Educational Innovation in Transdisciplinary Hubs

Microcosms of the Fourth Generation University

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Abstract

In recent years, the notions of fourth generation university and transdisciplinarity have become prevalent in academic discourse on higher education. Exemplary of these two trends is that universities increasingly take the lead in the design, implementation, and governance of so-called ‘innovation labs’ or ‘innovation spaces’ where science and society meet each other to co-create value in academia and practice. While innovation labs are well-documented in the literature, the multiplicity of implementations in academic contexts highlights their practical ambiguity in universities. Therefore, this thesis will introduce the term *transdisciplinary hubs*: university-based physical spaces in which traditional disciplinary boundaries are being transcended, science and society learn and work together, and education, research, and valorisation are ‘modernised’. Specifically, this thesis aims to better understand how transdisciplinary hubs are designed, organised, and governed. It asked the following research question: “What are the key factors that shape educational innovation in transdisciplinary hubs?” To answer the question an extensive literature review was conducted and ten semi-structured interviews were conducted with key figures in and from two case studies. The results indicate that the transdisciplinary-, ecosystem-, and process focus, future-, community-, and proactive orientation, real-world context, the educational activities, -competencies, -experiences, -scaffolding, -stakeholders, and -collaborations, level of organisational autonomy, -resource availability, -strategic alignment, -organisational flexibility, -organisational constraints, -disciplinarity, -engagement, and -emergence, the location, scale, network, space, structure, culture, and mindset, the achievement of purposes and objectives, tangible- and intangible results, and materialisation of roles and functions of transdisciplinary hubs shape educational innovation. Ultimately, the findings suggest that the definitions in the literature of both the fourth generation university and transdisciplinarity need to be expanded. Fourth generation universities should also be characterised by their multirole hosting, facilitating, and leading of a wide and diverse range of educational, research, and valorisation initiatives and activities, and transdisciplinarity should also be characterised by the creation, development, and use of boundary objects based on prototyping and tangibilizing.

Table of Contents

Chapter 1: Introduction

This chapter includes the research gap (Section 1.1), research background (Section 1.2), and research question (Section 1.3).

1.1: Research Gap

In a world that is marked by complex challenges that transcend disciplinary boundaries, involve multiple stakeholders, and are deeply rooted in socio-economical and -political contexts, research universities are increasingly expected to assume a more active role in society (Thomas et al., 2023). Over the past few decades, academic work has explored concepts like the triple- (Etzkowitz & Leydesdorff, 1995), quadruple- (Carayannis & Campbell, 2009), and quintuple helix (Carayannis & Campbell, 2010), entrepreneurial university (Clark, 1998), and engaged university (Boyer, 2019) as ways for research universities to not only study but also address the evolving demands of our times. However, these concepts narrow universities' roles to specific areas like civic engagement, entrepreneurship, and sustainability. Little is known about how research universities can create, facilitate, and stimulate impact beyond traditional knowledge and technology transfer in these domains (Thomas et al., 2023).

In recent years, the notion of the so-called fourth generation university has emerged, describing universities that proactively develop, foster, and sustain collaborative ecosystems focusing on holistic impact (Lukovics & Zuti, 2015; Pawłowski, 2009). The concept is characterised by the fluid boundaries between academic disciplines, the alignment and intertwinement of universities' agendas with local and global societal goals, and the focus on innovation not as a byproduct of academic pursuits, but as a fundamental goal of it (Lukovics & Zuti, 2015; Thomas et al., 2023). Practically, it is based on the principles of transdisciplinarity, which describe the integration of academic disciplines, professional practices, and societal perspectives (Jahn et al., 2012) through the engagement of, collaboration among, and co-creation by stakeholders from academia, industry, government, and civil society (Horn et al., 2022).

Together, the fourth generation university and transdisciplinarity represent a paradigm shift from isolated to interconnected thinking, from siloed to synergistic education, research, and valorisation, and from competing to collaborative impact (Bernstein, 2015; Thomas et al., 2023). The former encompasses the philosophical underpinnings (i.e. the 'why') and the latter covers the practical manifestation (i.e. the 'how' and 'what') of universities' changing role in society. However, while the discourse around the 'why' of this trend is converging, it is diverging when it comes to the 'how' and 'what'. The potential of fourth generation universities is recognised (Lukovics & Zuti, 2015; Oztel, 2019; Pawłowski, 2009), but the implementation of transdisciplinarity in research universities remains a challenge (Roux et al., 2017; Knickel et al., 2019). It is not just about integrating different disciplines and facilitating dialogue between academia and society, but also about systemic reforms that cover the modernisation of universities' education, research, and valorisation, the relationship between science and society, and the design, implementation, and governance of universities' infrastructures and policies.

1.2: Research Background

Over the past few years, a modest but thought-provoking body of academic work looked through the organisational ambidexterity lens at the gaps between the conceptualisation, planning, and implementation of transdisciplinarity in research universities. The notion of organisational ambidexterity is based on the definition of the latter term, which refers to the ability to use the right and left hands equally well. On the one hand, organisations need to effectively exploit their existing capabilities and resources to maintain competitive advantages (O'Reilly & Tushman, 2008). On the other hand, they need to actively explore new innovations and opportunities to create new competitive advantages (O'Reilly & Tushman, 2008). This simultaneous pursuit of exploitation and exploration is known as organisational ambidexterity.

However, looking at research universities through the dichotomous lens of exploration and exploitation "leads us to think of a person with two hands undertaking different activities at the same time", yet in reality "the university is more like an octopus with eight arms moving in a sometimes coordinated and sometimes unwieldy manner" (Thomas et al., 2023, p. 3). On the one arm, fourth generation universities need to exploit established educational, research, and valorisation frameworks. On the other arm, these universities need to explore new ways to foster academic knowledge, research, and innovation. On the other other arm, they need to proactively develop, foster, and sustain collaborative ecosystems with a focus on holistic impact. Therefore, instead of limiting our way of thinking to a binary perspective, Thomas et al. (2023) advocate for the development of a so-called *multidextrous* university model, where universities create, facilitate, and stimulate impact through educational, research, and valorisation activities based on synchronised scholarly and societal missions. Based on the work of Sliż and Dobrowolska (2023), a multidextrous university model would translate to a university as an overarching entity that coordinates a few larger, robust, centralised sub-units focused on stability, routinisation, and efficiency, and various smaller, agile, decentralised sub-units focused on discovery, experimentation, and innovation. While the larger sub-units build upon the established educational, research, and valorisation frameworks, the smaller sub-units move beyond these frameworks, seeking new ways to foster knowledge, research, and innovation through impactful collaborations across science-society interfaces. Still, all sub-units operate based on a common mission, vision, and strategy.

1.3: Research Question

The proposal of a multidextrous university model introduces a new framework for researching and addressing the complexities of implementing transdisciplinarity and realising the fourth generation university. However, while the current body of work effectively applies ambidexterity insights on the macro-level, focusing on universities and their external context (Thomas et al., 2023), it overlooks the micro-level intricacies of universities and their internal context. Therefore, little is known about how multidextrous sub-units within research universities can be and are designed, organised, and governed. To capture the subtleties needed for the development of a comprehensive and complete multidextrous university model, a more fine-grained and balanced investigation is thus necessary (Sliż & Dobrowolska, 2023).

One of the smaller sub-units that is increasingly being adopted at research universities in the Netherlands is the so-called innovation lab (Delgado et al., 2020). While innovation labs themselves are well-documented in the literature (Osorio et al., 2019; Schiuma & Santarsiero, 2023), the multiplicity of implementations in academic contexts highlights their practical ambiguity in universities. Because the labs have taken many forms and are known by various names (e.g. Co-Creation Lab, Design Lab, Fablab, Living Lab, Maker Lab, and Innovation Lab), there is a lack of comprehensive understanding concerning their roles and functions as sub-units in universities. Therefore, this thesis will introduce a new term: *transdisciplinary hubs* (see Section 2.4).

Ultimately, this thesis aims to better understand how transdisciplinary hubs are designed, organised, and governed. It does not aim to understand transdisciplinary hubs in their totality, which would require a longer-term and multi-phase study approach, but it does seek to lay the groundwork for such understanding by exploring one of its aspects in depth: educational innovation. Educational innovation is an important pillar of transdisciplinarity and fourth generation universities. It covers fundamental aspects of both, including the integration of academic disciplines, professional practices, and societal perspectives, the alignment and intertwinement of universities' agendas with local and global societal goals, and the focus on innovation not as a byproduct of academic pursuits, but as a fundamental goal of it.

Specifically, the research question is: "**What are the key factors that shape educational innovation in transdisciplinary hubs?**" In the context of this thesis, key factors are defined as elements that characterise the design, organisation, and governance of transdisciplinary hubs; the term shape refers to how these key factors determine and define the educational innovations in the hubs; educational innovation is defined as any development in terms of activities that result in learning, which is "the activity or process of gaining knowledge or skill by studying, practising, being taught, or experiencing something" (Encyclopædia Britannica, 2024); and transdisciplinary hubs are defined as university-based physical spaces in which traditional disciplinary boundaries are being transcended, science and society learn and work together, and education, research, and valorisation are 'modernised' (see Section 2.4).

Chapter 2: Theoretical Framework

This chapter includes four sections: organisational ambidexterity (Section 2.1), fourth generation university (Section 2.2), transdisciplinarity (Section 2.3), and innovation labs (Section 2.4). It is important to note that this chapter serves a descriptive purpose. The connections between topics and with the research question will be elaborated upon later (see Chapter 3).

2.1: Organisational Ambidexterity

Organisational ambidexterity, a field of study that has primarily focused on the private sector, has recently begun to explore its relevance and application within the public sector (e.g. Centobelli et al., 2019; Kolster, 2021; Thomas et al., 2023; Sliż & Dobrowolska, 2023). To understand the basic premises of ambidexterity, the concept will be discussed based on seminal works that were written in the context of the former. However, it should be noted that its application in the context of the latter is the primary focus of this study (see Section 1.2).

According to March (1991), organisations are always confronted with the adaptive challenge of pursuing two seemingly divergent activities: exploitation and exploration. Exploitative activities focus on refinement, efficiency, and execution, whereas explorative activities are centred around discovery, experimentation, and innovation (O'Reilly & Tushman, 2008). Based on the work of March (1991), Tushman and O'Reilly (1996, p. 24) define organisational ambidexterity as "the ability to simultaneously pursue both incremental and discontinuous innovation [...] from hosting multiple contradictory structures, processes, and culture within the same firm." This simultaneous pursuit of exploitation and exploration makes sense on paper but proves to be difficult to achieve in practice. Generally speaking, organisations can take three approaches to achieve ambidexterity: sequential, structural, and contextual. Sequential ambidexterity encompasses shifting organisational structures over time to accomplish ambidexterity (O'Reilly & Tushman, 2013). Structural ambidexterity involves separate and distinct organisational structures for exploitation and exploration (O'Reilly & Tushman, 2008). Contextual ambidexterity entails having organisational structures that empower and motivate individuals to autonomously manage ambidexterity (Gibson & Birkinshaw, 2004). In reality, organisations often achieve ambidexterity through a combination of the three (O'Reilly & Tushman, 2013).

Over the past few decades, this challenge of balancing exploitation and exploration has been examined in various settings, including organisational design, organisational adaptation, strategic management, technological innovation, and organisational learning (Raisch & Birkinshaw, 2008). In every case, the conclusion is similar: successful exploitation and exploration allow organisations to thrive in established markets with mature products and services, as well as be competitive in emerging markets with novel products and services (O'Reilly & Tushman, 2013). Organisations that overly emphasise exploitative activities may benefit from reliability and efficiency in the short term but run the risk of falling into so-called competency traps in the long term (March, 1991). Organisations that rely too heavily on exploration may be more adaptable over the long term but run the risk of never capitalising on their new discoveries because they do not implement and refine them (March, 1991).

2.2: Fourth Generation University

Historically, universities have revolved around education, research, and valorisation. The first generation university (≈ 1100 - 1700) concentrated on teaching students and the protection of truth; the second generation (≈ 1800 - 2000) focused on scientific inquiry and the understanding of nature; and the third (≈ 2000 - ...) actively pursued knowledge commercialisation and the creation of added value (Wissema, 2009). Today, as knowledge is becoming more problem-focused, relevant to, and co-created with stakeholders across science-society interfaces (Russell et al., 2008), universities are increasingly encouraged to leverage theirs to create, facilitate, and stimulate impact through educational, research, and valorisation activities based on synchronised scholarly and societal missions (Thomas et al., 2023).

As universities transitioned from being places of academic study to interconnected knowledge, research, and innovation spaces, new models highlighting their transforming position within society started to emerge. Initially, Etzokowitz and Leydesdorff (1995) introduced the triple helix model, which conceptualised universities as laboratories for knowledge-based economic and social development. Specifically, the model examines the socio-economic impact of interactions between universities, industries and governments (the triple helix). Following this, Carayanniss and Campbell (2009; 2010) proposed the quadruple- and quintuple helix models. These models respectively blend in the perspectives of civil society and natural environments. Over time, the increasing interactions between universities, industries, governments, civil society, and the natural environment became a driving force for universities to modernise their traditional activities. Instead of only studying the evolving interests and demands of our times, universities also started to address them. This process of modernisation, which is to a large extent based on the principles of transdisciplinarity (Section 2.3), is described as the transition from third- to fourth generation universities[1].

However, at this moment, there is not yet a commonly accepted definition for the fourth generation university. Generally speaking, the concept is characterised by fluid boundaries between academic disciplines, the alignment and intertwinement of universities' agendas with local and global societal goals, and the focus on innovation not as a byproduct of academic pursuits but as a fundamental goal of it (Lukovics & Zuti, 2015; Thomas et al., 2023). Efforts are not just reactive, but also proactive. Instead of only focusing on short-term socio-economic growth facilitation, fourth generation universities focus on long-term sustainable and holistic growth orchestration (Thomas et al., 2023). In a way, fourth generation universities try to bring together students and researchers, industry experts and entrepreneurs, policymakers and public administrators, and civic groups and local communities (Lukovics & Zuti, 2015; Pawłowski, 2009) to share their resources and knowledge, extending their impact (Asgari et al., 2021).

[1] However, it is important to note that not every research university is nor wants to follow this trend. Debates about the desirability and feasibility of becoming a fourth generation university are ongoing (Garretsen et al., 2023; Oztel, 2019).

2.3: Transdisciplinarity

The term transdisciplinarity was first introduced during the 1970s and initially represented a novel perspective on the philosophy of science and education (Bernstein, 2015). It originated as a critique of the compartmentalisation of education and research into traditional academic disciplines and called for the establishment of an all-encompassing set of axioms for academic work (Bernstein, 2015). At the same time, scholars started exploring the idea of integrating education, research, and service –shifting universities' role from passive consultants to active participants in society– to make the former two more societally relevant (Jantsch, 1972).

However, it was not until the 1990s that transdisciplinarity began to solidify and take shape. Following the end of the Cold War, socio-political changes triggered an increased awareness and newfound understanding of planet Earth's fragility and the imminent threat of catastrophic climate change caused by human activity (Bernstein, 2015). The themes of global environmental crisis and sustainability became key drivers in promoting transdisciplinarity to a prominent position in discussions about science and education. Specifically, two schools of thought emerged: the Nicolescuian- and Zurich schools. The first was built upon the work of theoretical physicist Nicolescu, who focused on transdisciplinarity as a new way of thinking about knowledge and inquiry, based on what is between, across, and beyond disciplines (Augsburg, 2014). The second expanded on the contributions of Gibbons et al. (1994), who concentrated on the collaborative creation of application-specific knowledge by experts from academia, government, and industry.

