical study with the characteristics described in previous studies focused on ITDRs (for more details, see Section 2). We have structured the remainder of this paper as follows: In Section 2, we provide a snapshot of the literature that characterizes researchers developing ITD research. The description of the empirical work and the results obtained are presented and discussed in Sections 3 and 4, respectively. Section 5 focuses on our results' implications for the future development of ITD, as well as for the future of the knowledge produced and promoted by universities and how this matters for human beings' collective capacity to respond to the challenges of this rapidly changing century.

2. Who are inter- and transdisciplinary researchers (ITDRs)?

To the best of our knowledge, only a few studies (Augsburg, 2014; Fam, Smith, & Cordell, 2017) have focused on understanding how a researcher identifies oneself as an ITDR, not as a discipline-based researcher. Given the focus of our research on *how* individuals become ITDRs, we have opted to review the studies that explicitly target the characteristics and the trajectories of individuals dedicated to ITD research.

The first part of this section focuses on the characterization of individuals who are engaged in ITD research. From this overview, our aim is to probe if these characteristics are observed in the empirical data collected. The characterization of ITDRs presented in Table 1 is divided into two parts: 1) the drivers for ITDRs (i.e., motivations) and 2) the kinds of abilities (i.e., skills) and attitudes that these researchers should possess. The second part of this section highlights the ongoing discussion regarding the behavior and the challenges of ITDRs in academia (Table 2). This overview provides the analytical framework for our empirical study and contributes to addressing our second research question regarding the extent to which inter- and transdisciplinary characteristics help individuals deal with the challenges of an academic career path.

2.1. Characteristics of ITDRs

In terms of motivations, ITDRs presuppose an individual ethical mindset reflecting a desire to improve society and contribute to the advancement of the common good (Augsburg, 2014). Augsburg (2014) distinguishes between extrinsic and intrinsic motivations. The former includes possible rewards or anticipated benefits; the latter focuses on the desire to engage with issues in the non-academic world that do not seem to lend themselves to easy solutions using traditional approaches. Montuori (2013) refers not only to intrinsic motivation but also to joy, passion, and emotion linked with the transdisciplinary inquiry that emerges from a felt need to go beyond some of the limitations of more traditional disciplinary academic approaches and certain established ways of thinking. Montuori (2013) relates transdisciplinary inquiry to the meaning of life and how people live together: "What I am looking for in the process of my inquiry is always returning to its applications and implications for my life, … for how we, as human beings, make sense of the world, how we live our lives together … grounded in experience, and the possibility of making a difference" (225).

With respect to skills and attitudes, several authors refer to openness and tolerance about ideas opposed to one's own, acceptance of the unknown, adaptability, and flexibility (de Freitas, Morin, & Nicolescu, 1994; Nicolescu, 1999). ITDRs are willing to learn from other disciplines and adopt a humble attitude toward the immensity of knowledge. They overcome the sense of being threatened by means of an inwardly felt need for other points of view (de Freitas et al., 1994; Bruce, Lyall, Tait, & Williams, 2004; Wall & Shankar, 2008). Jacobs and Nienaber (2011, 674) define this attitude as a "modest positionality," which they describe as the capacity to admit that "it is impossible to ever perfectly solve or understand an issue completely." Curiosity and creativity have been identified as the main traits of ITDRs (Augsburg, 2014; Bruce et al., 2004; Fam et al., 2017; Giri, 2002; Montuori, 2012).

An intertwined question is how someone starts to think and feel as an ITD individual. The literature shows that identifying when such an attitude begins is similar to trying to understand what comes first—the chicken or the egg. Fam et al. (2017) conclude that transdisciplinary competencies must be cultivated even though some characteristics might be innate. Montuori (2013) postulates that the emergence of a transdisciplinary attitude may be linked to the individual's cultural context and personal experience. Hirsch Hadorn et al. (2008) identify the need for a transdisciplinary attitude so that transdisciplinary teams are able to deal with the inherent heterogeneity existing in these research modes. As a result, we are confronted with a "transdisciplinary paradox"; the individual heterogeneity that occurs in transdisciplinary teams is at the same time a source of both richness and inefficiency due to the time needed to reach agreements (Hirsch Hadorn et al., 2008).

While scholars are still debating on whether the skills for ITD can be acquired and inculcated, several authors have attempted to list them. We summarize their key contributions in Table 1. The ITD skills and qualities include the capacity to build bridges and networks and develop good communication and listening skills (i.e., the capacity to engage in meaningful dialogue that suspends one's point of view); the ability to absorb information (Bruce et al., 2004; Fam et al., 2017; Giri, 2002; Jacobs & Nienaber, 2011; Nicolescu, 1999); the capacity to integrate knowledge, think in a complex and interlinked manner, and relate to the logic of complexity (Godemann, 2008; Jacobs & Nienaber, 2011); the ability to locate and work with pertinent information, compare and contrast different methods and approaches, clarify how differences and similarities relate to a designated task, and generate a synthesis, an integrative framework, or a more holistic understanding of a particular theme, question, or problem (Klein et al., 2008); the

Table 1
Review of the characterization of inter- and transdisciplinary individuals.

Topics	Title	Details	References
Motivation	ETHIC	Individual ethics, a desire to improve society and contribute to the advancement of the common good	Augsburg (2014), Bruce et al. (2004), de Freitas et al. (1994), Fam et al. (2017), Gibbons and Nowotny (2001), Giri (2002), Godemann (2008), Hoffmann et al. (2017a, 2017b), Jacobs and Nienaber (2011), Klein (2004), Montuori (2012, 2013), Nicolescu (1999), Robinson (2008), von Wehrden et al. (2019), Wall and Shankar (2008)
	REWARDS	Extrinsic motivation for rewards or anticipated benefits	
	REAL-WORLD PROBLEMS	A desire to engage with societal issues that do not primarily emerge from disciplinary journals or academic discourse alone	
	FULFILMENT	Grounded in experience and the possibility of making a difference in the life of the researcher and those of others	
Attitudes and skills of individuals	OPENNESS	Recognition of the existence of different levels of reality governed by different types of logic. Openness to myths and religions. Acceptance of the unknown. Ability to take on new ideas. Absolute respect for the collective, replete with shared knowledge and understandings, ability to look beyond one's own disciplinary boundaries.	
	TOLERANCE	Tolerance of ideas opposed to one's own. Ability to build networks within the realm of the "unfamiliar." Capacity to engage in meaningful dialogue that suspends one's point of view.	
	REFLEXIVITY	Rigor in argument. Capacity for disciplined self-reflexivity.	
	MODEST POSITIONALITY	Ability to admit that it is impossible to ever perfectly solve or understand an issue completely. Humble attitude toward the immensity of knowledge.	
	CREATIVITY	Individual creativity.	
	CURIOSITY	Permanent inquisitiveness. Curiosity about and willingness to learn from other disciplines.	
	FACILITATOR	Commitment, connectedness, good communication and listening skills, flexibility, adaptability, capacity to build bridges	
	INTEGRATION AND COMPLEXITY	Capacity to absorb information. Ability to reflect on knowledge integration processes. Ability to think in a complex and interlinked manner and relate to the logic of complexity. Ability to locate and work with pertinent information, compare and contrast different methods and approaches, clarify how differences and similarities relate to a designated task, and generate a synthesis, integrative framework, or more holistic understanding for a particular theme, question, or problem	
	AWARE	Societal conscience and awareness	
	CRITICAL THINKING	Metacognitive skills that enable lifelong learning, including critical-thinking skills, learning on demand, and self-directed learning	
Attitudes and skills of teams	TEAM MANAGEMENT	Ability to manage and work in a team	Augsburg (2014), Bruce et al. (2004), Hoffmann et al. (2017b), Hollaender et al. (2008), Pohl and Hirsch Hadorn et al. (2008), Robinson (2008), von Wehrden et al. (2019)
	FACILITATE COMMON LEARNING	Capacity to promote learning amid the diversity of participants and to explore and clarify their differences so that dialogue and collaborative integration can occur. Overall interest in facilitating common group learning and problem solving in ITD projects	
	SOCIABILITY	Ability to build good working relationships with team members	
	LEVEL HEADED	Capacity to understand theoretical and methodological issues surrounding inter- and transdisciplinary research questions	
	CONFLICT RESOLUTION	Ability to create synergies, resolve differences, and enable compromises among project participants	

metacognitive skills that enable lifelong learning, including critical thinking, learning on demand, and self-directed learning (Klein et al., 2008); the capacity for disciplined self-reflexivity (Godemann, 2008); and finally, the ITDRs' ability to distinguish themselves for having a powerful social conscience and awareness (Giri, 2002; Jacobs & Nienaber, 2011).

In exploring ITDRs' skills, an important distinction is made between individuals and teams because ITD research is essentially a "team science" (Wernli & Darbellay, 2016, 12). Whereas Nicolescu's overall work focuses on transdisciplinary selfhood, other authors concentrate not so much on individuals, individual behavior, or personal experience but on group function, process, and dynamics

Table 2
Review of the behaviors and the challenges of inter- and transdisciplinary individuals.

Topics	Title	Details	References
Behaviors	RISK TAKERS	Intellectual risk takers, confident enough in their own roles and professional identities to respect one another as equals and to share responsibilities, knowledge, and autonomy with others	Augsburg (2014), Fam et al. (2017), Gibbons and Nowotny (2001), Jacobs and Nienaber (2011), Klein et al. (2008), Nicolescu (1999), Robinson (2008), Stokols (2014), Wall and Shankar (2008)
	TRANGRESSION	Transgressive approach to knowledge and particularly to knowledge institutions, especially the university, since transdisciplinarity challenges the university modus operandi of disciplinarity. Engagement in new modes of thinking and taking action.	
	PRACTICAL	Co-producers of new hybrid forms of knowledge, issue driven, and prefer practice over theoretical or epistemological claims	
Challenges	SOLID DISCIPLINARY BACKGROUND	Need to have a qualification in a discipline or a profession to acquire a solid background before crossing boundaries between disciplines	
	RECOGNITION FIRST	Pursue ITD when well-grounded in a discipline/field/topic	

within teams (Augsburg, 2014; Hollaender, Loibl, & Wilts, 2008). In this case, the group identity needs to be cultivated by the team management throughout the duration of a specific project (Bruce et al., 2004; Hollaender et al., 2008; Robinson, 2008; von Wehrden et al., 2019). Pohl and Hirsch Hadorn et al. (2008) recognize the importance of learning more about the diversity of the participants' perspectives and of exploring and clarifying their differences so that dialogue and collaborative integration can take place within a group or a team. The overall interest is to facilitate common group learning and problem solving in ITD projects. This type of collaboration involves mutual trust, personal chemistry, and a feeling of safety (Augsburg, 2014; Hollaender et al., 2008). Hollaender et al. (2008) and Hoffmann, Pohl, and Hering (2017) describe the set of skills needed to manage ITD projects. Therefore, ITD managers must develop the following: a) social skills to build good working relationships with team members, b) communication skills to stimulate information flow and knowledge exchange, and c) cognitive skills to understand the theoretical and the methodological issues surrounding inter- and transdisciplinary research questions (Hollaender et al., 2008). Successful management is linked to developing an active role in conflict resolution within the team, facilitating moderation among the different members' viewpoints and motivations, creating synergies, and encouraging mutual adjustment and compromise among project participants (Hollaender et al., 2008; Hoffmann et al., 2017a; Hoffmann, Pohl, & Hering, 2017; von Wehrden et al., 2019).

However, the team dimension should not be reduced to individual skills and qualities; both play an essential role in ITD research. In line with Nicolescu's (1999) focus on the individual, Jacobs and Nienaber (2011) attempt to take the transdisciplinary discourse beyond the team model to examine the role of the individual and the internalization of transdisciplinarity as a mindset beyond collective models. Additionally, Jacobs and Nienaber (2011, 672) argue that "there will always be some individuals who are more prone to embracing this 'transdisciplinary profile'… and others who are more prone to achieving depth and specificity …. The two are not mutually exclusive." Stokols (2014, 61) furthermore realizes that collaborative orientations can be "defined either as individual- or group-level constructs" and concludes that more attention should be paid to the two dimensions since both have been under-researched.

Similarly, Wernli and Darbellay (2016) acknowledge the existence of ITD individuals who are able to develop competencies in more than one discipline and of individuals involved in collaborative research who are experts in one discipline but need a particular set of skills to be able to work in ITD teams or in team science. Therefore, the authors call for the need to create conditions and opportunities above the bachelor-degree level for ITD.

2.2. ITDRs' behaviors and challenges in their academic path

The ITDRs' characteristics (Table 1) provide a first starting point to answer our research question on career paths and the extent to which ITD characteristics help address the challenges of establishing a career. A second starting point comprises the ITD individuals' behaviors and challenges (Table 2). Some authors refer to the ITDRs' need to engage in new modes of thinking and taking action, which entail changes in behavior. Risk is a common theme; Wall and Shankar (2008, 552) observe that transdisciplinarians are "intellectual risk takers, confident enough in their own roles and professional identities to respect each other as equals, and share responsibilities, knowledge, and autonomy with others." Gibbons and Nowotny (2001) identify a behavior that goes beyond risk taking. In their view, ITD is a transgressive approach to knowledge, as well as to knowledge institutions, mainly universities. ITD challenges the university modus operandi of disciplinarity (Gibbons & Nowotny, 2001; Hirsch Hadorn et al., 2008). Those who engage in ITD, particularly junior researchers, reap lower career rewards by participating in these projects and are more intellectual risk takers (Augsburg, 2014). If they are not sufficiently established in their own research programs, by transgressing the academic convention, they put their careers at risk (Robinson, 2008). Robinson (2008) notes that ITDRs tend to find themselves in the uncomfortable borderlands between academia and the wider world; they are inclined to start from real-world issues and move into the arena of scholarly knowledge. Moreover, their interest lies more in reaching across disciplines for a particular purpose. Therefore, they are co-producers of new hybrid forms of knowledge, are issue driven, and prefer practice over theoretical or epistemological

claims (Robinson, 2008). Subsequently, Fam et al. (2017) identify the need for a commitment to creating change, as well as perseverance, tenacity, and a level of stubbornness to challenge the status quo, mainly within academia.