In response to a world that became 'too big to know', filled with increasingly complex scientific, technological, and societal challenges (often referred to as wicked problems), the disparate concepts of transdisciplinarity as a form of knowledge production (Nicolescuian school) and as a way to design and implement practical solutions to real-world challenges (Zurich school) converged. Transdisciplinarity became a means to rethink and reorganise our approaches to knowledge inquiry and production (Weinberger, 2011; Bernstein, 2015). Concentration on both the theoretical and practical benefits of overcoming compartmentalisation led to it being established as an independent area of study: "that relates societal with scientific problems; it produces new knowledge by integrating different and extra-scientific insights; its aim is to contribute to both societal and scientific progress; integration is the cognitive operation of establishing a novel, hitherto non-existent connection between distinct epistemic, social-organisational, and communicative entries that make up a given problem context" (Jahn et al., 2012, p. 8). Characterised by transdisciplinarity's own unique methodologies and frameworks (Jahn et al., 2012; Osborne, 2015), disciplines and the possibilities for combining them are re-imagined, stakeholders from both science and society are involved, wicked problems form the contextual backdrop, iterative, reflective and responsible methodologies are implemented, and lateral, creative, and systematic thinking about both problems and solutions is encouraged (Bernstein, 2015; Wickson et al., 2006).

2.4: Innovation Labs

Exemplary of the fourth generation university and transdisciplinarity trends is that universities increasingly take the lead in the design, organisation, and governance of so-called 'innovation labs' or 'innovation spaces' where science and society meet each other to co-create value in academia and practice (Delgado et al., 2020; Garretsen et al., 2023). While innovation labs themselves are well-documented in the literature (Osorio et al., 2019; Schiuma & Santarsiero, 2023), the multiplicity of implementations in academic contexts highlights their practical ambiguity in universities. Generally speaking, an innovation lab is defined as "an organisational initiative and management model based on the creation of an innovative environment [...] fostering creative and innovative thinking, promoting and supporting user-driven and open innovation approaches, to facilitate stakeholders engagement in innovation processes, to better understand users' needs, to drive technology transformation, to imagine and to define innovation opportunities, and to develop new business solutions capturing and delivering value" (Schiuma & Santarsiero, 2023, p. 14). However, because the labs have taken many forms and are known by various names (e.g. Co-Creation Lab, Design Lab, Fablab, Living Lab, Maker Lab, and Innovation Lab), there is a lack of comprehensive understanding of their roles and functions as sub-units in universities. Therefore, this thesis introduces the term *transdisciplinary hubs*.

In this thesis, transdisciplinary hubs are conceptualised as tangible spaces where the vision of the fourth generation university is brought to life and its principles are actualised. Traditional disciplinary boundaries are being transcended, science and society stakeholders learn and work together, and a more holistic approach to education, research, and valorisation is being developed. Students, researchers, businesses, public organisations, and citizens actively work together on making an impact. For example, transdisciplinary hubs host educational programmes in which students from various disciplines learn to work together, facilitate structural research collaborations like PhD- and postdoc projects, and accommodate innovation valorisation through real-world prototyping and testing. To support these activities, the hubs are equipped with facilities like makerspaces, fab labs, and multimedia studios. In essence, they are microcosms where the ideals of transdisciplinarity and fourth generation universities are tested against the realities of established university standards and practices.

In other words, a transdisciplinary hub is a specific kind of innovation lab. To be considered a transdisciplinary hub, the innovation lab should be university-based and have a dedicated physical space in which traditional disciplinary boundaries are being transcended, science and society learn and work together, and education, research, and valorisation are 'modernised'.

Chapter 3: Conceptual Framework

The conceptual framework has been developed to study how transdisciplinary hubs are designed, organised, and governed. It brings together this thesis' research gap, background, and question with the theoretical framework by describing the key factors that shape educational innovations in these hubs. It consists of five dimensions and thirty-three elements (i.e. key factors). In this chapter, the dimensions (Section 3.1) and elements (Section 3.2) are discussed.

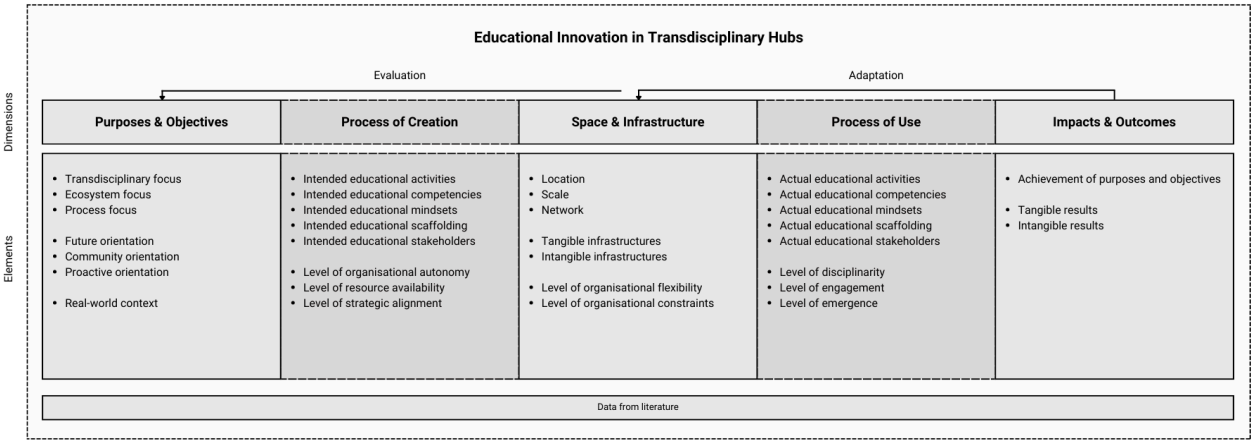

Figure 1: Conceptual Framework

The overall structure of the framework is based on the work of Osorio et al. (2019), but the dimensions' titles have been updated for clarity. All elements, except the three that are part of the impacts and outcomes dimension (Osorio et al., 2019), have been established based on careful consideration and critical cross-referencing of the works of Osorio et al. (2019), Schiuma and Santarsiero (2021), and broader literature (see Chapter 2).

3.1: Dimensions

The five dimensions of the conceptual framework are purposes and objectives, process of creation, space and infrastructure, process of use, and impacts and outcomes. The purposes and objectives dimension captures the mission, vision, and values of the transdisciplinary hub, outlining its overarching strategy and principles. The process of creation dimension describes the intended practical manifestation of the strategy and principles. The space and infrastructure dimension covers the spatial, infrastructural, and organisational aspects of the hub. The process of use dimension describes the actual practical manifestation of the strategy and principles, acknowledging that any hub will evolve beyond its original intentions. Finally, the impacts and outcomes dimension captures the impact that the hub has and the outcomes it creates, facilitates, and stimulates.

3.2: Elements

In this section, each of the **elements** (i.e. key factors) is described in the context of its dimension: purposes and objectives (Section 3.2.1), process of creation (Section 3.2.2), space and infrastructure (Section 3.2.3), process of use (Section 3.2.4), and impacts and outcomes (Section 3.2.5).

3.2.1: Purposes & Objectives

First of all, the purposes and objectives of educational innovation in transdisciplinary hubs are defined by a transdisciplinary-, ecosystem-, and process focus. The **transdisciplinary focus** is based on the hubs' transdisciplinary nature. Disciplines and the possibilities for combining them are re-imagined[2] and stakeholders from both science and society are involved[3], wicked problems form the contextual backdrop[4], iterative, reflective, and responsible methodologies are implemented[5] and lateral, creative, and systematic thinking about both problems and solutions is encouraged[6] (Bernstein, 2015; Wickson et al., 2006). Furthermore, the **ecosystem focus** builds upon the idea that fourth generation universities aim to play an active role in society and extend their impact by sharing their resources and knowledge (Asgari et al., 2021; Lukovics & Zuti, 2015). Transdisciplinary hubs play an important role in creating, fostering, and sustaining local ecosystems, with educational innovations bringing together students and researchers, industry experts and entrepreneurs, policymakers and public administrators, and civic groups and local communities (Lukovics & Zuti, 2015). Finally, the **process focus** is based on what Horn et al. (2022) describe as one of the fundamental aspects of transdisciplinarity: being aware of and dealing with its 'messy' nature. In the context of transdisciplinary hubs, this translates to a continuous iteration of defining and redefining educational innovations.

Second, the purposes and objectives are oriented based on the future, a community, and proactivity. The **future orientation** is based on the idea that fourth generation universities do not only focus on short-term socio-economic growth facilitation but also on long-term sustainable and holistic growth orchestration (Thomas et al., 2023). In other words, educational innovation is not only shaped by reactive present-day efforts but also proactive future-oriented ones. Moreover, the **community orientation** describes transdisciplinary hubs' aim to build and grow a community of engaged students, teachers, and stakeholders (Osorio et al., 2019). Finally, the **proactive orientation** is based on the aim of fourth generation universities to be proactive in terms of making an impact (Pawłowski, 2009). The evolving demands of our times are not only studied but also addressed in educational innovations.

Third, the purposes and objectives are informed by the **real-world context**, which describes transdisciplinary hubs' aim to capture and resemble the real-life environment. For instance, to

[2] See **level of disciplinarity**
[3] See **intended**- and ***actual educational stakeholders***
[4] See **real-world context**
[5] See **process focus** and **intended**- and **actual educational scaffolding**
[6] See **intended**- and **actual educational mindsets**

better understand the content and context of societal challenges, hubs help students, teachers, and stakeholders connect with the real-world lived experiences of one another (Osorio et al., 2019). Educational innovation is not only based on theory and hypotheses but also on experience and reality.

3.2.2: Process of Creation

First, the process of creation in transdisciplinary hubs is defined by the intended educational activities, -competencies, -mindsets, -scaffolding, and -stakeholders. The **intended educational activities** describe the variety of possibilities transdisciplinary hubs have for creating learning opportunities. Educational activities could be (extra-)curricular one-day events like thematic workshops, meetups, networking events, and brainstorming sessions, multi-day events like idea competitions, hackathons, and boot camps, and long-term programs like courses, electives, lifelong learning tracks, and even complete bachelors and masters (Osorio et al., 2019; Schiuma & Santarsiero, 2021). Furthermore, the **intended educational competencies** refer to the different competencies students, teachers, and stakeholders can develop in the hub, ranging from disciplinary to transversal. Disciplinary competencies are associated "with specific technical knowledge and task-oriented skills to be applied in a specific field" and transversal competencies with critical thinking, cooperation, collaboration, communication, and creativity and innovation (Miranda et al., 2021, p. 4). In addition, the **intended educational mindsets** refer to the different ways of thinking (e.g. iterative, reflective, responsible, lateral, creative, and systematic) that students, teachers, and stakeholders can develop (Bernstein, 2015; Wickson et al., 2006). Moreover, the **intended educational scaffolding** describes the variety of possibilities transdisciplinary hubs have to structure and support education. For example, educational innovation is often based on pedagogical approaches such as challenge-based learning, problem-based learning, project-based learning, learning-by-doing, and gamification-based learning (Miranda et al., 2021). Finally, the **intended educational stakeholders** describe the range of people who are involved in the transdisciplinary hub, which includes stakeholders from academia, industry, government, and civil society.

Second, the process of creation is dependent on the level of organisational autonomy, -resource availability, and -strategic alignment. The **level of organisational autonomy** builds upon transdisciplinary hubs' need to have the freedom to design, organise, and implement educational innovations. It is based on the findings of Meyer et al. (2019), which suggest that successful innovation labs need to be set up with a high degree of autonomy. Therefore, it is expected that the hubs are structurally ambidextrous units –separate and distinct organisational structures– within the university (O'Reilly & Tushman, 2008). In addition, the **level of resource availability** describes the extent to which the hub's leadership and management have access to assets like financial, human, and technological resources (O'Reilly & Tushman, 2008). For example, educational innovation is dependent on the availability of funding, skilled personnel, and up-to-date IT systems. Finally, the **level of strategic alignment** refers to the overlap and intertwinement of the universities' mission, vision, and strategy with the transdisciplinary hubs' purposes and objectives (Sliż and Dobrowolska, 2023).

3.2.3: Space & Infrastructure

First of all, the space and infrastructure of transdisciplinary hubs are defined by their location, scale, and network. The **location** refers to the physical location of the hubs and their place within the university. It may range from standard shared educational spaces to custom-made exclusive spaces (Osorio et al., 2019). Furthermore, the **scale** of the hubs ranges from a single room, to multiple rooms, to a dedicated building (Osorio et al., 2019). Finally, the **network** of the hubs describes the level of interconnectedness with stakeholders from industry, government, and civil society (Carayannis & Campbell, 2009; Caryannis & Campbell, 2010). It is based on the findings of Meyer et al. (2019), suggesting that successful innovation labs need to integrate a large network. For example, educational innovations in transdisciplinary hubs involve students, researchers, businesses, public organisations, and citizens.

Second, the space and infrastructure of hubs can be understood in terms of tangible- and intangible infrastructures. The **tangible infrastructures** refer to the equipment, facilities, digital technologies, technical resources, and tools that support educational innovation in transdisciplinary hubs. It may include things like "whiteboards, writing spaces [...], post-its, markers, moveable barriers, canvas, cubicles, 3D walls, furnished open and coworking spaces, creativity and prototyping rooms, testing rooms, [and] immersive rooms" (Schiuma & Santarsiero, 2021, p. 6). Additionally, the **intangible infrastructures** refer to the atmosphere of the hub, including how people feel about being in the hub, how they engage with the facilities, and how they interact with one another (Schiuma & Santarsiero, 2021). In other words, the intangible infrastructures element describes the distinguishing energy of the space.

Third, the space and infrastructure of the hubs are dependent on the level of organisational flexibility and -organisational constraints. The **level of organisational flexibility** describes the degree to which the evolution of the transdisciplinary hubs is planned to meet its future goals. The hub may consider no future changes, expect to do some minor changes over time, or adapt educational innovations however needed (Osorio et al., 2019). Moreover, the **level of organisational constraints** refers to the different constraints like a lack of administrative, legal, financial, and human resources and limitations in terms of alternative configurations and uses of the physical space.

3.2.4: Process of Use

First, the process of use is defined by the **actual educational activities**, -**competencies**, -**mindsets**, -**scaffolding**, and -**stakeholders**, which describe the extent to which what actually happens in the transdisciplinary hub is aligned with what was intended as part of the process of creation. For example, educational innovations can range from being totally different from intended to being totally as intended (Osorio et al., 2019). In other words, the process of creation elements describe hubs' original intention and the process of use elements the realised intention.

Second, the process of use is dependent on the level of disciplinarity, -engagement, and -emergence. The **level of disciplinarity** refers to the different ways in which the involved students, teachers, and stakeholders in the transdisciplinary hub can learn and work together. Working within the confines of a single discipline[7] is identified as intradisciplinarity; if people from different disciplines are working towards a shared goal but with multiple objectives, it is known as multidisciplinarity (Tress et al., 2005); the collaboration between different disciplines aimed at the integration and synthesis of knowledge is referred to as interdisciplinarity (Bernstein, 2015); and the idea of transcending disciplines to create intellectual frameworks beyond disciplinary perspectives is known as transdisciplinarity (Bernstein, 2015). Furthermore, the **level of engagement** describes the extent to which the involved stakeholders from academia, industry, government, and civil society engage, collaborate, and co-create educational innovations. For example, collaborations may range from short-term one-off to long-term strategic partnerships and stakeholders' involvement may range from occasional participants to dedicated co-located project teams (Osorio et al., 2019). Finally, the **level of emergence** describes how when different individuals, various ways of working, and multiple sources of information are combined, something new is created that cannot be reduced to or predicted based on the individual pieces of that equation (Leavy, 2011). This process, which is based on forming previously non-existent connections, is characteristic of transdisciplinarity (Jahn et al., 2012) and plays an important role in educational innovation.