Scholars' intellectual orientation and inclination to engage in cross-disciplinary research are cumulatively influenced by the educational environments, multiple mentors, and collaborative opportunities that they encounter over the course of their careers (Stokols, 2014). Fam et al. (2017) conclude that many of the skills and the dispositions of ITDRs can be grouped into two broad categories: operational and innate characteristics. Some characteristics, such as communication and pattern-recognition skills, are operational in nature, whereas others, such as creativity and curiosity, require experiential learning and/or are innate characteristics of an individual. Curricular strategies designed to promote an ITD orientation among undergraduate and graduate students have been put in place in several academic contexts worldwide (Klein, 2010; Stokols, 2014). However, there is a limited level of consensus about which skills might be successfully taught (Fam et al., 2017). Besides the content of inter- and transdisciplinary academic training, the question is raised regarding when this type of training should be introduced. Nicolescu (1999) considers both necessary conditions, a qualification in a discipline or a profession and openness to accessing other fields. In line with this perspective, Jacobs and Nienaber (2011) argue that for ITD to occur, an individual needs to be embedded sufficiently in a discipline to know that the discipline is in itself diverse and heterogeneous. In fact, the generally acknowledged top recommendation for students involves crossing boundaries between disciplines and taking a broad range of courses while developing a solid background in one discipline (Klein et al., 2008). The educational typology described by Klein et al. (2008) is explained in terms of a quadrangulation of disciplinary depth, multidisciplinary breadth, interdisciplinary integration, and transdisciplinary competencies (i.e., T-shaped training). The interest in cross-disciplinary approaches is found in a wide range of scientific communities (Stokols, 2014). For example, Robotham, Raine, Nates, and White (2013) describe a T-shaped training program following a bachelor's degree for engineering designers. Tranquillo (2013) also advocates for the provision of these types of education to the broader group of students in science, technology, engineering, and mathematics. The same call is also found in other fields and disciplines, including natural resource management, computer and information sciences, and innovation studies (Barile, Saviano, & Simone, 2015; Kaspersma, Alaerts, & Slinger, 2012; Sanchez, Ruddell, Schiesser, & Merwade, 2016).

Despite the cited findings, the required/desired level of students' disciplinary grounding and depth is disputed in the literature. For example, Tranquillo (2013) claims that the current trials of T-shaped education are still failing because they do not focus on the linkages between teaching depth and breadth and because these subjects are mostly taught separately. A common controversy in several academic contexts is whether specialized disciplinary training is an essential prerequisite for and should always precede an individual's efforts in cultivating ITD competencies (Stokols, 2014). Furthermore, T-shaped recommendations underpin a specialization in at least one discipline, while the rapidly growing field of team science is focused on improving the effectiveness of future collaborations between academics and societal actors (Bammer, 2013; Stokols, 2014). Bruce et al. (2004) report the ITDRs' common view that attitudes are at least as important as disciplinary depth and specialization for the successful undertaking (and especially coordination) of inter- and transdisciplinary research projects. In discussing the issue of individual embeddedness in a discipline, Jacobs and Nienaber (2011) recognize that someone loses track of one's own discipline and struggles to find time to prioritize 'deep' knowledge acquisition if too much time is spent on trying to work with people from other disciplines or sectors. Therefore, the common criticism of ITD regarding the less intense disciplinary depth of ITD (years of experience and deep knowledge acquisition in a specific field) needs careful consideration. Jacobs and Nienaber (2011) argue that this is a question of how individuals decide to build their careers; some become committed to a narrow set of disciplinary goals and depth in a specific issue only, whereas others are energized by more generalist topics, yet both routes are considered necessary.

Despite the many different perspectives on the disciplinary depth and breadth required and/or desired for ITD careers, there is a certain agreement that choosing an ITD path does not appear to offer the same career opportunities compared to opting to be based firmly on disciplines. In the INTREPID (interdisciplinarity in research programming and funding cycles) Policy Brief on 'Exploring Interdisciplinary Careers,' based on interviews and workshops, Lyall (2019), 3) finds that even "ITD enthusiasts recognized that most universities are not well structured to support these types of careers," referring to both epistemological challenges and very clear institutional barriers to such careers. Wernli and Darbellay (2016) call for attention mainly at an early stage of an ITD research career, with the current system for promotion and tenure preventing ITDRs from gaining recognition. Related to this issue is the common conception that ITD is reserved for tenure-track professors who have mastered their disciplines (Brown, Deletic, & Wong, 2015; Jacobs & Nienaber, 2011; Wernli & Darbellay, 2016). Wernli and Darbellay (2016) observe the need to reconsider and adapt current researchers' careers to incorporate those who have been devoted to ITD since an early stage. The LERU recognizes that ITDRs often face a multiple load of teaching, administration, and committee duties, particularly in cases where reporting lines are unclear. This situation may result in the considerably decreased time available for conducting research.

A further challenge beyond the academic system is that the roles and the responsibilities of researchers and practitioners within ITD have been neither sufficiently discussed in the literature nor reflected in research practices (Hoffmann et al., 2017a, 2017b; Jahn, Bergmann, & Keil, 2012). Hoffmann et al. (2017a) state that transdisciplinary integration requires professional competencies, management skills, and enough time. Recent findings indicate that ITD project leaders should focus their time on developing the competence and the skills required for knowledge integration rather than concentrating on acquiring in-depth knowledge within a specific discipline or field of study (Stokols, 2014), as it is highly unlikely that these leaders could possess all the subject expertise relevant to ITD projects. This point has major implications for science funding policies, which tend to avoid differentiating, in terms of the available time and overall funds, between single discipline and ITD-based approaches in response to standard calls (INTREPID, 2017).

This overview of the literature on ITD research and researchers' skills and behaviors (Tables 1 and 2, respectively), as well as the discussion on the links and the implications for careers and organizational structures, provides the essential analytical framework for

the following analysis and discussion of our empirical work.

3. Materials and methods

In March 2016, a two-week field trip to Switzerland was undertaken to interview individuals formally engaged in ITD (e.g., those who include in their curriculum vitae an explicit reference to ITD and consider themselves ITDRs). The interviews were financed by a Short-Term Scientific Mission (STSM) under the cost action INTREPID. INTREPID is a 32-country network whose overall aim is to gain a better understanding of how more efficient and effective interdisciplinary research in Europe can be developed in the future.[2] From the INTREPID network, we selected a leader for ITDRs as the host institution for this STSM. Previous to the field trip, a list of potential participants (16 in total) was built in collaboration with a local host to assure diversity in academic status, gender, and age. The list of potential participants solely included researchers with an explicit link to the transdisciplinary concept. Prior to the interviews, the prospective participants were informed about the study goals and the INTREPID cost action. Most importantly, they were asked if they considered themselves ITDRs; all 16 potential participants did. The interviews were then arranged by email before the field trip. Due to unavailability of 4 recruits during the dates of the visit, only 12 were interviewed. The 12 interviewees worked in 5 different institutions; 5 were researchers in the host institution, and 7 were employed in other institutions.

A general interview guide was used to ensure that the same general areas of information were collected from each interviewee (Gall, Gall, & Borg, 2003). Nonetheless, each interview was adapted based on the contents of each interviewee's publications and the information from his or her CV, which was obtained through an online search. The adaptation of the questions to the interviewees' profiles allowed a more personal approach, which reportedly increases an interviewee's interest in the interview (Turner, 2010). All questions were open-ended, and the same interviewer conducted all 12 interviews. The interview guidelines were divided into six sections:

1) *Personal background.* This section included questions directed toward understanding how and when the interviewees' interest in ITD started. We also tried to understand whether the interviewees' career satisfaction and personal happiness were specifically related to their involvement in ITD. Information from their CV, where available, was used to ensure that the participants recalled as far back as possible their connection to ITD.
2) *Understanding ITD concepts from the interviewee's perception*. The questions in this section were aimed at collecting each interviewee's perception and definition of ITD concepts. The information collected from the publications of the interviewee as the first author was used as a guide. This adaptation allowed the identification of possible evolutions in the understanding and the use of the concepts.
3) *Leadership*. The fact that we were targeting individuals in well-known institutions within the ITD community would partially explain the inclusion of this section. We wanted to understand if the interviewees considered themselves leaders of ITD development, either by being part of a specific institution or by individually taking a leadership role.
4) *Putting ITD into practice.* The goal of this section was to obtain more detailed information on the researchers' routines.
5) *Funding.* This specific section on the funding of research activities was included to ensure that the interviewees would reflect on this component. The questions included those addressing issues about research funding, jobs, and career opportunities.
6) *Obstacles.* Considering the well-reported difficulties in developing ITD, this section aimed to grasp the participants' perceptions about the existence of obstacles and whether these obstacles affected their research activities, as well as their professional and personal lives.

The interview guide was developed on the basis of the insights obtained from our extensive literature review and the condensed findings, as shown in Tables 1 and 2. Given our main research questions, the interviews were developed in a way that encouraged the interviewees to express their own motivations, attitudes, skills, and behaviors in ITD.

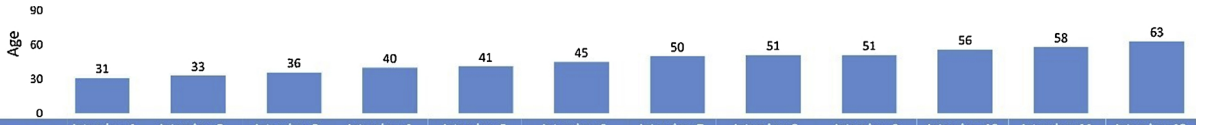
All interviews were audio recorded, transcribed, and coded thematically. For the present analysis, only those passages dealing with the interviewees' paths toward ITD, motivations, skills, attitudes, and behaviors were considered. We were able to retrieve the data used in the present analysis from all sections of the interviews although most of the selected excerpts were derived from sections 1 and 2 (mainly for identifying motivations, attitudes, and skills) and sections 4 and 6 (where challenges and behaviors within academia were discussed).

Each of the 12 interviews lasted between 1 and 2 h. No time limitation was imposed, and each interview was finished when the interviewee had replied to all questions in the guidelines. The youngest and the oldest interviewees were 31 and 63 years old, respectively, and 7 of the 12 participants were female (Fig. 1). Of the 12 interviewees, 10 had PhD degrees, 4 were engaged in project management, 5 held leadership positions in the governing boards of their institutions, 3 were professors, 7 were involved in educational activities, and 7 were engaged in research activities.

4. Results and discussion

This section provides selected excerpts from the interviews to develop a descriptive, qualitative analysis that presents the perspectives of this study's participants. The passages are representative examples of the data used to identify the patterns presented in

[2] More information here: http://www.intrepid-cost.eu.



Characteristics	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5	Interview 6	Interview 7	Interview 8	Interview 9	Interview 10	Interview 11	Interview 12
Gender	Female	Female	Female	Female	Male	Female	Male	Male	Female	Male	Male	Female
Academic level	PhD	PhD	PhD	PhD	Master	Master	PhD	PhD	PhD	PhD	PhD	PhD
Educational background	Engineering	Environmental Engineering	Biotechnology	Environmental Sciences	Geography	Environmental Sciences	Environmental Sciences	Sociology	Geography	Veterinary medicine	Environmental Sciences	Educational science
Position	Senior researcher	Postdoc researcher	Project manager	Project manager	Scientific collaborator	Governing board	Senior researcher	Adjunct professor	Scientific collaborator	Titular professor	Senior researcher	Adjunct professor
Nationality	Lithuanian	Chinese	Swiss	Swiss	Swiss	Austrian/ German	Swiss	Swiss	Colombian	Swiss	Swiss	German

Fig. 1. The interviewees' profiles by age, gender, and academic status.

Tables 3–5. The first column of each table lists the short titles for the patterns, with the selected excerpts exemplifying the patterns shown in the second column. When a pattern is similar to one from the literature review, the same title is given. The results are divided into three tables, referring to the interviewees' self-described motivations (Table 3), attitudes and skills (Table 4), and behaviors (Table 5). Regarding the behaviors, we focus mainly on the participants' actions with respect to career development, specifically, career trajectories and research performance within academia, as well as the challenges encountered. The tables overlap to a certain degree because some excerpts refer to the diverse features of interest to us. Tables 3 and 4 provide the data for answering the first research question (What characterizes ITDRs?). The data presented in Table 5 (which also builds on the literature review

Table 3
What drives interviewees towards ITD – motivations.

Motivations	Selected passages
ETHIC	Stat1: *"…Mittelstrass said in a way, ok we have problems and TD means that we need to* ***reorganize the production of knowledge in a different manner so that we produce knowledge that is helpful in solving the society problems****. I don´t know if Mittelstrass say that really but that was how I understood him, how I read him… So that was how I became interested in TD."*
REAL WORLD PROBLEMS	Stat 2: *I had a class… that made me aware of the responsibility of science to really do something for society…* ***For me science is*** *not just trying to find answers to unsolved question but to me it's also trying* ***to be aware of its social responsibility."***
FULFILMENT	Stat 3: *"I personally believe that you do what you need to do and that leads you where you should be, if that is a professorship fine if not that is fine to.* ***What I don´t want is to look back at 15 years of work, after becoming a professor, and say ok so now what? I feel empty.*** *To me that is a bigger risk in terms of personal fulfillment….From an objective point of view, it is risky but from a personal point of view I know I wouldn´t evaluate it in that way."*
BRINGING TOGETHER	Stat 4: "*…I think it's a pity that the people that are working in the theoretical part don´t come together with those working in the empirical part. The theoretical researchers' don´t see the practical problems and have assumptions that are not quit adequate. So* ***I wanted to make a contribution of bringing these 2 communities together****."*
GOING BEYOND DISCIPLINES	Stat 5: *"My bachelor was quite traditional…Back then I worked in a power engineering company and realized that this discipline was not enough. So I did a lot of energy plans for cities and so on and there are not often social or political elements coming in.* ***So that was when I got interested of going beyond engineering****."*
BEING REVOLUTIONARY	Stat 6: "…it was really in my mother's milk this urge to get out of the box."
UNDERSTANDING COMPLEX ISSUES	Stat 7: "**I am happy when I can somehow structure and understand a complex issue.** This is very rewarding for me. I had this experience both when I did philosophy and I found the same happiness in developing TD research. When I understand something, I am very happy and I'm also happy when I see that this field is developing. That is a great thing to see and if I stayed in basic research I think I wouldn´t have shaped the field in such a way. It was a chance of an emergent field."
BEING REFLECTIVE, CONNECTED AND CONNECTING FIELDS	Stat 8: *"…I did a long master and a PhD with a lot of lab and realized that in the lab you are becoming more and more of an expert and you are not seeing the other fields… in the lab where I started my PhD… once a month one very renown research would come to give a lecture and I would go and listen, no matter what the topic was because it was always very interesting, and all my colleagues in the lab, started laughing at me, and ask me why are you going when it's not your field, it's not relevant. I also started working in an open lab where… people would come and I had to explain things I thought it was impossible to explain and it was not.* ***They would also ask some basic questions that as specialized scientist you don´t ask yourself anymore and I really had to think what to answer because I never thought about it anymore and actually you should.*** *What your research means to life and what life is and so on. From them on I though what I am doing becoming a specialist? Sitting alone in my Lab.* ***I have to work with people and see the connection between biology and people, so sociologic questions.*** *Then I started thinking what would my dream be, what would I like to do … So then I quite my PhD (I didn´t finish), after a long period thinking. I really thought if I finish, it would take me 3 more years what could I do in this 3 years…"*