3.2.5: Impacts & Outcomes

First, the impacts and outcomes of educational innovation in transdisciplinary hubs are based on the **achievement of purposes and objectives**, which refers to the extent to which the mission, vision, and values of the transdisciplinary hub are achieved. Its overarching strategy and principles can range from being not achieved at all to being fully achieved as intended (Osorio et al., 2019). The main reason for this is that educational innovations can align differently with hubs' focus, orientation, and context. For example, one innovation may successfully contribute to the transdisciplinary hubs' community but not be conducive to creating, fostering, and sustaining local ecosystems, whereas another innovation may really be future-oriented but miss today's real-world context. In other words, how the transdisciplinary-, ecosystem-, and process focus, the future-, community- and proactive orientation, as well as the real-world context, are implemented determines the extent to which the hubs' purposes and objectives are achieved.

Second, the impacts and outcomes can be understood in terms of tangible- and intangible results. **Tangible results** refer to the practical and visible outcomes of educational innovation in transdisciplinary hubs. Examples include the number of stakeholders that have participated, the success of partners (e.g. in terms of monetary value created through knowledge and technology transfer), the level of diffusion through media, the number of new educational innovations that have been supported, and the enrichment of the regional labour pool (Osorio et al., 2019). In

[7] In general, a discipline can be described as a delimitable (academic/professional) subject that is characterised by communities with similar (academic/professional) qualifications, working with comparable theories and methods on determined problem areas (Godemann, 2008).

other words, tangible results are those that could be measured quantitatively. In addition, the **intangible results** refer to the non-practical and invisible outcomes of educational innovation in transdisciplinary hubs. Examples include changes in students', teachers', and stakeholders' mindsets, attitudes, and curiosity, an increased sense of belonging and shared experiences, and the space itself becoming an iconic place (Osorio et al., 2019). In other words, intangible results are those that could be measured qualitatively.

Important to note is that in effective transdisciplinary hubs the purposes and objectives, space and infrastructure, and impacts and outcomes are "balanced and correlated through monitoring, control and evaluation metrics, indicators and tools" (Schiuma & Santarsiero, 2021, p. 14). However, at this moment, evaluation and assessment methods with specific indicators and metrics still have to be implemented for the tangible- and intangible results (Osorio et al., 2019; Schiuma & Santarsiero, 2021). Therefore, transdisciplinary hubs struggle to structurally and systematically make sense of their educational innovations. They have a feeling for but do not exactly know what works well and what does not work well, making it difficult to assess their efficiency and effectiveness.

Chapter 4: Methodology

This chapter includes the study design (Section 4.1), case identification and selection (Section 4.2), case descriptions (Section 4.3), data collection (Section 4.4), and data analysis and synthesis (Section 4.6).

4.1: Study Design

This thesis aims to better understand how transdisciplinary hubs are designed, organised, and governed. To study the key factors that shape educational innovation in transdisciplinary hubs, an extensive literature review was conducted. The approach to reviewing, analysing, and synthesising the literature was organic and iterative, resulting in the conceptual framework (Chapter 3) consisting of five dimensions and thirty-three elements (i.e. key factors). To further develop the conceptual framework, case studies were conducted. The case study approach (Yin, 2009) allows for a detailed examination of the transdisciplinary hubs within their real-life setting. In support of this approach, the data collection, analysis, and synthesis were semi-structured and open-ended to capture the subtleties needed for a comprehensive and complete corroboration and iteration of the framework.

4.2: Case Identification & Selection

To identify innovation labs that can be considered transdisciplinary hubs, a systematic search was conducted. First, a list of public research universities in the Netherlands was created. Next, a list of search terms was compiled to identify potential case studies. This list included various combinations of the following words: transdisciplinary, transdisciplinarity, innovation, maker, space, and lab. Based on both lists, two search strategies were carried out: search terms were entered on universities' websites and Google. The search results were assessed based on the characteristics of transdisciplinary hubs: the innovation lab should be university-based and have a dedicated physical space in which traditional disciplinary boundaries are being transcended, science and society learn and work together, and education, research, and valorisation are 'modernised'.

The search revealed several university-based initiatives that matched the characteristics of transcending disciplinary boundaries, collaborating across science-society interfaces, and modernising education, research, and valorisation. For example, Erasmus University Rotterdam has a minor titled "Impact Space: your first steps into making positive societal impact" (EUR, 2022), Utrecht University has a transdisciplinary institute where students, policymakers, artists, and activists collaboratively explore sustainable and meaningful democratic futures (UU, 2024), and the University of Groningen recently initiated the establishment of an interdisciplinary makerspace (UG, 2023). However, only two university-based initiatives matched all the characteristics –including being university-based and having a dedicated physical space– of a transdisciplinary hub: DesignLab at the University of Twente (UT) and Innovation Space at Eindhoven University of Technology (TU/e).

4.3: Case Descriptions

DesignLab is described as “an ecosystem facilitating creative collaboration and knowledge transfer between researchers, societal organisations, students, and citizens” that focuses on three societal domains: health innovation, digital society, and climate resilience (UT, 2024). The mission of DesignLab is to bridge the gap between science and society, enabling impactful and responsible innovations. The overall goals of DesignLab cover three domains: transdisciplinary innovation, citizen science, and educational innovation (UT, 2024). Its activities “are shaped by the theme of Responsible Futuring – a unique approach towards science-based innovation to design ethically for society” (UT, 2024)

Figure 2: Impression of DesignLab (UT, 2024)

The Innovation Space is defined as “the centre of expertise for challenge-based learning (CBL) and student entrepreneurship” and described as “a learning hub for education innovation and an open community where students, researchers, industry, and societal organisations can exchange knowledge and develop responsible solutions to real-world challenges” (TU/e, 2024). The mission of the Innovation Space is to educate ‘engineers for the future’. The overall goals of the Innovation Space cover five domains: challenge-based learning education; entrepreneurial awareness and education; extracurricular activities, start-ups, and student teams; community building and student connection within the ecosystem; and management, office, and technical facilities (TU/e Innovation Space, 2020). Its activities are “in close collaboration with all involved stakeholders; in hands-on and pragmatic way; entrepreneurial; continuously reflecting, learning, and improving; and professional, with high quality standards, aiming for world top” (TU/e Innovation Space, 2020, p. 6)

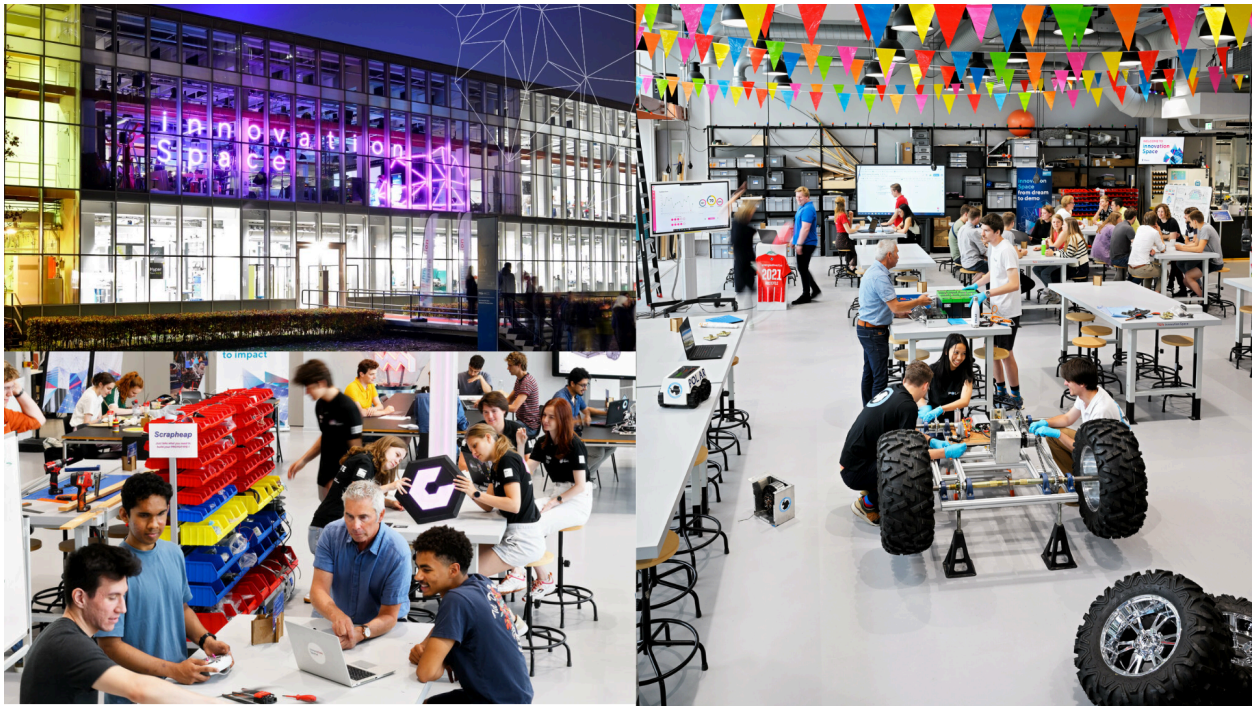

Figure 3: Impression of Innovation Space (TU/e, 2024)

The contextual similarities and differences between DesignLab and Innovation Space provide a robust foundation for a comprehensive case study analysis. On the one hand, both transdisciplinary hubs are part of a technical university and have large custom-made educational spaces (i.e. location element) in a dedicated building (i.e. scale element). On the other hand, the hubs differ in their educational approach. DesignLab takes a more transdisciplinary and societally oriented approach, whereas Innovation Space takes a more challenge-based learning and industrially oriented approach. These similarities and differences are important because the corroboration and iteration of the framework can be based on complementary instead of circumstantial evidence. Ultimately, taking the case study approach will allow for a better understanding of how transdisciplinary hubs are designed, organised, and governed.

4.4: Data Collection

To collect data, ten semi-structured interviews were conducted with key figures in and from DesignLab (6) and Innovation Space (4). The interviewees included founders, members of the management team, and teachers/researchers[8]. This variety of interviewees' roles contributed to a rich, nuanced, and comprehensive dataset. Furthermore, the interviews were designed to unpack interviewees' lived experiences and their semi-structured nature allowed for the exploration of individual insights, experiences, and reflections in greater detail.

[8] To protect the anonymity of the interviewees, their full titles and affiliations are not disclosed.

To systematically conduct the interviews, the interview questions were carefully crafted and strategically sequenced based on the work of Krueger (2014) and the conceptual framework (Chapter 3). The questions were easy to say, clear, short, open-ended, one-dimensional, and progressed from general introductory- to transitional-, key-, and ending questions (Appendix A). The interviews themselves were conducted following a semi-structured approach, supporting the exploratory nature of this thesis. This meant that the key questions were not always asked in the exact order as they were listed.

Before conducting the interviews, the interview protocol and questions were submitted for ethical approval to the University of Twente's BMS Ethics Committee. After receiving the ethical approval[9], potential interviewees were approached via email. Upon scheduling an interview, interviewees received the informed consent form and, at the start of the interview, interviewees were reminded of the agreements outlined in the form. To securely handle the data and guarantee its confidentiality, the necessary precautions were taken. Immediately following the interviews conducted via Microsoft Teams[10], the video recordings were deleted and the audio recordings were extracted and saved on a local hard drive. Immediately following the face-to-face interviews using Apple's built-in voice memos app[11], the audio recordings were extracted and saved on a local hard drive.

4.5: Data Analysis & Synthesis

To analyse the gathered data, the conducted interviews were first transcribed. Initially, the audio recordings were uploaded to amberscript[12], which transcribed the recordings using AI. Following this, the interviews were re-listened and any mistakes in the transcriptions were corrected by hand. Immediately upon having all interviews transcribed, the audio files were deleted from Amberscript and the transcriptions were stored locally. ATLAS.ti[13] was then used to analyse the dataset.

Overall, a dual parallel approach for data analysis and synthesis was applied, using deductive framework-based analysis (Pearse, 2019) and inductive thematic analysis (Braun & Clarke, 2006). The deductive framework-based analysis allowed for the examination of the gathered data through the lens of the conceptual framework. As such, it served as a way to corroborate the framework's dimensions and elements using the collected data. Simultaneously, the inductive thematic analysis allowed for freely identifying patterns within the interview data that might not have become apparent when only following a pre-existing framework. The method has the potential to not only highlight commonalities across the data set but also shed light on the data's complexity and potential discrepancies. Furthermore, to ensure reliability and validity, the data analysis consisted of three sequential coding rounds.

[9] Request number: 240846
[10] Version: 24124.1412.2911.3341
[11] Version: 2.4
[12] Version: 'March 2024'
[13] Version: 24.1.1

During the first round, the data was coded following the deductive framework-based analysis (see Appendix B). Based on the conceptual framework a list of codes, with each code representing one of the thirty-three elements (i.e. key factors), was created. Starting with the deductive coding approach allowed for a deeper familiarisation with the data, as well as the immediate documentation of preliminary associates made based on the conceptual framework. All elements, except for the future orientation, location, scale, and achievement of purposes and objectives elements, were touched upon by one or more interviewees and supported by two or more direct quotes.

During the second round, the data was coded following inductive thematic analysis (see Appendix C and Appendix D). The inductive analysis was not only done after the deductive analysis to offload any preliminary associations that were made but also to stimulate reflexivity. In other words, it was done to increase the likelihood of finding patterns and themes that are not based on what was already known (i.e. the conceptual framework). Furthermore, the inductive analysis surfaced three so-called aggregate dimensions: transdisciplinary hub characteristics, -collaborations, and -challenges with thirteen themes: culture in-, experiences in-, mindset in-, role of-, space of-, structure of-, value of transdisciplinary hubs; external-, internal-, and societal collaborations; and challenges of addressing ambiguity, -collaborating more, and -scaling up, all supported by several inductive codes with each two or more direct quotes.

Finally, during the third round, the deductive and inductive analyses were cross-referenced with handwritten notes that were taken during the interview and data coding process. Ending with cross-referencing the analyses with notes ensured the alignment between interpretation and initial observations, as well as the capturing of additional nuances and insights noted during the interviews that might not be reflected in the formal coding.

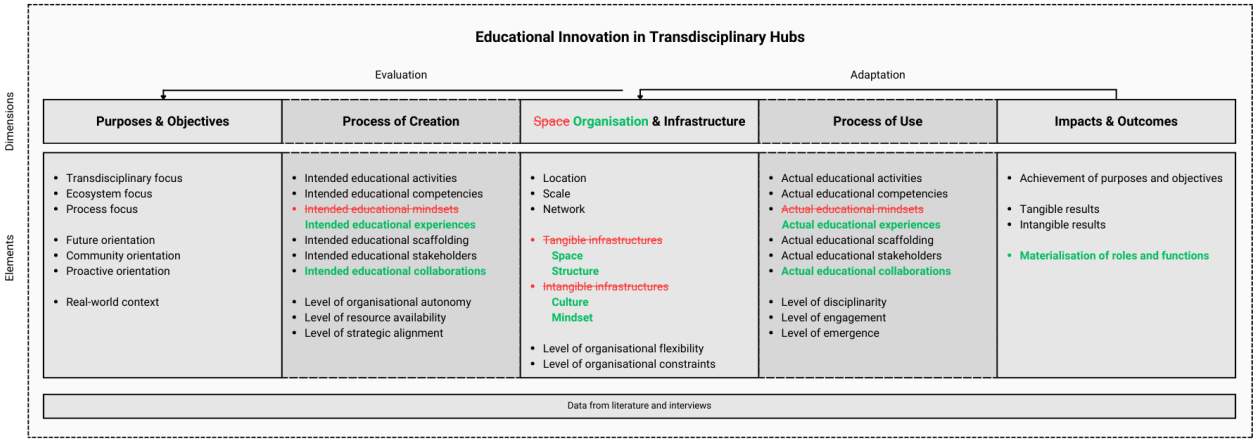

Figure 4: Updated Conceptual Framework

Ultimately, the conceptual framework was updated based on the collected, analysed, and synthesised data (Figure 4). The colours red and green highlighted the updates. In the following subsections, the data analysis and synthesis are shortly described for each dimension: purposes and objectives (Section 4.5.1), process of creation (Section 4.5.2), organisation and infrastructure (Section 4.5.3), process of use (Section 4.5.4), and impacts and outcomes (Section 4.5.5). Each subsection ends with a summary table presenting the elements of the initial conceptual framework in the deductive codes column (left) and the updated/new elements in the inductive themes and codes columns (right). Furthermore, the titles of the dimensions and elements of the final conceptual framework follow the colour coding in Figure 4 and are identifiable by their bold formatting[14]. Finally, the number between square brackets (e.g. [28]) indicates the number of quotes linked to that specific code or theme.