Table 4
What characteristics interviewees expressed when talking about IT- attitudes and skills.

Attitudes/ Skills (see also Table 1)	Selected passages
OPENNESS	Stat 1: "***We have really different background and research interest. In my opinion, we are together because we share some fundamental values about what it means to be a human at the core of it.*** *We should always remain open to all people meanings and knowledge, we fundamentally believe that there is something to learn from every body and that is why we talk about co-construction of knowledge. Another core value is about being open in any disciplinary background and learn by keeping these boundaries open."*
FACILITATOR	Stat 2: "***I read a lot from different disciplines but for a real research project I realized that I have to somehow work with these colleagues because they have a broader background, but I had to read about it otherwise we cannot relate with each other.*** *So the challenge is the relationship. … you have to go back to the discipline and understand what is behind, and this limits your competence and this makes you dependent on colleagues who are interested in doing so, and sometimes you are lucky and most of the times you are not lucky to have that configurations. There were periods where I was lucky to have this kind constellations and other times not. This is research reality and one as to deal with that…"* Stat 3: "***I would say right know different roles are becoming visible and we are starting to understand that there are different roles on such process and we give names to them, like facilitator. From a sociology science perspective, I would say that right know we find that there is boundary work on what is still science and what is not science anymore****, some people say, all these roles that are the moderators, this is no longer science, this can be done by a moderator from outside science, should not be done be our job, should not be the job of a PhD student, they should produce truth. Some other like me would say oh, there are interesting jobs popping up in the field, we should make it part of the field of science…they always said that research is about truth and involving stakeholders is the TD part, but that is something else. I say no,* ***let's call all that TD research****. Let's say that this is a different way of doing science, and all these facilitators becomes part of the system of science and then we have to create theories about that and jobs. …"*
TOLERANCE MODEST POSITIONALITY	Stat 4: *"To get this democratic discussion within the society and with scientist, because I am always a bit astonish that the natural scientists always see failures as positivistic think since now you know more and the others have to really prove that what they are doing is really research and that what they are doing is really an outcome.* ***I think that ID and TD researchers are more critical and respectful of what they are doing while the others are not so critical on what they are saying and their limitations****."*
REFLEXIVITY AWARE CRITICAL-THINKING	*Stat 5: "****If you don´t reflect you are not a TD person****, you are disciplinary transdisciplinary(ien), if you don´t reflect about why and how you are doing it, you are not a TD anything, you are just doing something."*
CREATIVITY CURIOSITY	Stat 6: ***"I get bored when its repetitive****, I am extremely curious****. I am not a good person for doing always the same****. I move on, to new topics and I try to link several things together…So new topics are helpful and I was looking at different disciplines since my bachelor."*
INTEGRATION & COMPLEXITY	Stat 7: "***I don´t think that this skill is trainable… The way to think in complex loops*** *is a way of thinking, it as to do with what happens to you in the first 5 years of your life…Each of us have abilities that are part of us and with the proper trainee you will be best but if you do not have the ability than you will not.* ***Thinking in complex system, comprehending complexity is an ability*** *… I have experience many people that try to learn complexity by books or course, it doesn´t happen."*
SPECIFIC TRAITS ARE NEEDED, CONSIDERED LINKED WITH PERSONALITY	Stat 8:"*I think the individuals are quite important because we are very small team and such a specialized work… and* ***when we decided to hire someone it was very difficult to define the profile we wanted to publicize****…"* Stat 9: ***"I believe that to a large extend is also a case of personality****.* ***Certain types of people are really interested and able to do this link and others are more disciplinary working people.*** *Not meaning that any is better or worse, just very different…"*
INTERESTS SPAN MULTIPLE AREAS, RATHER THAN BEING STRONG IN JUST ONE	Stat 10: **"*I couldn´t do purely disciplinary research. I think it's a question of personality****; if you need to be in a comfortable community I don´t think you can do TD in the long run but if you like to be on the edges on the boarders looking there and anywhere…then it's a really nice task."* Stat 11***"I would say no, when people ask me what is your profession I don´t know, depending on the day I answer something different, I really don´t know.*** *When you have a path like this,* ***you understand complexity quite easily but you don´t have the deep knowledge on something, so I cannot talk with you about specific topics and this sometimes is a big gap.*** *What I want to say is that I think both things are important, my preference is to look at the links between things but this is my personal decision. I would disagree if someone would tell me that this is the important thing, because all the times in my career I needed the specialist that gave the depth knowledge…"* Stat 12: *"…* ***I don´t have a T shape, I try to construct the disciplinary grounding by developing a theory of the practice of TD research.*** *From my personality I am a qualitative researcher but my disciplinary forming I would say I tried to construct or help to construct with others a theory of TD research and that is the field where I think I know something. So disciplinary identity is not like I am a geographer, I am a sociologist because that is not true for me. But I know that a lot of other people don´t think that way…*
TD AS AN ATTITUDE TO BE TRAINED	Stat 13: "To a certain extend yes, but on the other hand I think we have seen numerous student master, PhD, pos-docs all of them with quite different personalities, all of them more

(*continued on next page*)

Table 4 (*continued*)

Attitudes/ Skills (see also Table 1)	Selected passages
CULTURAL CONTEXT LINKAGE WITH ITD	or less involved in this kind of activities maybe with some few exceptions, that lack certain personality factors that are key and essential. But a part from that I still believe that the majority can and likes to do it but maybe is afraid, as never been expose to it, as never had the opportunity to develop this kind of skills…***That´s it [education is important] and that is why I am still at … and not in a place where it would be a little easier and that you wouldn´t need to defend yourself regularly for this type of work."*** Stat 14: *"I think TD should be an attitude in all of us and then there are people who are able to facilitate the process …* ***I think that everyone should get training in TD: either because you use it or allow others to use it. You see the value of the all thing."*** Stat 15: *If you say that happy is finding meaning and purpose in what you do than I am happy. If it represents the hole of who you are than yes. For me specially this his important,* ***I was born in China and raised in the US so I am between 2 worlds. I was trained as an engineer but did a lot of science. I have always been interested in philosophy and humanities. So in terms of my personality it comes naturally, makes more sense to do research that way."***

summarized in Table 2) allows us to answer the second research question (To what extent do inter- and transdisciplinary characteristics help ITDRs deal with the challenges of an academic career path?).