It is important to note that the subsections below serve a descriptive purpose. They merely summarise the data and analysis that led to the updated conceptual framework (Figure 4). The final conceptual framework (Figure 5) itself will be elaborated upon and supported by quotes in Chapter 5. The changes and updates to this final framework will be discussed in Chapter 6.

4.5.1: Purposes & Objectives

Based on the data analysis and synthesis, the purposes and objectives dimension remained unchanged. The **transdisciplinary**-, **ecosystem**- and **process focus**, the **community**- and **proactive orientation**, and the **real-world context** elements were all corroborated by multiple direct quotes. In addition, the **future orientation** element of transdisciplinary hubs was indirectly corroborated.

Purposes & Objectives Dimension		
Deductive Codes	Inductive Themes	Inductive Codes
Transdisciplinary focus [28]		
Ecosystem focus [24]		
Process focus [20]		
Future orientation [0]		
Community orientation [15]		
Proactive orientation [13]		
Real-world context [36]		

Table 1: Purpose & Objectives Synthesis

[14] Some inductive themes and codes have been shortened or altered for the sake of clarity and brevity.

4.5.2: Process of Creation

The process of creation dimension was both changed and added to based on the data analysis and synthesis. The **intended educational activities**, -**competencies**, -**scaffolding**, and -**stakeholders**, as well as the **level of organisational autonomy**, -**resource availability**, and -**strategic alignment** elements were all corroborated by multiple direct quotes. Furthermore, the intended educational mindsets element was corroborated by quotes but ultimately combined with and changed to the **intended educational experiences** element and the **intended educational collaborations** element was added. Important to note is that both of these elements were based on their counterparts in the process of use dimension (see Section 4.5.4).

Process of Creation Dimension		
Deductive Codes	Inductive Themes	Inductive Codes
Intended educational activities [37]		
Intended educational competencies [16]		
~~Intended educational mindsets [8]~~	*Based on corresponding element in the process of use dimension (see Table 4) → **intended educational experiences**	
Intended educational scaffolding [36]		
Intended educational stakeholders [7]		
	*Based on corresponding element in the process of use dimension (see Table 4) → **intended educational collaborations**	
Level of organisational autonomy [14]		
Level of resource availability [41]		
Level of strategic alignment [60]		

Table 2: Process of Creation Synthesis

4.5.3: Organisation & Infrastructure

Based on the data analysis and synthesis, the space and infrastructure dimension was updated to the organisation and infrastructure dimension and changed. The **network** and **level of organisational flexibility** and -**organisational constraints** elements were all corroborated by multiple direct quotes but the **location** and **scale** elements were not. These elements were already defined in the case descriptions (see Section 4.3). Moreover, two elements were changed to four elements in the updated conceptual framework. The tangible infrastructures element was changed to the **space**- and **structure** elements of transdisciplinary hubs and the intangible infrastructures element was changed to the **culture**- and **mindset** elements of transdisciplinary hubs. These new elements were supported by four, six, six, and five additional inductive codes with multiple direct quotes respectively.

Space & Infrastructure → **Organisation & Infrastructure** Dimension		
Deductive Codes	Inductive Themes	Inductive Codes
Location [0]		
Scale [0]		
Network [38]		
~~Tangible infrastructures [46]~~	**Space** of transdisciplinary hubs [12]	A space build by its users [3] | A space displaying its projects [2] | A space that is free to use [2] | A space with its own rules [5]
	Structure of transdisciplinary hubs [51]	Project-based [9] | Student-driven [10] | Organisation develops organically [4] | Organisation is agile [7] | People are the foundation [9] | People have multiple roles [17]
~~Intangible infrastructures [39]~~	**Culture** in transdisciplinary hubs [19]	A sense of belonging [6] | A sense of care [3] | A start-up like culture [2] | A tight-knit community [4] | An engaged alumni network [2] | An informal setting [6]
	Mindset in transdisciplinary hubs [47]	To challenge the status quo [4] | To take responsibility [14] | To make things tangible [12] | To start from the positive instead of the negative [14] | To practise what you preach [5]
Level of organisational flexibility [12]		
Level of organisational constraints [36]		

Table 3: Organisation & Infrastructure Synthesis

4.5.4: Process of Use

The process of use dimension was both changed and added to based on the data analysis and synthesis. The **actual educational activities**, -**competencies**, -**scaffolding**, and -**stakeholders**, as well as the **level of disciplinarity**, -**engagement**, and -**emergence** elements were all corroborated by multiple direct quotes. Furthermore, the actual educational mindsets element was corroborated by quotes but ultimately combined with and changed to the **actual educational experiences** element, supported by five inductive codes with multiple quotes. Finally, the **actual educational collaborations** element was added based on the combination of the external collaborations, internal collaborations, and societal collaborations inductive themes, each of which was supported by five, two, and four inductive codes respectively.

Process of Use Dimension		
Deductive Codes	Inductive Themes	Inductive Codes
Actual educational activities [75]		
Actual educational competencies [30]		
~~Actual educational mindsets [27]~~	Experiences in transdisciplinary hubs [32] → **Actual educational experiences**	Getting to know yourself [5] | Getting to know each other [2] | Learning experienced as impactful [14] | Informal learning [6] | Peer-to-peer learning [5]
Actual educational scaffolding [39]		
Actual educational stakeholders [21]		
	External collaborations [19] + Internal collaborations [35] + Societal collaborations [29] → **Actual educational collaborations**	Collaborations with other organisations [4] | Collaborations with other universities [15] | Regional collaborations [4] | National collaborations [4] | International collaborations [12] Inter-faculty collaborations [27] | Inter-faculty integration [9] Science and society should be connected [5] | Science and society collaborations should involve multiple perspectives [19] | Science should make an impact [4] | Society should be the starting point [13]
Level of disciplinarity [19]		
Level of engagement [43]		
Level of emergence [19]		

Table 4: Process of Use Synthesis

4.5.5: Impacts & Outcomes

Based on the data analysis and synthesis, the impacts and outcomes dimension was added to. The **tangible**- and **intangible results** elements were both corroborated by multiple direct quotes. In addition, the **achievement of purposes and objectives** element was indirectly corroborated. Finally, the **materialisation of roles and functions** element was added based on the role of the transdisciplinary hub inductive theme, which was supported by thirteen inductive codes.

Impacts & Outcomes Dimension		
Deductive Codes	Inductive Themes	Inductive Codes
Achievement of purposes and objectives [0]		
Tangible results [98]		
Intangible results [48]		
	Role of transdisciplinary hub [103] → **Materialisation of roles and functions**	Transdisciplinary hub as agent of change [12] | Transdisciplinary hub as front door [6] | Transdisciplinary hub as frontrunner [7] | Transdisciplinary hub as home base [8] | Transdisciplinary hub as host of activities [24] | Transdisciplinary hub as incubator of the university mission [4] | Transdisciplinary hub as inter-faculty unit [6] | Transdisciplinary hub as linking pin [23] | Transdisciplinary hub as place of dialogue [6] | Transdisciplinary hub as place of experimentation [10] | Transdisciplinary hub as place of informality [6] | Transdisciplinary hub as place of serendipity [6] | Transdisciplinary hub as place of support [6]

Table 5: Impacts & Outcomes Synthesis

Chapter 5: Results

In this chapter, the results are discussed based on the five dimensions of the final conceptual framework (Figure 5): purposes and objectives (Section 5.1), process of creation (Section 5.2), organisation and infrastructure (Section 5.3), process of use (Section 5.4), and impacts and outcomes (Section 5.5).

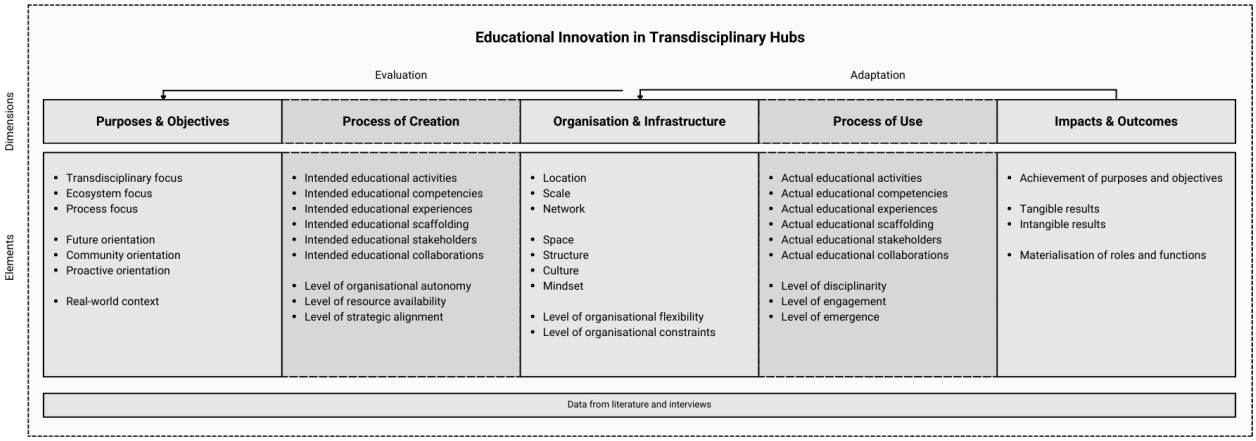

Figure 5: Final Conceptual Framework

5.1: Purposes & Objectives

First of all, the purposes and objectives of educational innovation in transdisciplinary hubs are defined by a transdisciplinary-, ecosystem-, and process focus. The interviews highlighted the hubs' **transdisciplinary focus** time and time again. For example, one interviewee stated that "*we are bringing disciplines together to solve societal challenges, but also get knowledge from society and have collaborative relations with societal partners*" (INT. 2) and another mentioned that "I *work together with other colleagues to develop projects, methods, and also networks that have to do with transdisciplinarity*" (INT. 10). In other words, disciplines and the possibilities for combining them are re-imagined and stakeholders from both science and society are involved. Furthermore, the interviewees often affirmed the **ecosystem focus** of the hubs, which are actively involved in creating, fostering, and sustaining local ecosystems. One of the interviewees even mentioned that: "*I think the purpose for existence of [X][15] is to create that ecosystem that you won't have elsewhere. To create a safe space where researchers, students, companies, citizens feel like they can walk in [and] work on these challenges*" (INT. 7). This means that the hubs aim to bring students and researchers, industry experts and entrepreneurs, policymakers and public administrators, and civic groups and local communities together. Finally, describing the constant defining and redefining –**process focus**– of educational innovations in transdisciplinary hubs, one interviewee highlighted that "*you always have to move back and forth between trying to put it into practice and then going back to the strategy again*" (INT. 9), with

[15] It is important to note that [X] means that the name of the transdisciplinary hub was mentioned. Similarly, [Y] means that a name of a project/organisation was mentioned. To protect anonymity, these titles are not disclosed.

another stating why: "*the purpose is to innovate education in a very rapidly changing world. Like everything changes and needs to be adapted all the time*" (INT. 1). Thus, being able to constantly adapt to and be ready for what comes is a key purpose and objective of transdisciplinary hubs.

Second, the purposes and objectives are oriented based on the future, a community, and proactivity. When talking about the actual educational activities and scaffolding, interviewees highlighted that educational innovations are not only shaped by a reactive present-day orientation but also a proactive **future orientation**. They often stated that as the complexity of today's and tomorrow's societal challenges increases, the importance and necessity of universities' involvement in addressing those challenges also increases. For example, one interviewee concluded that "*we have to tackle very big problems that we're facing [...] and we need science to step in as well*" (INT. 10). Moreover, describing the importance of the **community orientation**, interviewees stated: "*our activities and events have always been a way to nurture the community*" (INT. 1) and "*we're focusing on building this learning community*" (INT. 4). In other words, building and growing an engaged community of students, teachers, and stakeholders is a central purpose and objective of educational innovation in the hubs. Elaborating on the reason why this is important, another interviewee said that "*if you are from different backgrounds, it takes time to learn how to talk and think, and especially to start to appreciate each other. So, in that sense, having a community helps*" (INT. 2). Finally, the interviewees stated that in transdisciplinary hubs "*we're taking, I think, more and more responsibility. First, we were focusing on students and now we [...] also start moving with the stakeholders*" (INT. 3). The evolving demands of our times are not only studied in educational innovations but also addressed. students and researchers, industry experts and entrepreneurs, policymakers and public administrators, and civic groups and local communities actively work together based on a **proactive orientation** to tackle relevant societal challenges and make an impact.

Third, the purposes and objectives are informed by the **real-world context**, the importance of which was continuously highlighted in the interviews. For example, one interviewee said that "*we really want to build students who can [...] link their knowledge to actual real-world problems and make something or contribute to something*" (INT. 8). To do so, another interviewee stated that "*we need to give some distilled set of notions and knowledge and for that I'm using a lot of examples from everyday life [...] to make things relatable, because otherwise, it's really hard to understand*" (INT. 10). Educational innovation is thus not only based on theory and hypotheses but also on experience and reality. In other words, making the connection between the content and context of societal challenges proves to be crucial for creating valuable learning experiences.

5.2: Process of Creation

First, the process of creation is defined by the intended educational activities, -competencies, -experiences, -scaffolding, -stakeholders, and -collaborations. The **intended educational activities** indeed range from (extra)curricular one-day and multi-day events, to long-term programmes. For instance, one interviewee said "*it's not only about knowledge transfer in the*

traditional way. It's also about, for example, hackathons or doing things together in bootcamps, and [...] maybe moving towards something like that could be an option" (INT. 6) and another mentioned that "*we're currently looking at how we can do it in a 15 EC learning line*" (INT. 3). In other words, the variety of possibilities transdisciplinary hubs have for creating learning opportunities is big. Furthermore, the **intended educational competencies** that were mentioned during the interviews align with the range of disciplinary and transversal competencies that were originally described. For example, one interviewee stated that "*we're trying to push for more arts in the engineering sciences because we think it's an important competence for students*" (INT. 3). Students learn about the arts and its applications in an engineering context, which helps them develop both disciplinary and transversal competencies. In addition, the **intended educational experiences** do not only refer to the different ways of thinking that students, teachers, and stakeholders can develop (i.e. intended educational mindsets) but also the different perspectives that they are exposed to and experience. For instance, one interviewee talked about the "*proactiveness and open mindedness that we try to develop in our students*" (INT. 8), and another about the "*courage you could say to change things in society*" and the "*ways for students to really experience what the perspective of society are*" (INT. 2). These examples do not really describe taught mindsets but rather experienced mindsets. In other words, students develop these ways of thinking through the different perspectives they experience. Moreover, the **intended educational scaffolding** was described several times during the interviews: "*our goals in terms of how to educate within a CBL context are learning by doing, dealing with uncertainty, and are based on the design thinking process*" (INT. 1), "*it needs to be interdisciplinary, challenge-based learning with authentic stakeholders. That's the basic package*" (INT. 3). These two examples illustrate the wide variety of possibilities transdisciplinary hubs have to structure and support educational innovation. They also showcase that educational scaffolding is not only about the approach to (i.e. pedagogy) but also about the content of (i.e. curriculum design) educational innovations. Additionally, one interviewee summarised the **intended educational stakeholders** involved in transdisciplinary hubs aptly: "*we aim for students from all over the university" and "we aim to collaborate with different kinds of stakeholders. But you could say the whole quadruple helix is normally present*" (INT. 2). Another interviewee further corroborated this by saying "*our program, in that sense, is open to students of whichever institution*" (INT. 5), and another one expanded upon both statements by stating: "*we call it already the six folded helix instead of the quadruple helix, and with the six folded helix you add nature and design to [...] academia, industry, government, and civic society*" (INT. 9). These statements not only capture the wide variety of stakeholders transdisciplinary hubs intend to involve but also describe the inclusive nature of their approach. Finally, the **intended educational collaborations** describe the different intended educational innovation collaborations that are hosted, facilitated, and organised in transdisciplinary hubs. These collaborations can be internal (within the university) or external (outside the university) and happen at local, regional, national, and international levels.