4.1. Characteristics of ITDRs

4.1.1. Motivations for engaging in ITD

The interviewees offer a spectrum of motivations for engaging in ITD (Table 3), from ITD being a source of personal fulfilment (i.e., research with meaning and impact [Stat. 3 in Table 3]) to drivers related to curiosity (Stat. 7 in Table 3). These are probably the driving forces for the vast majority of individuals engaged in scientific research. However, some of the motivations seem intertwined with the characteristics of ITD: the urge to establish links, understand complex issues, and connect and be connected with the real world (Stat. 2 and 4 and Stat. 8 in Table 3). The fact that ITD is considered a transgressive and risk-taking activity also appears to explain the attractiveness of being in this field, as some interviewees express a willingness to step "out of the box" (Stat. 6 in Table 3). The strong emphasis on personal fulfilment supports Montuori's (Montuori, 2013) argument about the linkage with the meaning of life. Several drivers, such as social responsibility and problem solving, as described by Augsburg (2014), are also mentioned in the participants' discourse.

A particular finding of the present study is the connection between attitudes and skills, as described in the literature (e.g., to understand complex issues), and the reasons for the interviewees' interest in ITD. These results emphasize the difficulty in understanding the difference between innate dispositions or "personality traits," as expressed by the interviewees, and competencies acquired by means of education/training. Our findings suggest that some features of ITD, such as dealing with complexity and the need to achieve a systemic or holistic understanding of a problem, might work as appealing factors for individuals with a disposition toward this manner of thinking.

4.1.2. Lack of extrinsic motivation

In contrast to Augsburg's (2014) findings, none of the participants indicates the existence of extrinsic motivations, such as rewards and/or anticipated benefits. In fact, the discourse presented in Table 5 shows that extrinsic motivation (Robinson, 2008) is not common in the context of the present study. Even those participants in high-level academic positions express challenges linked to professional progression that are caused by their engagement in ITD (Stats 1, 2, 3, 4, 10, 13, 14, 15, and 16 in Table 5). Therefore, although the interviewees do not explicitly describe perseverance and commitment, as described by Fam et al. (2017), the overall trajectories of the participants in academia suggest that these two traits might have played a crucial role in attaining their academic positions.

4.1.3. Specific characteristics that define ITDRs

A general theme in the interviewees' discourse is the existence of specific characteristics that define an inter- and transdisciplinary individual (Table 4, structured according to the findings from the literature, as shown in Table 1). We find disagreements on whether these characteristics can be acquired through education/training (Stats 7, 8, 9, 13, and 14 in Table 4). The interviewees describe understanding complex issues and establishing links as inherent abilities, not abilities that can be acquired through higher education/training (Stat. 7 in Table 4). Nonetheless, the importance of having access to educational opportunities is a common component of the discourse, either to improve innate dispositions or to gain new competencies that enable the development of ITD (Stats. 13 and 14 in Table 4). The interviewees also relate their life histories and cultural contexts to their interest in ITD. This connection reinforces Montuori's (2013) claim regarding the linkages between personal experience, culture, and context, and the emergence of an inter- and transdisciplinary attitude. In accordance with the results reported by Augsburg (2014), among other authors, the interviewees show a tendency toward integrative approaches, practice, and reflexivity.

Table 5
Behaviors and challenges, mainly about career development.

Behaviors/Challenges (see also Table 2)	Selected passages
RISK TAKERS	Stat 1: *"We think that research evaluation should consider other criteria than high impact publication and also consider the component ITD, because many researchers say to me that* ***of course this work is important; however, it's so time consuming, during the same time I could be writing articles.*** *I don´t want to replace this system; however, this other kind of research should also be valued equally…"* Stat 2: "There is still a lot of people that think the kind of mixture is not proper science and this kind of educational profile are not successful in the academic career…" Stat 3: *"… But in the academia I know some professors that deal with real world problems and are solution oriented they* ***question if it's a good thing to hire PhD students to work on TD topics because they think that it might hamper their future academic track****, even if there is a small percentage that ends up as a professor."* Stat 4: *"Some of the most interesting results that I have had in my research came from very interdisciplinary approaches. That was easy to publish and got lot of attention and I think the reason for that is because it was novel and interdisciplinary. In that sense I think it's an advantage because there is a lot of new things that can be done than if you just follow the usual approaches. Now on the other hand it was a bit disadvantage* ***because I think it requires way more time and it might be easier for senior people in academia but if you are a junior research what you need to do is to be competitive and have outputs very quickly and so it is a bit risk to do inter and even more transdisciplinary work****. So on a bad day I question what I am doing. On a good day I think maybe it's not too bad…"* Stat 5: *"In my PhD committee I had people from very different disciplinary backgrounds and having the team agreeing on what was a legitimate PhD work was not easy. At the end they couldn´t decide what could pass through as a PhD thesis that could work for all of them and so they just relied on the oldest and most renowned person in the committee to say if it was fine.* ***So I was expecting to have a co-construction process with this committee but in the end those with more time ended up tutoring me. So my conclusion to this is that you should only embark in this kind of work when you know the level of commitment of all participants."***
TRANGRESSION	Stat 6: *"****We are doing this (integration) and this also gives us an identity but still in such a hard world in academia it is still hard to survive with such identity.*** *It depends on the people, if they don´t see it as a threat to what they are doing then they are fine with us and in a way they accept what we are doing but they don´t have a clear idea of what we are doing…So my strategy has always been to…rather say listen maybe your research will become even better if you bring this and this piece together, and then we can create a kind of added value****. My strategy now is have a kind of a niche were you build a kind of expertize and you fill comfortable with, it gives me a better feeling, being in the system for 30 years know I realize that you need a kind of discipline anchoring or expertize anchoring. You can be recognized as a TD expert but what is it in the end?*** *… I always ask myself what would happen if I would have to leave here? If I need to apply to another university outside here, I wouldn´t have any chance for sure if it was based on a blind application."* Stat 7: **" [could you identify yourself with a specific discipline?]** ***No definitely not,*** *I think it's important to have a certain background that you fill comfortable and know I found a kind of a niche about this justice issues that I can say that it is my disciplinary anchoring but I do so many different topics. But it's not so easy not to have this anchoring, were you say that you have this and this expertise. So that is a bit tricky sometimes, when you are moving from one field to the other…I mean integrating things is a very important task and I have thought about this several times and we are also discussing this.* ***If we can say that we are specialist in integration, on how to integrate different disciplines and knowledge outside research."***
PRATICAL	Stat 8: *"****I am more a process person*** *and not a research person that is more on the side. I am trying to catch up what is going on TD research…"*
SOLID DISCIPLINARY BACKGROUND/RECOGNITION FIRST	Stat 9: *"****I am very well rooted in disciplinary research and today I am recognized as disciplinary specialist.*** *I would argue that it is very important to be very well grounded in one science; you must be a recognized specialist in your field. You cannot be a specialist in 2 fields today; you must be recognized in one field because the disciplines are too much split up. But from there you can develop to interact with other scientists. Once you have been recognized and you keep publish in that field you develop your reputations, then nobody can take that away from you, as long as what you do is well grounded in your own field but then don´t dare to apply methods yourself from another science for example, I would never dare to apply an anthropological questionnaire, I would never dare to do deep bioinformatics myself, because let the specialists do that but we need people to interconnect the results. I have people around me that have difficulties to talk with each other. I would say that this is my competence to be able to talk with anthropologist, economics, mathematicise…Know I say something very strong, ID and TD science should not make conception of disciplinary excellence, what you do technically and scientifically should always be cutting edge, and* ***therefore you yourself can only do this in your own field, otherwise you are not competent and therefore that is the reason I will do this in strong collaboration between disciplinary specialist. The excellence you bring in is the capacity to interconnect these things."*** Stat. 10: *"I think they are happy with us if we do teaching and if we involve a lot of stakeholders, that is my hypothesis.* ***If we do a lot of research they will start being very skeptical because we are not really professors.*** *They don´t like groups that do research not controlled by professors…"* Stat 11: *"****I would still consider myself has being trained as sociologist but of a specific type, somebody who has been working 20 years at a technical university together with engineers and natural scientists.*** *So not a classical sociologist."*