Second, the process of creation is dependent on the level of organisational autonomy, -resource availability, and -strategic alignment. Interviewees not only described the need for transdisciplinary hubs to have a high **level of organisational autonomy** but also included the importance of maintaining a close alignment with the rest of the university. For example, one interviewee stated, "*I think [X] is trying to hopefully have the best of both worlds. On the one hand, to have autonomy, to be different. On the other hand to really be connected to the whole university and outside world*" (INT. 2), because as mentioned by another interviewee: "*in the end, we are also very dependent on the vision of the university [and] our goals are very connected to the new education vision of the university*" (INT. 1). In other words, even though the hubs require a high level of organisational autonomy in terms of day-to-day operations, they do need to be tightly connected to the wider university in terms of long-term visions. In addition, the **level of resource availability** also proved to be important. For instance, interviewees indicated that financially speaking "*we are fully financed by the university, but with the idea that we also have [...] partners contributing financially in one way or another*" (INT. 1) and that "*we have some central funding [but] the rest of it has to come from money that we generate ourselves by doing projects*" (INT. 4). In other words, transdisciplinary hubs do receive funding from the university but cannot be dependent on it. To also give an example in terms of human resources, one interviewee mentioned that "*[X] has upwards of seventy people [and] more than half of them are student assistants*" (INT. 5). Interestingly, compared to universities' faculties and departments, hubs' staff is primarily filled with part-time student assistants opposed to full-time employees. These students have the responsibility to exercise that day-to-day operational autonomy, whereas the employees work more on those long-term visionary activities. Finally, the **level of strategic alignment** was mentioned various times by interviewees. One interviewee indicated that "*our mandate and responsibility is directly to the executive board [...] and deans together. So that makes that we are strategically on a high level in the governance model of the university*" (INT. 4) Another interviewee further corroborated this by stating that transdisciplinary hubs are "*subsidised by the university [so they] need support from the board and in our case also directly or indirectly from the different deans of the faculties*" (INT. 2). In other words, the level of organisational autonomy, -resource availability, and -strategic alignment are tightly connected.

5.3: Organisation & Infrastructure

First of all, the organisation and infrastructure of transdisciplinary hubs are defined by their location, scale, and network[16]. Interviewees indicated that transdisciplinary hubs indeed need to be and are interconnected with a large **network** of stakeholders from industry, government, and civil society, stating that "*some of the partners like the province and municipality have been involved in multiple collaborations at [X]*" (INT. 2) and "*we have good links here with the province, with the region, with the city*" (INT. 9). Important to note is that, according to these interviewees, developing a large network of stakeholders proves to not only be based on the quantity of but also the quality of the relationships.

[16] The location and scale elements are not discussed here but in Sections 4.3 and 4.5.3

Second, the organisation and infrastructure of hubs can be understood in terms of the space- and structure of and the culture- and mindset in transdisciplinary hubs. The **space** is defined by the equipment, facilities, digital technologies, technical resources, and tools that support educational innovation in transdisciplinary hubs. For example, interviewees said that "*immediately in the first building [we] had a service desk with some tools, and now we have three workshops, for example, one with 3D printing facilities*" (INT. 1), "*there's the makerspace to make all kinds of prototypes and there's all kinds of video equipment that students can use*" (INT. 2), and "*there are a lot of materials present in the rooms that can be used for those activities that are not standards, such as doing prototyping*" (INT. 10). The space is readily accessible and free to use: "*we have large opening hours and all our prototyping facilities are for free*" (INT. 3). Importantly, its equipment, facilities, and tools come with their own policies and procedures, independent from the rest of the university. One interviewee explained how and why: "*we have the educational spaces, but they are not part of [Y: university's facility management] and there, for instance, it's in the rules that if you use the space [...] you need to leave everything in the place where it was [...]. Whereas in [X] we deliberately choose to have certain spaces where you're just allowed to make a mess*" (INT. 4). Together, the availability and flexibility of the space give students, teachers, and stakeholders the opportunity to innovate in education. They are allowed to and even encouraged to think outside the box. Furthermore, the **structure** of hubs is people-based and student-driven. It builds upon students, teachers, and stakeholders' various roles in other departments and organisations and relies on students' input, participation, and engagement in coordinating, managing, and advancing operations. Interviewees stated that "*lots of students work at [X]*" (INT. 3) and that "*[X] has upwards of seventy people [and] more than half of them are student assistants*" (INT. 5). In other words, hubs' staff is primarily filled with student assistants opposed to full-time employees. Not only that, interviewees mentioned that "*a lot of people within our team, I would say even half of the staff, also works in other departments*" (INT. 1), which is something that is considered extremely important and helpful. One interviewee said that "*what I found really helpful is that I basically have three positions [in the university] as one person*" (INT. 4) because it contributes to sharing one's own and learning from others' educational innovations. This people-based and student-driven nature is further cemented in hubs' agile and project-based structures: "*we don't have that much staff directly employed in [X], so we are really lean in terms of structure*" (INT. 4), "*it's learning to and trying to stay flexible, to really connect, to stay flat*" (INT. 1) and "*we have a number of projects running with specific questions*" (INT. 2). In other words, these structures foster a dynamic and flexible working environment that builds upon individual responsibility and ownership, supporting both students and employees in their work and professional development. In addition, the **culture** refers to the atmosphere in the hub, describing how people feel about being in the hub, how they engage with the facilities, and how they interact with one another. Throughout the interviews, it became clear that it is primarily based on informality and engagement: "*I mean, the most valuable things come out of these quick [informal] conversations*" (INT. 7) and "*we also see that students who were engaged in the community of [X] keep on coming back*" (INT. 3). This makes the hubs a place that people like to come to with a culture that people want to be part of. One interviewee summarised it aptly by stating that "*we have created a very community-like space,*

where people like to be, where students like to come to work, and where people that visit are always like: wow!" (INT. 1). Finally, the **mindset** refers to the basic attitudes and perspectives in the hub. Emphasis is placed on the importance of challenging the status quo, taking responsibility for societal challenges, making abstract concepts tangible, starting from the positive, and practising what is preached. For example, interviewees mentioned that they "*would argue, even if it's maybe not formalised as such, that one of the main attitudes that is required is to really challenge your own assumptions, your own status quo*" (INT. 10) and that "*there is not just: 'this is how you should do it', but we are finding it out along the way*" (INT. 2) mentality. Interestingly, none of the interviewees indicated that these mindsets (nor the culture) are deliberately promoted, implying that they emerge and develop organically.

Third, the organisation and infrastructure of the hubs are dependent on the level of organisational flexibility and -organisational constraints. The importance of transdisciplinary hubs having a high **level of organisational flexibility** was mentioned several times. Interviewees stated that "*I think it's successful due to the fact that we're not forcing things to happen*" (INT. 7) and "*we have changed so many things in all these years, just trying and seeing if they work. And then if it doesn't work: evaluate and reflect*" (INT. 1). This high level of flexibility enables hubs to adapt educational innovations however is needed based on its current and future goals. Moreover, it allows hubs to deal with the **level of organisational constraints**. Interestingly, the constraint that was most often mentioned by interviewees did not relate to financial, human, or technical resources. Instead, it is a constraint that affects all of these: time. One interviewee explained why, stating that "*I think one of our biggest challenges is that time is becoming more valuable to people*" (INT. 7). Combined with the "*the fact that we are in a way involved in quite teacher-intensive educational programs is a serious challenge*" (INT. 8). Important to note is that this is not only the case for teachers, researchers, and stakeholders but also for students. As explained by one interviewee "*offering a program that's done [...] on top of another master is hard for some students to make it feasible to do that program.*" (INT. 4). In other words, the substantial amounts of time that educational innovation in transdisciplinary hubs takes may be the most important organisational constraint now and in the foreseeable future.

5.4: Process of Use

First, the process of use is defined by the actual educational activities, -competencies, -experiences, -scaffolding, -stakeholders, and -collaborations. The **actual educational activities** in transdisciplinary hubs consist not only of formal learning experiences, "*we have the curricular and extracurricular role in [X]*" (INT. 1), but also informal learning experiences[17]. On the one hand, students learn working in the hubs as student-assistants, with interviewees having seeing that "*some students who really grew in their role* (INT. 8) and that their involvement in the day-to-day operations is one of "*the biggest learning opportunity for these students, to set up an educational space, to make it their own*" (INT. 7). On the other hand, students learn by being in the hubs, "*and that's how you've got like all these, let's say, non-planned educational projects in [X]*" (INT. 7).

[17] It is important to note that the additions to this element (as well as other elements in the process of use dimension) also hold for their corresponding process of creation dimension elements.

Furthermore, the **actual educational competencies** are aptly summarised by one of the interviewees: "*if you stay closer to what students learn and what they directly see after their learning as the added value, then that is clearly articulated in the things like: new methods, new ways of working, learning to collaborate with students from all the disciplines, leadership and collaboration [...] reality shocks, shocks about chaos and how to deal with that, that the outside world is not neatly organised along the lines that we have thought of, being surprised that it really matters what you think, that life is not just a textbook exercise*" (INT. 2). However, the interviewees also often discussed two new transversal competencies: prototyping and tangibilizing. They consistently highlighted the importance of being able to build working prototypes and make abstract ideas concrete, saying that "*we do prototyping because it's a boundary object and it often enables the collaboration between the students*" (INT. 3). One interviewee explained that the reason for it is that "*if you make something tangible, you can put that object on the table and you can start discussing that [...]. Whereas if you have just verbal communication, it's automatically 'you' saying something against 'me' saying something*" (INT. 4). In other words, being able to prototype and tangibilize seems to be of great importance for the students, teachers, and stakeholders involved in transdisciplinary hubs' educational innovations. In addition, when interviewees talked about the **actual educational experiences**, they highlighted how these experiences do indeed not only refer to learning about and being exposed to different ways of thinking but also to different ways of viewing the world. What interviewees often "*hear is that it often broadens their perspective*" (INT. 3). Moreover, the **actual educational scaffolding** that happens is indeed about both the approach to and content of educational innovations. For instance, one interviewee mentioned that they are scaffolding a "*way for students to design their own rubrics so that they can understand how they are evaluated and why they are evaluated in a certain way*" (INT. 10). Additionally, the **actual educational stakeholders** that were mentioned by interviewees aligned with the stakeholders transdisciplinary hubs intended to involve. For example, one interviewee said that "*in some of our courses and student teams there are also students from [Y: a university of applied sciences] and there have been some students involved in the past from [Y: a university of the arts]*" (INT. 1), and another stated that "*some of the partners like the province and municipality have been involved in multiple collaborations at [X]*" (INT. 2). Finally, the **actual educational collaborations** describe the actual internal and external collaborations that are hosted, facilitated, and organised in transdisciplinary hubs. Interviewees gave several examples of internal collaborations with individuals and faculties, stating that "*we have the different researchers from faculties attached to [X]. There are now sixty, I think. And that means we have veins to all the faculties*" (INT. 9), and "*if you look at the projects that we set up, we also do that with other faculties*" (INT. 8), respectively. In a similar fashion, interviewees gave various examples of external collaborations. Interestingly, these collaborations did not only happen at a local and regional level but also at a national and international level. For example, one interviewee talked about a national collaboration between "*[X] and the tax authorities within a bigger consortium of companies*" (INT. 8) and another about an international collaboration: "*one of the things we're working on right now is a study abroad program [...], and after this first pilot year, which was very successful, we have three [Y: international] universities that are going to join*" (INT. 7).

Second, the process of use is dependent on the level of disciplinarity, -engagement, and -emergence. The **level of disciplinarity** varies. Interviewees often stated that they "*often try not to stick to one perspective from society, but either bring in different stakeholders ourselves or have [...] students look beyond, let's say, the partner, to others that are also involved*" (INT. 2) and that they have "*had students from all the faculties*" (INT. 8) participate in their educational innovations. However, based on the interviews it is difficult to conclude whether these and other examples lean towards being interdisciplinary or transdisciplinary. In both cases, it is clear that there are multiple ways in which the involved students, teachers, and stakeholders learn and work together. Furthermore, the **level of engagement** varies from collaboration to collaboration, project to project, and person to person. Generally speaking, the level of engagement is considered to be low by the interviews. However, they all talked about the goal of and effort from transdisciplinary hubs to increase that level of engagement. For example, interviewees stated that "*some of the partners like the province and municipality have been involved in multiple collaborations at [X]*" (INT. 2) and that "*the people that bring challenges –and that could be municipalities, NGOs, companies, or [...]– are also involved in some of our events and courses as coaches*" (INT. 1). Interestingly when talking about the level of engagement several interviewees again highlighted the constraint of time to be one of the biggest challenges for transdisciplinary hubs. Finally, the **level of emergence** was aptly illustrated by one interviewee: "*we had an event going on here [...] and they brought citizens here to talk about, you know, what is your flight experience from booking to coming back home after your trip. [...], in one of the other rooms here, there were researchers working on [Y: a robot helping passengers to get to gates]. [...]. And as that robot was helping here, they were getting in contact with these people, having a different event on the same type of ideas. And after talking to one another, they connected on what can this robot do, and could we not change things that I'm doing in my research while the citizens are here?*" (INT. 7).

5.5: Impacts & Outcomes

First, the impacts and outcomes of educational innovation in transdisciplinary hubs are based on the **achievement of purposes and objectives**. However, when talking about the extent to which the mission, vision, and values of the transdisciplinary hub are achieved, many interviewees did not have self-evident answers. Even though interviewees mentioned things like "*we have created a very community-like space, where people like to be, where students like to come to work, and where people that visit are always like: wow!*" (INT. 1) and know that "*there are clear indicators that there is value, that there is impact"* (INT. 2), they also ask themselves *"how big is it, how long lasting is it, how does it really show?*" (INT. 2). In other words, determining how the implementation of the transdisciplinary-, ecosystem-, and process focus, the future-, community- and proactive orientation, as well as the real-world context influences the extent to which the hubs' purposes and objectives is difficult. Yet, interviewees do recognise its importance. For example, one of them stated that "*the challenge is how to make the claim that these things actually occur in a way that is respected*" (INT. 6)

Second, the impacts and outcomes can be understood in terms of tangible- and intangible results. The interviewees talked about numerous **tangible results**, giving plenty of examples of practical and visible outcomes of educational innovation in transdisciplinary hubs. One interviewee highlighted three initially unexpected but now considered invaluable outcomes, stating that "*it's hard to think of a more stable mechanism for both talent development, university reputation development, and startup development. Even if those things were not intended as outcomes [...] they end up happening all three quite naturally*" (INT. 5). Several interviewees also said that "*the most visible success was winning the Dutch Higher Education Award*" (INT. 2). Both transdisciplinary hubs have won the award and are still benefiting from the increased recognition and visibility, as well as the associated financial reward. However, next to the impact of big prizes like these and their resulting exposure, interviewees also mention that the smaller and seemingly insignificant impacts sometimes make a real difference, "*you know [...] where [X] is working with the father on an electric wheelchair for his son. It's a small thing, but there you can see how makerspaces and digital fabrication help on a personal level.*" (INT. 9). Yet, the interviewees often reiterated that the most important practical and visible outcomes is still that "*[X] provides a set of methods, tools, techniques, best practices, guidelines, ways of working, and networks that can be used to directly bring [...] in what we learn in each faculty and in each institute*" (INT. 10). In addition, the interviewees gave plenty of examples of **intangible results**. For example, interviewees talked about how stakeholders experience value: "*we also have happy stakeholders who confirmed that working with these students was a pleasure. They get new insights. They also are drawn out of their comfort zone. So, there are clear indicators that there is a value, that there is impact*" (INT. 2). However, the non-practical and invisible outcome that is mentioned most has little to do with individual experiences and more with a collective sense of purpose. Interviewees often struggled to put it into words but frequently summarised it by stating that "*I think the [X] is a great place of dialogue, of belonging, of care*" (INT. 10) and describing it as "*a sense of a home base, a sense of belonging, and having a place and community*" (INT. 4). Ultimately, they say that "*having created this unifying space where students from all different disciplines, but also stakeholders, feel welcome and they like to come to*" (INT. 1) is one of, if not, the biggest intangible outcomes. Interestingly, interviewees from both transdisciplinary hubs questioned their names. They said "*it's a very personal opinion, but maybe we're working very much with the name [X] and not the purpose. And then people seeing: 'oh, [X] again got a price' but they don't have a clue what happens in [X]*" (INT. 1) and "*I think the term [X] is misleading because it's not a [X: Lab/Space] about [X: Design/Innovation]. We do [X: Design/Innovation]. We use [X: Design/Innovation]. [...]. But the place is not about [X: Design/Innovation]. It's a futures lab [...], that's I think something that maybe would be a bit clearer*" (INT. 10). In other words, they questioned whether the names DesignLab and Innovation Space describe what actually happens in the hubs and capture that collective sense of purpose accurately.