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Table 5 (*continued*)

Behaviors/Challenges (see also Table 2)	Selected passages
GOING INTO ITD BY CHANCE	Stat 12: *"So if you are looking back and you are a little bit older, you of course you tend to assume that everything has been consistently development through a guiding idea of myself…**So I would make a distinction between when I was made for the first time explicitly aware of that there is something like ID and TD and that the second element would be what I have been doing over the years without having knowing that it could be called like that.** So this are two different things so If I look back even back into my basic education at high school or at my bachelor degree I would say I can observe a lot of elements which I would call a clear drive for or idea for ID and TD but not using this world."*
WORKING STRATEGIES BASED ON DOUBLE ROLE	Stat 13: *"…I get more comments like ah, you also do that? I go to energy modelling meetings and they say that kind of things. It's not worst or better but just different. But **that is a little bit the strategy since by doing the disciplinary work I publish more.** But one could say that I would probably have much more paper at this time but that is ok."*
NON-ACCEPTANCE, NON-RECOGNITION	Stat 14: *"…It wasn't easy to get in and it is still not easy…we try always to convince the social sciences, humanities, medical that this ID and TD approaches are also for them and very important. **We have a space, but it's always a place we have to defend**."* Stat 15: *"…we are not representative of the academic system, we were not selected by the filters, we do not know what the truth is, I think that to became part of that truth community, to became a professor…**I think the filter somehow is very strong, you won't pass this filter if you are not looking for truth.** I don´t know why but this is the case. We are extremely lucky, this is a lot of coincidence and good will from the department and I think we will survive, as senior scientists, we will never be part of the class of real professor, but that is ok for us."*
LACK OF FUNDING TO DO RESEARCH ON TD	Stat 16: *"I have to say that **we are very weak is in funding TD projects** … We are in little bit difficult situation where we promote methods, the projects where people can actually work on that are not very often, or completely over burned with work. This situation is not ideal."*

In the ITD literature that we consulted, we could not find an explicit account of an interest in several topics, a need to change, and a need to escape from a routine manner of working and thinking, although these characteristics are found in the interviewees' discourse (Stats. 6, 10, and 11 in Table 4). We identify similar characteristics and attitudes within the concept of multipotentialites. Wapnick (2017) defines a multipotentialite as someone with many interests and creative pursuits but without a single true calling as a specialist. Multipotentialites thrive on learning, exploring, and mastering new skills, and they are described as being excellent at bringing disparate ideas together in creative ways. Therefore, multipotentialites are associated with innovation and problem solving. An additional aspect of these individuals is their tendency to become bored, seek change, and take on new challenges. Wapnick has created a series of online networking opportunities for these individuals to promote and acknowledge multipotentialites and support their progress as useful members of society. These actions have been taken in response to the situation described by Wapnick, where multipotentialites are often made to feel discouraged for [their] supposed inability to 'master' something. This concept provides a frame for some of the identified attitudes and characteristics and offers new arguments for the need to support the full potential of scholars in academia who can be identified as multipotentialites. Therefore, our results support some authors' (Fam et al., 2017; Wernli & Darbellay, 2016) arguments for the need to rethink the academic system in order to accommodate ITDRs' learning and progression.

4.2. What career paths are developed by ITDRs, and to what extent do ITD characteristics contribute to these paths?

Most interviewees define their trajectory in ITD (i.e., their entry into ITD and their continuing development within it) as something that just happened and is linked to a specific way of perceiving science (Table 5). Most of them do not present a well-established career path and consider that this option is unavailable with the CV profiles that they have developed so far (Stat. 12 in Table 5). A few of the young researchers aim at developing a career in academia; therefore, their inter- and transdisciplinary activities to date have been intermingled with disciplinary knowledge production (Stat. 13 in Table 5). Generally, professors and master's/PhD supervisors do not advise young researchers to move into ITD because of its impact on career advancement or of the lack of supervision for inter- and transdisciplinary research compared with disciplinary projects. At different career stages, most interviewees have considered that entering ITD after completing a bachelor's degree is possible but not supported by current conditions. Most of the described challenges are related to the lack of recognition for ITD within the academic system (Stats. 3, 4, 14, and 15 in Table 5). Therefore, independent of the individual's age or years spent on working in academia, the general perception is a lack of opportunities to progress in academia. Those who intend to attain a professorship position or have already achieved this level of career advancement describe a dual role, one focused on disciplinary excellence and the other on ITD. Most of the interviewees recognize several possibilities to enroll in ITD at the different stages of higher education; therefore, the challenges are not found in the content of research but in its social dimensions of supervision, revision, and assessment of quality. Another described challenge is the lack of inter- and transdisciplinary projects for the advancement of ITD theories, methods, and tools (Stat. 16 in Table 5). Within this discussion, some interviewees suggest creating a discipline, a field, or a community focused on the formalization of ITD, as well as on its development. Others view this track as a threat to the inherent openness of ITD to other disciplines.[3]

[3] While not the focus of this research, we note that a similar debate, and tension, can be found in the field of future studies, and specifically in

4.2.1. Training for ITD

Although most of the interviewees identify the interest in or tendency to engage in ITD as occurring early in their education and academic path, the need for some anchoring in a discipline, a field, or a community is common to the majority. With respect to anchoring, two main strategies are found. One group does not agree on the need for ITD to be anchored in a specific discipline, while calling for strategies that allow the acknowledgment of ITD competencies and specialization. This specialization is based on the capacity to facilitate knowledge integration and to develop theories, methods, and tools for ITD (Stat. 3 in Table 4). According to the other group, ITD activities should start after a well-established career path has been developed within a clearly defined field or discipline, where ITD could be a source of innovation and a manner of developing research on a specific topic or question (Stat 9 in Table 5). Collaboration is described as a key behavior, as is the ability to find ways to spark others' interest in ITD. Collaboration between disciplinary researchers and ITDRs is considered a challenge because of the individuals' unwillingness to interact, the lack of time linked to the tradeoffs between disciplinary and ITD outcomes, and the level of trust needed to effectively work together (Stat. 2 in Table 4).

Consistent with those of Becher and Trowler (2001), our results show that although the academic system generates cutting-edge disciplinary knowledge that is beneficial to the implementation of concerted and negotiated ITD, it also persistently engenders the lack of communication among researchers who claim to follow different conceptual and methodological paradigms and belong to various types of tribes in independent territories. The interviewees' discourse (see the excerpts in Table 5) indicates the absence of a wide recognition of the importance of ITD in academia, and this situation continues to hamper the transformative potential of ITD (Darbellay, 2015). In different academic contexts, we find several examples of changes (e.g., departmental reorganizations, changes in the training provided to students) that on one hand, try to accommodate the training of ITDRs and professionals, and on the other hand, can create career opportunities for these individuals (Fam et al., 2017; Klein, 2010; Robotham et al., 2013; Stokols, 2014). However, our findings indicate that a T-shaped training framework does not explain all the profiles that we have detected. Returning to the concept of multipotentialites (Wapnick, 2017), this type of academic training does not appear to sufficiently prepare these types of individuals. In reviewing the call for T-shaped education, we find it predominantly in traditionally highly specialized fields (e.g., engineering). Therefore, it seems that the implementation of T-shaped training could be of some utility for educating specialists who are able to work in ITD teams, but the full potential of ITDRs is not served by this strategy.

5. Looking forward and conclusions

In this final section, we reflect on our findings and their implications for the future of ITDRs, and more broadly, for the future of the knowledge produced and promoted by universities and how this matters for human beings' collective capacity to respond to the challenges of this rapidly changing century.

5.1. Future of ITDRs – what we have learned

Notwithstanding all the talk and policy support, the transformative capacity and the potential of ITD research, as well as its crucial role in shaping knowledge to address future challenges, our results are not encouraging. The findings from the interviews reinforce the previous critique that the existence of institutional discipline-based organizations continues to hinder the establishment of a knowledge dialogue, as well as its connection and integration across and beyond disciplinary boundaries. This issue is particularly significant because despite its small sample, our case study presents the findings from several institutions that are formally and explicitly related to ITD, and where ITD is somehow valued. In other words, they represent some of the leading institutions embarking on this endeavor, yet the discourse of the interviewees within these institutions indicates that ITD recognition remains at a level that is separate from where operationalization occurs, making the realization of ITDRs' potential still difficult if not problematic.

Regarding our first research question about what characterizes ITDRs, our empirical findings confirm a range of characteristics identified in the literature (see Tables 1, 3 and 4). Significant traits, attitudes, and skills of ITDRs include personal fulfilment, the calling to respond to the social responsibility of science, a problem-solving urge (including going beyond disciplines), which often requires the capacity to work together and use knowledge in an operationalized manner, and being reflexive. We find similarities between ITDRs and multipotentialites—referring to individuals with a diverse set of interests and skills, who are unable to continuously focus on the same topic or task, and for whom change is perceived as a necessity. The possibilities of building bridges between unrelated areas, facilitating integration, and dealing with complexity and the "out of the box" nature of ITD are all identified as attractive features of ITD, capable of motivating scholars to engage in this type of research. This means that the aspects used to characterize the concepts of ITD also pull individuals into its practice. We also note that many of these traits coincide with the characteristics of future studies, as discussed in the introduction, further confirming the relevance of ITD research characteristics for the development of futures literacy.

With respect to our second research question about how ITD characteristics help overcome the challenges faced in developing an academic career path, our findings are less than encouraging; the pursuit of ITD research tends to coincide with the lack of aspiration to build a career in academia. Most of the interviewees do not aspire for a standard academic career due to a general sense that an

(*footnote continued*)
recent debates on 'anticipation' and 'futures literacy' (see for example, Miller, R. (Ed.) (2018) Transforming the Future. Anticipation in the 21st Century, UNESCO and Routledge, Paris and Abingdon).

academic career path based on ITD is unavailable to these researchers, although the majority were working in academia when interviewed. The few who are at a high level of the academic career ladder or aspire to reach such a level share a common strategy for career advancement—mixing disciplinary with ITD research activities—suggesting that the disciplines' hold of power over academia's organization, structure, and ethos remains strong and potentially problematic, as discussed by Connell (2019) and Sardar (2010), among others. Therefore, our results highlight the well-documented academic context and conditions, which continue to hinder the evolution of ITD, notwithstanding the many resounding policy statements in support of such forms of knowledge production. The interviews suggest that the capabilities to work collaboratively, facilitate/moderate interaction, be pragmatic, and be sensitive to other fields are characteristics contributing to the development of ITD work within academia, *despite* the lack of conditions for evolving more quickly. As such, although the road seems long and difficult, ITDRs are still on the move within academia.

Our sample of ITDRs is too small and exploratory to allow us to establish whether their uncovered characteristics and perspectives resonate in other academic institutes that are explicitly intent on promoting ITD research. However, there is a significant resonance between our findings and the conclusions and the lessons presented in the existing literature. More studies that focus on ITDRs and their personal experiences are needed to further strengthen the understanding of the mixture of relevant characteristics that they present, as well as how these relate to the research conducted by these individuals and their career progression.

5.2. Future of knowledge in universities – implications

In "*The Good University. What Universities Actually Do and Why It's Time for Radical Change,*" Connell (2019) makes a comprehensive case for transforming academia and in doing so, rediscovering connectedness in human beings' way of knowing, the diversity of epistemological and even cosmological traditions, and openness to a wider range of actors with the legitimacy to contribute ideas and worldviews—all play fundamental roles. As discussed in the introduction, it is widely agreed that the challenge of acquiring and sharing the knowledge that the public needs for sustainable futures, and the complexity of current societal problems, require such a "radical change," both in universities and beyond. Higher education is perceived as playing a critical role in building the capacity to design the appropriate responses to the challenges characterizing this century, yet "most universities remain caught up in business-as-usual thinking" (Slaughter, 2012, 123), especially in the way that disciplines still define both the organization and the governance of universities and their members.

Focusing on knowledge produced through ITD research, as well as the sustainability of ITDRs' careers in the short and the long terms, we find both seeds of hope and persistent obstacles. A range of roles has emerged, along with specific competencies that are no longer considered strictly discipline bounded but are capable of promoting collaboration with actors other than academics. The future of ITD within academia partly depends on each institution's capacity to find the proper framing of profiles that are not based on disciplines. Most of the educational offers for ITDRs are based on a quadrangulation of disciplinary depth, multidisciplinary breadth, interdisciplinary integration, and transdisciplinary competencies. However, our findings suggest a wider diversity of profiles, and this type of educational offer might be insufficient to support the full potential of some types of ITD individuals who struggle to find the disciplinary depth that should characterize them.

Compared with the lofty promises and the acknowledgments of how important, urgent, and even essential ITD knowledge production is today, the state of ITD research and of ITDRs' motivations, training, and career options seem to fall short. Perhaps in line with the times in which we are writing, our understanding is that most of the answers and the solutions to the establishment of academic paths for ITDRs have already been discussed and identified; the next step is more in the realm of choice.

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