Finally, the interviewees brought to light new impacts and outcomes in form of the **materialisation of roles and functions**. They stated and reiterated that the transdisciplinary hubs play several distinct roles. For example, interviewees often said that the hubs serve as a front door, as "*a lot of visitors that come to the university pass [X]. So, it's also a way for the university to show a space that is different and to show the innovations that take place*" (INT. 1). At the same time, the hubs are also frontrunners, as "*the role of [x] within the university is basically to be the frontrunner for the university to really work in this transdisciplinary way, to really address societal challenges*" (INT. 4). One interviewee even stated that "*you could also say that the current mission of the university was invented in [X]*" (INT. 2). The main reason for this is that the transdisciplinary hubs are places "*where if you have ambitions on educational innovation, you can really play around*" (INT. 3) and simply "*meet people there just spontaneously*" (INT. 8). Interviewees also think that this has been "*the strength and the challenge for [X] from day one is that we are really an entity that is university wide [...], that is used by all of the faculties*" (INT. 4). However, it is important to note that "*[X] is not an academic department, but it provides support to academics*" (INT. 5). Therefore, the hubs have mostly been described as agents of change, front doors, frontrunners, home bases, hosts of activities, incubators of the university mission, inter-faculty units, linking pins, places of dialogue, places of experimentation, places of informality, places of serendipity, and places of support. In that sense, its roles and functions are much more about hosting, facilitating, and leading a wide and diverse range of educational innovations as opposed to organising, executing, and implementing them. This means that transdisciplinary hubs more often than not work together with people based at the rest or outside of the university instead of inside the hub. Yet, creating, fostering, and sustaining these connections comes with several complications and obstacles. One interviewee mentioned that "*this connection to the departments is one of the biggest challenges*" because "*sometimes we run too fast, as the university is slower and has its ways, its protocols, its processes*" (INT. 1). Another explained that "*maybe the most difficult thing is that you don't have any formal power, to no one*" so "*for everything that you do, you have to show something that people get excited about*" (INT. 2). In other words, despite transdisciplinary hubs' collaborative nature, they face significant challenges when it comes to integrating their educational innovations within the rest of the university.

Chapter 6: Discussion

This chapter includes a discussion of findings (Section 6.1) and reflections (Section 6.2). Each finding and reflection will shortly be discussed in light of the theoretical framework (Chapter 2) and initial conceptual framework (Chapter 3).

6.1: Findings

In the following subsections, the findings related to the conceptual framework are discussed based on the five dimensions: purposes and objectives (Section 6.1.1), process of creation (Section 6.1.2), organisation and infrastructure (Section 6.1.3), process of use (Section 6.1.4), and impacts and outcomes (Section 6.1.5).

6.1.1: Purposes & Objectives

The **transdisciplinary**-, **ecosystem**- and **process focus**, the **community**- and **proactive orientation**, and the **real-world context** were all corroborated by multiple interviewees. In addition, the **future orientation** was indirectly corroborated. Together, these elements can be considered the key factors that shape the purposes and objectives of educational innovation in transdisciplinary hubs.

6.1.2: Process of Creation

The **intended educational activities**, -**competencies**, -**experiences**, -**scaffolding**, -**stakeholders**, and -**collaborations**, as well as the **level of organisational autonomy**, -**resource availability**, and -**strategic alignment** were all corroborated by multiple interviewees. These elements can be thought of as the key factors that shape the process of creation in the hubs. Additionally, two of them were updated based on the interviews. First, the definition of **intended educational experiences** was expanded to cover both the intended different ways of thinking (Bernstein, 2015; Wickson et al., 2006), as well as the perspectives and experiences that people are exposed to in the hubs. Based on what interviewees mentioned, educational innovation in transdisciplinary hubs is not only aimed at developing ways of thinking but also at developing attitudes. For example, proactiveness, open-mindedness, and courage seem to be developed through what Miranda et al. (2021) would likely refer to as learning-by-doing. It is important to note that these attitudes are not developed through specific and deliberate efforts, but instead emerge as a byproduct of the different educational activities in transdisciplinary hubs. Second, the understanding of the **level of organisational autonomy** was enriched. It not only describes the need for transdisciplinary hubs to be set up with a high degree of autonomy (Meyer et al., 2019) but also the need for hubs to be closely aligned with the rest of the university. Based on interviews, it became clear that the hubs do have a high degree of autonomy, but that they just as well need the overlap and intertwinement with the universities' mission, vision, and strategy (Sliż and Dobrowolska, 2023). Interviewees stated that to establish, develop, and foster its connections to the different faculties, transdisciplinary hubs must be different from the rest of the university to be of value, but recognised by it to be credible and utilised. It thus seems like the level of organisational autonomy and -strategic alignment are two sides of the same coin.

6.1.3: Organisation & Infrastructure

The **location**, **scale**, **network**, **space**, **structure**, **culture**, and **mindset**, as well as the **level of organisational flexibility** and -**organisational constraints**, can be regarded as the key factors that shape the organisation and infrastructure of transdisciplinary hubs. In addition, based on the interviews, it became clear that both the designers and operators of the hub have a significant impact on it. Designers are responsible for choosing the layout, resources, tools, and equipment that form the functional and aesthetic features of the space, while the operators are responsible for day-to-day activities such as managing and supporting projects, welcoming and assisting guests, and planning and coordinating events (Schiuma & Santarsiero, 2021). In other words, they essentially establish, develop, and foster the **space** and **structure** of, as well as **culture** and **mindset** in transdisciplinary hubs.

6.1.4: Process of Use

The **actual educational activities**, -**competencies**, -**experiences**, -**scaffolding**, -**stakeholders**, and -**collaborations**, as well as the **level of disciplinarity**, -**engagement**, and -**emergence** were all corroborated by multiple interviewees. These elements can be considered as the key factors that shape the process of use in the hubs. Additionally, three of these elements were updated based on the interviews. First, the definition of **actual educational activities** was updated to describe both the (extra)curricular education (Osorio et al., 2019; Schiuma & Santarsiero, 2021) and the informal education that takes place in transdisciplinary hubs. Based on what the interviewees mentioned, educational innovation seems to not only happen based on planned and structured learning experiences (formal education) but also emerges as a byproduct of non-planned and organic learning experiences (informal education). Interviewees highlighted how student assistants who work in the hubs grow in their roles as, for example, project coordinators and operators. They learn a lot as they run the space, create operational procedures, and host educational activities. Additionally, interviewees mentioned that students who come to visit the hubs also learn based on spontaneous interactions with other students, staff, and stakeholders. For example, they learn how to use technical facilities like 3D printers and laser cutters from the support staff. Second, the list of **actual educational competencies** expanded with two competencies: prototyping and tangibilizing. Based on what interviewees mentioned it seems like prototyping and tangibilizing are so widely applicable that they fall between both the transversal and disciplinary competencies (Miranda et al., 2021). On the one hand, they are transversal because they support communication –"to effectively express [...] ideas in oral, graphic, or written ways, even using media or any technological resources" and creativity and innovation: "to design, develop, and research to materialise creative and innovative problem solutions" (Miranda et al., 2021, p. 4). On the other hand, they are disciplinary because they can be associated "with specific technical knowledge and task-oriented skills to be applied in a specific field" such as 3D printing, programming, and CAD modelling (Miranda et al., 2021, p. 4). Third, the **actual educational collaborations** –and with that the intended educational collaborations element– was added to the conceptual framework. Based on the interviews, it became clear that the hubs integrate a large network of people and organisations (Meyer et al., 2019), bringing together students and researchers, industry experts and

entrepreneurs, policymakers and public administrators, and civic groups and local communities (Lukovics & Zuti, 2015), through different internal and external collaborations that are hosted, facilitated, and organised in transdisciplinary hubs. These collaborations can happen at local, regional, national, and international levels.

6.1.5: Impacts & Outcomes

The **achievement of purposes and objectives**, the **tangible**- and **intangible results**, and the **materialisation of roles and functions** can be thought of as the key factors that shape the impacts and outcomes of educational innovation in transdisciplinary hubs. Initially, the impacts and outcomes were considered to be difficult to assess. However, based on the interviews, two important insights related to them surfaced. First, the **materialisation of roles and functions** was discovered and added to the conceptual framework. It describes how transdisciplinary hubs' roles and functions are much more about hosting, facilitating, and leading a wide and diverse range of educational innovations as opposed to organising, executing, and implementing them. The hubs are, among other things, considered to be agents of change, front doors, home bases, linking pins, as well as places of dialogue, -experimentation, and- support. Essentially, these roles and functions capture the various ways in which transdisciplinary hubs by virtue of their existence create value. Second, the interviews suggest that the indicators and metrics needed to monitor, control, and evaluate the educational innovations in transdisciplinary hubs might be more readily accessible than expected. Currently, transdisciplinary hubs still struggle to structurally and systematically make sense of their impacts and outcomes because specific evaluation and assessment methods have yet to be implemented (Osorio et al., 2019; Schiuma & Santarsiero, 2021). However, interviewees regularly implied that the key factors shaping the organisation and infrastructure and the process of use of transdisciplinary hubs could be considered as outcomes in and of themselves. Osorio et al. (2019, p.19) already found that managers of innovation labs "believe that the space itself seems to become an iconic place, attracting communities, and favouring brand recognition [...]", indicating that the space and culture elements can indeed be considered impacts and outcomes. Yet, the interviewees highlighted that next to the space, also the structure and mindset, as well as the actual educational competencies and -experiences, were often experienced as valuable and impactful. For example, interviewees gave numerous examples of what students, teachers, and stakeholders see as added value, including learning to collaborate with people from other disciplines, experiencing reality shocks, being part of a community, learning new skills, broadening their perspectives, finding out that life is not just a textbook exercise, learning how to deal with autonomy and responsibility, and many more. In other words, the examples that were given while describing the key factors related to the organisation and structure and the process of use of transdisciplinary hubs should be considered as a starting point for translating the feeling of what works well to a more exact understanding of what works well and what does not work well.

6.2: Reflections

In the following subsections three broader reflections termed ambidexterity and autonomy (Section 6.2.1), multirole and multifunctional (Section 6.2.2), and prototyping and tangibilizing (Section 6.2.3) will be discussed.

6.2.1: Ambidexterity & Autonomy

The literature related to organisational ambidexterity (Section 2.1) and the initial level of organisational autonomy element (Section 3.2.2) suggested that transdisciplinary hubs would be structurally ambidextrous units within the university, as they are considered separate and distinct organisational structures (O'Reilly & Tushman, 2008) that are set up with a high degree of autonomy (Meyer et al., 2019). However, even though the hubs are indeed strategically considered structurally ambidextrous, they are practically functioning as contextually and sequentially ambidextrous. In other words, it became evident that transdisciplinary hubs achieve ambidexterity through a combination of the three approaches: sequential, structural, and contextual (O'Reilly & Tushman, 2013). All three approaches were corroborated by interviewees, but the contextual ambidextrous nature of the hubs was implied particularly often. Various interviewees stated that the students, academics, and externals that are involved in or using the hub are often affiliated first and foremost with their own study programmes, faculties and departments, and organisations respectively. As one of the interviewees mentioned, people often hold multiple positions within the university at the same time. In practice, this means that there are only a handful of people who work in the hub on a full-time basis. This highlights the importance of the transdisciplinary hubs' community orientation, level of strategic alignment, and its network, which essentially function as organisational incentives and structures that empower and motivate individuals to autonomously manage ambidexterity (Gibson & Birkinshaw, 2004).

6.2.2: Multirole & Multifunctional

The data collected, analysed, and synthesised based on the interviews, suggests that the multirole and multifunctional nature of the transdisciplinary hub is one of its main features. Interviewees mentioned that hubs are simultaneously agents of change, front doors, frontrunners, home bases, hosts of activities, incubators of the university mission, inter-faculty units, linking pins, places of dialogues, places of experimentation, places of informality, places of serendipity, and places of support. Furthermore, they indicate that all of these roles and functions are impactful. For instance, the hubs create marketing and branding value as front doors, support and lead innovative research initiatives as frontrunners and places of experimentation, and facilitate meaningful and rich social interactions as places of informality and serendipity.

This multirole and multifunctional nature of transdisciplinary hubs says something about the future fourth generation university. As previously established, there is not yet a commonly accepted definition for the fourth generation university, which tries to bring together academia, industry, government, and civil society (Lukovics & Zuti, 2015; Pawłowski, 2009) to share its

resources and knowledge, extending its impact (Asgari et al., 2021). Generally speaking, literature (Lukovics & Zuti, 2015; Thomas et al., 2023) indicates that the concept is characterised by fluid boundaries between academic disciplines, the alignment and intertwinement of universities' agendas with local and global societal goals, and the focus on innovation not as a byproduct of academic pursuits, but as a fundamental goal of it. However, based on this reflection and the previous, one characteristic should be added to this list. The interview data indicates that fourth generation universities are also characterised by their multirole hosting, facilitating, and leading of a wide and diverse range of educational, research, and valorisation initiatives and activities based on primarily contextual ambidextrous instead of individual structural ambidextrous efforts.

6.2.3: Prototyping & Tangibilizing

The interview data highlights the importance of prototyping and tangibilizing. Interviewees often mentioned how both competencies are crucial for students and researchers, industry experts and entrepreneurs, policymakers and public administrators, and civic groups and local communities to learn and work together. They explain that prototyping and making ideas tangible helps people from different (disciplinary) backgrounds to collaborate better. Instead of discussing ideas based on individuals' mental models and subjective viewpoints, they talk about them using concrete representations and objective references. In other words, prototyping and tangibilizing help people to create boundary objects that can be used to enable collaboration.

The centrality of prototyping and tangibilizing in transdisciplinary hubs says something about transdisciplinarity. As previously elaborated upon, transdisciplinarity is characterised by its own unique methodologies and frameworks (Jahn et al., 2012; Osborne, 2015). Disciplines and the possibilities for combining them are re-imagined, stakeholders from both science and society are involved, wicked problems form the contextual backdrop, iterative, reflective and responsible methodologies are implemented, and lateral, creative, and systematic thinking about both problems and solutions is encouraged (Bernstein, 2015; Wickson et al., 2006). However, based on this reflection, one addition should be made to the list. The interview data suggests that transdisciplinarity is also characterised by the creation, development, and use of boundary objects based on prototyping and tangibilizing.

Chapter 7: Conclusion

This thesis aimed to better understand how transdisciplinary hubs are designed, organised, and governed. First, a literature review on organisational ambidexterity, the fourth generation university, transdisciplinarity, and innovation labs was conducted (Chapter 2). Based on this review, a conceptual framework consisting of five dimensions and thirty-three elements (i.e. key factors) was developed (Chapter 3). To corroborate and iterate the conceptual framework, a case study approach was applied. Ten semi-structured interviews were conducted with key figures in and from the two cases: DesignLab and Innovation Space. The data analysis and synthesis resulted in an updated conceptual framework consisting of five dimensions and thirty-eight elements (Chapter 4). The results were discussed using direct quotes from interviewees (Chapter 5). Finally, the findings and reflections related to the final framework were discussed (Chapter 6).

Overall, this thesis asked the question: **"What are the key factors that shape educational innovation in transdisciplinary hubs?"** and found that the **transdisciplinary**-, **ecosystem**-, and **process focus**, **future**-, **community**-, and **proactive orientation**, **real-world context**, the **educational activities**, -**competencies**, -**experiences**, -**scaffolding**, -**stakeholders**, and -**collaborations**, **level of organisational autonomy**, -**resource availability**, -**strategic alignment**, -**organisational flexibility**, -**organisational constraints**, -**disciplinarity**, -**engagement**, and -**emergence**, the **location**, **scale**, **network**, **space**, **structure**, **culture**, and **mindset**, the **achievement of purposes and objectives**, **tangible**- and **intangible results**, and **materialisation of roles and functions** of transdisciplinary hubs shape educational innovation (Figure 5). Ultimately, they determine and define the purposes and objectives, process of creation, organisation and infrastructure, process of use, and impact and outcomes of educational innovations in the hubs.

7.1: Theoretical Implications

Theoretically, the three broader reflections related to ambidexterity and autonomy, multirole and multifunctional, and prototyping and tangibilizing, suggest additions to both the definitions of the fourth generation university and transdisciplinarity.

Based on the literature, fourth generation universities are characterised by fluid boundaries between academic disciplines, the alignment and intertwinement of universities' agendas with local and global societal goals, and the focus on innovation not as a byproduct of academic pursuits, but as a fundamental goal of it. However, based on this thesis, *fourth generation universities should also be characterised by their multirole hosting, facilitating, and leading of a wide and diverse range of educational, research, and valorisation initiatives and activities*. This addition to the literature was particularly illustrated by the fact that a lot of what happens in transdisciplinary hubs is based on contextual ambidextrous efforts. Instead of having specific sub-units, departments, or project teams work on educational innovations, most of the time these innovations are worked on by students, academics, and externals that are affiliated first and foremost with their own study programmes, faculties and departments, and organisations

respectively. However, the literature on fourth generation universities has, similarly to the current body of work on organisational ambidexterity in the public domain, primarily been concerned with universities and their external context instead of their internal context. As a result, a lot is known and written about the macro-level relationship with and the role of universities in society, but little is known about the micro-level intricacies of fourth generation universities and their internal context. This addition to the literature is a first step towards addressing this gap, highlighting the importance of examining how fourth generation universities operate internally.

Based on the literature, transdisciplinarity is characterised by re-imagining disciplines and the possibilities for combining them, involving stakeholders from both science and society, wicked problems that form the contextual backdrop, iterative, reflective, and responsible methodologies that are implemented, and lateral, creative and systematic thinking about both problems and solutions that is encouraged. However, based on this thesis, *transdisciplinarity should also be characterised by the creation, development, and use of boundary objects based on prototyping and tangibilizing*. This addition to the literature became specifically apparent as various interviewees highlighted how prototyping and making ideas tangible is one of the key activities in transdisciplinary hubs. It helps students, academics, and externals to learn and work together. This addition to the literature provides a new pathway for defining and developing the more practical aspects of transdisciplinarity.

7.2: Practical Implications

This thesis has three practical implications. First, it provides suggestions for how transdisciplinary hubs can share and showcase their impacts and outcomes. Second, it illustrates why and gives recommendations as to how hubs can structure and systematise. Third, it provides guidelines for how transdisciplinary hubs can be set up and supported.

First, transdisciplinary hubs need to work on sharing and showcasing their impacts and outcomes. Based on the interviews, it became clear that the hubs create a lot of tangible- and intangible results. However, most of these results are and the value created is rarely shared or showcased. The literature suggested developing evaluation and assessment methods with specific indicators and metrics to monitor, control, and evaluate the impacts and outcomes. In turn, this thesis suggests that those indicators and metrics might be more readily accessible than expected. While talking about their experiences in the transdisciplinary hubs, interviewees shared plenty of examples of what they felt was making an impact. Practically, translating that feeling to a more exact understanding of what works well and what does not work well is the first step to sharing and showcasing hubs' impact and outcomes. Therefore, it is recommended that hubs start capturing and tracking students', teachers', and stakeholders' personal experiences. For example, they could be asked to record a video testimonial, fill in a survey, or write a reflection report. Together, this documentation can inform the stories about, the best practices from, and the lessons learned in the transdisciplinary hub, which can then be shared with a wider audience. For instance, a student testimonial about gaining courage and developing proactiveness could be shared via social media and put on the hub's website to persuade other

students to join, an open survey capturing the best practices from teachers on how to structure workshops to maximise engagement could inform a future educational innovation manual, and a reflection report describing the lessons learned by stakeholders during a life-long learning trajectory could help improve hubs' offerings to better meet stakeholder needs.

Second, transdisciplinary hubs need to work on developing operational structures and systems. Based on the interviews, it became apparent that transdisciplinary hubs often host, primarily facilitate, and sometimes lead educational innovations. In other words, most of the hubs' activities are not carried out by the hub itself but rather by students, academics, and externals who come to visit, work in, or use the hub. However, what is done, how it is done, or why it is done is not always documented and formalised. Therefore, transdisciplinary hubs struggle to structurally and systematically make sense of educational innovations. They do not know what works well and what does not work well, making it difficult to assess their efficiency and effectiveness. Hosting, facilitating, and leading numerous educational innovations is possible so long as there is adequate support with sufficient resources. Yet, as the demand for and necessity of educational innovations in transdisciplinary hubs increases, the strain on that support and those resources intensifies. For example, a transdisciplinary hub only has so much time and space available. However, without formalised decision-making procedures in place that help hubs determine which educational innovations to prioritise, they run the risk of overextending their efforts, compromising the quality and impact of their activities. To counteract this, the educational innovations in transdisciplinary hubs should be systematically recorded and evaluated. This will not only provide an overview of the hub's activities but could also serve as the starting point for informed decision-making procedures and formalising the best practices and lessons learned. Additionally, it will help to capture and track the earlier mentioned personal experiences of students, teachers, and stakeholders. However, the starting point for practically developing structures and systems is different from recording testimonials, sending out surveys, and getting feedback reports. Instead, it is about establishing clear and fitting standard operating procedures (SOPs) and key performance indicators (KPIs). Important in this process is that hubs keep their dynamic and flexible way of working that builds upon individual responsibility and ownership. Pursuing operational excellence while protecting individual autonomy is seemingly contradictory but absolutely possible. Specifically, it is recommended that hubs start testing and experimenting with SOPs and KPIs. For instance, student assistants could create procedural SOPs for the use of equipment, facilities, and tools, support staff could summarise the captured best practices and lessons learned into educational innovation manuals, and the management team could formulate a set of target KPIs based on the strategy, mission, and vision of the hub. Together, these actions can simplify and improve the work in the transdisciplinary hub. For example, the procedural SOPs can be used by teachers and researchers to easily make the use of technical facilities part of their educational innovations, the manuals can inform other departments about and help them with implementing educational innovations, and the KPIs can be used to assess the effectiveness of current and future educational innovations.

Third, transdisciplinary hubs require a specific setup and support system. Based on the interviews, it became apparent that the operational design and management of the hub have a huge influence on the activities and experiences in the hub. On the one hand, universities have to think about the layout, resources, tools, and equipment that form the functional and aesthetic features of the hub. On the other hand, they have to take into account the management and support of day-to-day activities and longer-term projects in the hub. Important to note here is that changes to the design or management of the hub do not have to be big to make a difference. For instance, the replacement of a fixed wall with a flexible wall or the extension of opening hours might already open up new opportunities for larger scale and different educational innovations. Therefore, it is recommended that universities take action to come together and learn from each other. For example, the student assistants, teachers and researchers, and management teams of the hubs –but also the university's board of directors– could visit different transdisciplinary hubs, they could set up monthly or quarterly (online) meetings to discuss the successes and challenges they experienced, and they could organise cross-hub events and activities exchange ideas. Together, actions like these can improve and solidify transdisciplinary hubs' setup and support systems. For instance, the visit could spark the insight to develop a new open workspace plan, which gets further discussed during an online meeting, to ultimately be concretised during a cross-hub event.

The applicability of these three recommendations becomes evident when looking at them through the lens of DesignLab and Innovation Space, the two cases in this thesis. Both transdisciplinary hubs could ask their university's video team to record student, teacher, and stakeholder testimonials and put those on their website. Additionally, the hubs could develop educational innovation manuals in a series of workshops with teachers and researchers organised by support staff. Finally, the two transdisciplinary hubs could visit each other to get new ideas and gather insights. For instance, DesignLab could go to Innovation Space to see how they host and house their student teams. Similarly, Innovation Space could visit DesignLab to learn more about their lifelong learning trajectories.

7.3: Limitations

This exploratory thesis was subject to six limitations. First, the people who were interviewed joined on a voluntary basis and were all actively involved in their respective transdisciplinary hubs. Because the interviewees willingly volunteered their time, it is likely that they were happy to speak about their hubs and their activities. This potentially led to an overly positive perspective on the hubs. Furthermore, because the interviewees were all actively involved in their respective hubs –as founders, members of the management team, and teachers or researchers– it is likely that they have an interest in presenting the hubs favourably. It would have been interesting to interview people with different affiliations and perhaps more critical views of the transdisciplinary hubs. Second, no interviews were conducted with support staff, students, or stakeholders. Given their prominent role in the transdisciplinary hubs, their perspectives would have enriched the findings of this thesis. Third, the number of people that were interviewed is small. Considering the large number of and various ways in which people

are involved in the transdisciplinary hubs, a larger sample size would have better captured the diversity of experiences and thus provided a more representative view of the hubs. Fourth, the thesis only looked at two case studies. Considering the large variety of forms hubs can take, looking at more cases would have further solidified the findings of this thesis. Fifth, the semi-structured nature of the interviews may have led to the interviewer's unintentional biases creeping in through the way in which questions were asked and interviews unfolded. To minimise this risk, an interview protocol (Appendix A) was developed and reviewed by experts. Finally, the data was analysed and synthesised by only one researcher. This possibly introduced personal biases, limiting the objectivity of the analysis. Multiple researchers analysing the data would have enhanced the reliability of the findings. Altogether, these six limitations negatively affected the validity and generalisability of the outcomes and conclusion, which should be thought of as preliminary insights and a foundation upon which to build a more complete and comprehensive understanding.

7.4: Future Research

Based on the results, findings, reflections, and limitations, several suggestions for future research directions can be made. First of all, the limitations of this thesis could be addressed by diversifying the sample both in terms of interviewees and cases, as well as using multiple methods and researchers for data collection and analysis. This would enhance the validity and reliability of the findings. Second, the three reflections related to ambidexterity and autonomy, multirole and multifunctionality, and prototyping and tangibilizing serve as starting points for new research. For example, it could be interesting to look at which organisational incentives and structures help individuals to successfully hold multiple positions within a university. In addition, it could be worthwhile to further research the different roles of transdisciplinary hubs and develop a theoretically sound and practically applicable taxonomy for them. Moreover, it could be relevant to look at how the different ways in which disciplines lo-fi prototype and tangibilize their ideas contribute to transdisciplinary collaboration. Finally, the two theoretical implications provide new avenues for future research. Both of them will need to be verified and substantiated before they can be accepted and integrated.

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Appendix A: Interview Questions

Opening Question

To get us started, could you briefly describe your role within [DesignLab/Innovation Space] and your main responsibilities?

Transition Question

Could you briefly describe the educational innovations (workshops, multi-day events, long-term programmes) that you've been part of within [DesignLab/Innovation Space]?

Could you briefly list (some of) the (disciplinary) backgrounds of students, teachers, and stakeholders that were involved?

Key Questions

Could you describe the educational competencies (ways of working: skills) that are developed through these educational innovations?

Could you describe the educational mindsets (ways of thinking: attitudes) that are developed through these educational innovations?

Could you describe the educational pedagogies that are used as part of these educational innovations? Potential follow-up question: are these pedagogies further developed as part of the educational innovations?

How have the physical space and infrastructure played a role in the educational innovations achieving these outcomes and impacts?

How is [DesignLab/Innovation Space] connected to the region and which stakeholders (industry, government, civil society) participate in its activities?

How is [DesignLab/Innovation Space] connected to the university and how autonomous does it operate?

What are the resources (administrative, financial, human) that [DesignLab/Innovation Space] has access to? Potential follow-up question: in what way do these resources enable/constrain educational innovations?

What tangible outcomes and impacts (practical and visible – e.g. increasing number of students, better evaluations, more interested stakeholders) have you observed from these educational innovations in [DesignLab/Innovation Space]?

- On the individual (students, teachers, stakeholders) level?
- On the organisational (hub) level?
- On the institutional (university) level?
- On the regional (industry, government, civil society) level?

What intangible outcomes and impacts (non-practical and invisible – e.g. changes in mindset, increased student well-being, enthusiastic stakeholders) have you observed from these educational innovations in [DesignLab/Innovation Space]?

- On the individual (students, teachers, stakeholders) level?
- On the organisational (hub) level?
- On the institutional (university) level?
- On the regional (industry, government, civil society) level?

Could you describe the purposes and objectives of [DesignLab/Innovation Space]? Why does it exist?

Could you briefly describe how [DesignLab/Innovation Space] is strategically aligned with the university?

Ending Questions

What have been the biggest challenges that [DesignLab/Innovation Space] faced?

What have been the biggest successes and/or achievements of [DesignLab/Innovation Space]?

Reflecting on our conversation, what aspects of [DesignLab/Innovation Space] do you think are most crucial for their success?

Is there anything important regarding [DesignLab/Innovation Space]'s impact or educational innovations that we have not discussed but should also be mentioned?

Appendix B: Deductive Codes & Exemplary Quotes

Table 7 includes the deductive codes and corresponding exemplary quotes. Generally speaking, the quotes have been taken from interviewees of both cases. The quotes are presented true to their original spoken form, with only minor (grammatical) adjustments made to ensure anonymity, readability, and clarity. Furthermore, to protect the anonymity of interviewees, exemplary quotes are not linked to specific interviews in this table but are provided with these links in the results chapter (Chapter 5) to guarantee transparency. Finally, the number between square brackets (e.g. [105]) indicates the number of quotes linked to that specific code.

Deductive Codes	Exemplary Quotes
Purposes & Objective [105]	
Transdisciplinary focus [28]	"[X] is a place where we tackle societal challenges with the different parties involved in a transdisciplinary way" "I work together with other colleagues to develop projects, methods, and also networks that have to do with transdisciplinarity"
Ecosystem focus [24]	"for example, we now have a partnership manager who is really connected to the region, municipality, and companies" "if we want to make impact regionally, then we need to create that ecosystem around it"
Process focus [20]	"you always have to move back and forth between trying to put it into practice and then going back to the strategy again" "the purpose is to innovate education in a very rapidly changing world. Like everything changes and needs to be adapted all the time."
Future orientation [0]	-
Community orientation [15]	"our activities and events have always been a way to nurture the community" "we're focusing on building this learning community"
Proactive orientation [13]	"I see that we're taking, I think, more and more responsibility" "we have to tackle very big problems [...] and we need science to step in as well"
Real-world context [36]	"we really want to build students who can [...] link their knowledge to actual real-world problems" "it's very recommendable to have experiences which are close to the real-life experience"
Process of Creation [176]	
Intended educational activities [37]	"it needs to be interdisciplinary, challenge-based learning with authentic stakeholders. That's the basic package" "in my opinion, there should also be a master accredited that stands on its own feet"
Intended educational competencies [16]	"we are actually now providing education focused on how to address societal challenges, and in particular, how to develop those transdisciplinary change making competencies" "we're trying to push for more arts in the engineering sciences because we think it's an important competence for students"
Intended educational mindsets [8]	"I think that shows the proactiveness and open mindedness that we try to develop in our students" "and a third one is that students learn how to tackle grand societal challenges so that they have the courage [...] to be a change agent"
Intended educational scaffolding [36]	"our goals in terms of how to educate within a CBL context are learning by doing, dealing with uncertainty, and are based on the design thinking process"

	“we are experimenting with different methods to see how you get to weighing and integrating different perspectives”
Intended educational stakeholders [7]	“we aim for students from all over the university” “we aim to collaborate with different kinds of stakeholders. But you could say the whole quadruple helix is normally present”
Level of organisational autonomy [14]	“I think [X] is trying to hopefully have the best of both worlds. On the one hand, to have autonomy, to be different. On the other hand to really be connected to the whole university and outside world” “in the end, we are also very dependent on the vision of the university”
Level of resource availability [41]	“we are fully financed by the university, but with the idea that we also have [...] partners contributing financially in one way or another” “we have some central funding [and] the rest of it has to come from money that we generate ourselves by doing projects”
Level of strategic alignment [60]	“we are strategically on a high level in the governance model of the university” “on the other hand, we’re subsidised by the university. So, you need support from the board and in our case also directly or indirectly from the different deans of the faculties”
Space & Infrastructure [135]	
Location [0]	-
Scale [0]	-
Network [38]	“some of the partners like the province and municipality have been involved in multiple collaborations at [X]” “[X] through its many local and regional contacts, [...] can bring students closer to society”
Tangible infrastructures [46]	“we immediately in the first building had a service desk with some tools, and now we have three workshops, for example, one with 3D printing facilities” “there’s the makerspace to make all kinds of prototypes and there’s all kinds of video equipment that students can use”
Intangible infrastructures [39]	“we have created a very community-like space, where people like to be, where students like to come to work, and where people that visit are always like: wow!” “what I hear from students is that they the place an inspiring place to be”
Level of organisational flexibility [12]	“we have changed so many things in all these years, just trying and seeing if they work. And then if it doesn’t work: evaluate and reflect” “we had this vision document, but five years later, this has also been changing a bit. That doesn't mean that we do not have goals or priorities. [...] But maybe tomorrow it is not CBL, but it's a different type of new education that works for the challenges of today. You know?”
Level of organisational constraints [36]	“I think one of our biggest challenges is that time is becoming more valuable to people” “what we see now is that, also in light of all the political changes that are there, that offering a program that's done [...] on top of another master is hard for some students to make it feasible to do that program.”
Process of Use [191]	
Actual educational activities [75]	“we have the curricular and extracurricular role in [X]” “the students said [...] how about we sit here and work? And that’s how you’ve got like all these, let’s say, non-planned educational projects in [X]”
Actual educational competencies [30]	“if you stay closer to what students learn and what they directly see after their learning as the added value, then that is clearly articulated in the things like: new methods, new ways of working, learning to collaborate with students from all the disciplines, leadership and collaboration [...]” “we do prototyping because it’s a boundary object and it often enables the collaboration

	between the students”
Actual educational mindsets [27]	“if you stay closer to what students learn and what they directly see after their learning as the added value, then that is clearly articulated in the things like: [...] reality shocks, shocks about chaos and how to deal with that, that the outside world is not neatly organised along the lines that we have thought of, being surprised that it really matters what you think, that life is not just a textbook exercise” “what we hear is that it often broadens their perspective”
Actual educational scaffolding [39]	“the other type of scaffolding that we are doing is a bit more of a scaffolding about the [...] way for students to design their own rubrics so that they can understand how they are evaluated and why they are evaluated in a certain way” “we are not providing lectures, but we still need to give some distilled set of notions and knowledge that needs to be digested, and for that part I’m using a lot of examples from everyday life”
Actual educational stakeholders [21]	“in some of our courses and student teams there are also students from [Y: a university of applied sciences] and there have been some students involved in the past from [Y: a university of the arts]” “some of the partners like the province and municipality have been involved in multiple collaborations at [X]”
Level of disciplinarity [19]	“we’ve had students from all the faculties” “we often try not to stick to one perspective from society, but either bring in different stakeholders ourselves or have [...] students look beyond, let’s say, the partner, to others that are also involved”
Level of engagement [43]	“it's not so much that people just provide a case and in the end are there for the presentations, but they're really part of the whole learning process.” “the people that bring challenges [...] are also involved in some of our events and courses as coaches”
Level of emergence [19]	“we had an event going on here [...] and they brought citizens here to talk about, you know, what is your flight experience from booking to coming back home after your trip. [...], in one of the other rooms here, there were researchers working on [Y: a robot helping passengers to get to gates]. [...]. And as that robot was helping here, they were getting in contact with these people, having a different event on the same type of ideas. And after talking to one another, they connected on what can this robot do, and could we not change things that I'm doing in my research while the citizens are here?” “it could also be things that people are building in workshops that they might get sparked by an idea that they say: oh [...] you use the Arduino to do something like that and I have a project, it’s very different, but I see how [...]”
Impacts & Outcomes [124]	
Achievement of purposes and objectives [0]	-
Tangible results [98]	“I think one of our big outcomes is having created this unifying space where students from all different disciplines, but also stakeholders, feel welcome and they like to come to” “the most visible success was winning the Dutch Higher Education Award”
Intangible results [48]	“I think, for me, the biggest success is that students really like to come to work here and they see value in what we give them” “I think the [X] is a great place of dialogue, of belonging, of care”

Table 7: Deductive Codes & Exemplary Quotes

Appendix C: Inductive Thematic Analysis

Table 8 summarises the inductive thematic analysis, which surfaced three aggregate dimensions: transdisciplinary hub characteristics, collaborations, and challenges with thirteen themes: culture in-, experiences in-, mindset in-, role of-, space of-, structure of-, value of transdisciplinary hubs; external-, internal-, and societal collaborations; and challenges of addressing ambiguity, -collaborating more, and -scaling up. Finally, the number between square brackets (e.g. [6]) indicates the number of quotes linked to that specific code, theme, or aggregate dimension.

Inductive Codes	Themes	Aggregate Dimensions
1a. A sense of belonging [6]	1. Culture in Transdisciplinary Hub [19]	Transdisciplinary Hub Characteristics [256]
1b. A sense of care [3]		
1c. A start-up like culture [2]		
1d. A tight-knit community [4]		
1e. An engaged alumni network [2]		
1f. An informal setting [6]		
2a. Getting to know yourself [5]	2. Experiences in Transdisciplinary Hub [32]	
2b. Getting to know each other [2]		
2c. Learning experienced as impactful [14]		
2d. Informal learning [6]		
2e. Peer-to-peer learning [5]		
3a. To challenge the status quo [4]	3. Mindset in Transdisciplinary Hub [47]	
3b. To take responsibility [14]		
3c. To make things tangible [12]		
3d. To start from the positive instead of the negative [14]		
3e. To practise what you preach [5]		
4a. Transdisciplinary hub as agent of change [12]	4. Role of Transdisciplinary Hub [103]	
4b. Transdisciplinary hub as front door [6]		
4c. Transdisciplinary hub as frontrunner [7]		
4d. Transdisciplinary hub as home base [8]		
4e. Transdisciplinary hub as host of activities [24]		

4f. Transdisciplinary hub as incubator of the university mission [4]		
4g. Transdisciplinary hub as inter-faculty unit [6]		
4h. Transdisciplinary hub as linking pin [23]		
4i. Transdisciplinary hub as place of dialogue [6]		
4j. Transdisciplinary hub as place of experimentation [10]		
4k. Transdisciplinary hub as place of informality [6]		
4l. Transdisciplinary hub as place of serendipity [6]		
4m. Transdisciplinary hub as place of support [6]		
5a. A space build by its users [3]	5. Space of Transdisciplinary Hub [12]	
5b. A space displaying its projects [2]		
5c. A space that is free to use [2]		
5d. A space with its own rules [5]		
6a. Project-based [9]	6. Structure of Transdisciplinary Hub [51]	
6b. Student-driven [10]		
6c. Organisation develops organically [4]		
6d. Organisation is agile [7]		
6e. People are the foundation [9]		
6f. People have multiple roles [17]		
7a. Collaborations with other organisations [4]	8. External Collaborations [19]	Transdisciplinary Hub Collaborations [80]
7b. Collaborations with other universities [15]		
7c. Regional collaborations [4]		
7d. National collaborations [4]		
7e. International collaborations [12]		
8a. Inter-faculty collaborations [27]	9. Internal Collaborations [35]	
8b. Inter-faculty integration [9]		
9a. Science and society should be connected [5]	10. Societal Collaborations [29]	
9b. Science and society collaborations should involve multiple perspectives [19]		
9c. Science should make an impact [4]		

9d. Society should be the starting point [13]		
10a. Transdisciplinary hub impact can be hidden [6]	11. Challenges of Addressing Ambiguity [12]	Transdisciplinary Hub Challenges [61]
10b. Transdisciplinary hub name can be misleading [3]		
10c. Transdisciplinary hub role can be difficult to know [5]		
11a. Challenging to develop inter-faculty collaborations [10]	12. Challenges of Collaborating More [28]	
11b. Challenging to balance differing speeds of the university and transdisciplinary hub [8]		
11c. Challenging to connect to society [4]		
11d. Challenging to keep up with the fast-changing society [7]		
12a. Challenging to deal with time scarcity [14]	13. Challenges of Scaling Up [24]	
12b. Challenging to deal with information quantity [4]		
12c. Challenging to deal with formalisation necessity [8]		

Table 8: Inductive Thematic Analysis

Appendix D: Inductive Codes & Exemplary Quotes

Table 9 includes the inductive codes and corresponding exemplary quotes. Generally speaking, the quotes have been taken from interviewees of both cases. The quotes are presented true to their original spoken form, with only minor (grammatical) adjustments made to ensure anonymity, readability, and clarity. Furthermore, to protect the anonymity of interviewees, exemplary quotes are not linked to specific interviews in this table but are provided with these links in the results chapter (Chapter 5) to guarantee transparency. Finally, the number between square brackets (e.g. [6]) indicates the number of quotes linked to that specific code.

Inductive Codes	Exemplary Quotes
1a. A sense of belonging [6]	"and the feeling of belonging… those are the things that we really see and that students often mention" "it's a sense of an home base, a sense of belonging"
1b. A sense of care [3]	"I think the [X] is a great place of dialogue, of belonging, of care" "when I see the people that are living locally, nationally, and internationally dropping by, working with students, working with other people to figure things out [...], those are the things that make me feel: okay, this is a place of belonging, care, and change"
1c. A start-up like culture [2]	"what makes me most proud is our culture, that we really have that startup culture within the [X]" "we work very much like a startup"
1d. A co-learning community [4]	"it's a place where they [referring to students] create a community" "you can say that the pillars that we have are [...] within a community of students and teachers, a co-learning community"
1e. An engaged alumni network [2]	"we also see that students who were engaged in the community of [X] keep on coming back" "The [X] is really building some kind of community, also of alumni. And you can see that they tend to come back"
1f. An informal setting [6]	"I mean, the most valuable things come out of these quick conversations" "also the fact that you can really meet people there just spontaneously"
2a. Getting to know yourself [5]	"if you stay closer to what students learn and what they directly see after their learning as the added value, then that is clearly articulated in the things like: [...] discovering interests in other fields that you didn't know you were interested in" "another thing that appears a lot is that they [referring to students] become aware of the things that they like to do in the future"
2b. Getting to know each other [2]	"it's a place where they create a community, they find their own way of working, they get to know each other" "every time I go there, even though it's not always or every week, it feels like: "oh cool, there's someone I know, I can say hi [...] and then we have a nice chat and you learn something"
2c. Learning experienced as impactful [14]	"you always hear from the students that they learn more from a year in a student team or one of these courses that connects you more with the outside world, then that they learn during the whole degree" "there are all kinds of eye-openers that work for them [referring to external stakeholders]. And they don't get that in the end, it's mostly during the process"
2d. Informal learning [6]	"I think it's [referring to students working for the transdisciplinary hub] one of

	the most informal ways of learning" "the students said [...] how about we sit here and work? And that's how you've got like all these, let's say, non-planned educational projects in [X]"
2e. Peer-to-peer learning [5]	"many of the, especially in the extracurricular context, many of the new techniques or new knowledge that is developed is transferred between peers" "I think it's more about teaching each other like: let's share what we've been doing and how that's been working"
3a. To challenge the status quo [4]	"I would argue, even if it's maybe not formalised as such, that one of the main attitudes that is required is to really challenge your own assumptions, your own status quo" "it means that this approach is not only about transdisciplinarity, so to [...], but also about having an ethical, socially oriented, and critical perspective. So, to challenge somehow the status quo"
3b. To take responsibility [14]	"[X] is all about addressing societal challenges. So, it's not about generating new knowledge [...], it's not about generating technology, it's really about, in the end, addressing a societal challenge" "we have to tackle very big problems [...] and we need science to step in as well"
3c. To make things tangible [12]	"we do prototyping because it's a boundary object and it often enables the collaboration between the students" "I think the making things tangible is part of what we think is important at [X]"
3d. To start from the positive instead of the negative [14]	"I think another way of creating impact within the university is –and also why we are successful within the university– is that if anyone asks us anything, our first answer is yes" "if you start from the problem-solving part, then you're stuck already. If you open it up and if you really try to see what is behind it, then you can come up with completely other ideas"
3e. To practise what you preach [5]	"CBL was kind of implemented in the organisation itself" "we are also developing the concept of transdisciplinary education and [...] in parallel with what we are doing. So there is not just: 'this is how you should do it', but we are finding it out along the way"
4a. Transdisciplinary hub as agent of change [12]	"to work together in a space that is also connected to the outside world, to the societal challenges is key for any university" "the role of [x] within the university is basically [...] to really address the societal challenges, to really collaborate with stakeholders on topics and not just asking things"
4b. Transdisciplinary hub as front door [6]	"a lot of visitors that come to the university pass [X]. So, it's also a way for the university to show a space that is different and to show the innovations that take place" "guests from other universities who come to [Y: the university] always have to go to [X] because it's a nice space"
4c. Transdisciplinary hub as frontrunner [7]	"the role of [x] within the university is basically to be the frontrunner for the university to really work in this transdisciplinary way, to really address societal challenges" "what we really did was pioneering with [X]"
4d. Transdisciplinary hub as home base [8]	"[X] also legitimises the student teams as having a home" "what we actually also saw, [...], is that the international community really finds [X] as an home base"
4e. Transdisciplinary hub as host of activities [24]	"And [X] is also a place which offers other programs room to give part of their classes" "I also hosted our own department's research seminar at the [X]"

4f. Transdisciplinary hub as incubator of the university mission [4]	“you could also say that the current mission of the university was invented in [X]” “our goals are very connected to the new education vision of the university”
4g. Transdisciplinary hub as inter-faculty unit [6]	“I think the strength and the challenge for [X] from day one is that we are really an entity that is university wide [...], that is used by all of the faculties” “[X] is in a unique position as a hub between the different faculties”
4h. Transdisciplinary hub as linking pin [23]	“our activities and events have always been a way to nurture the community [...] we are a connector ” “it serves as this in-between space, between university and society”
4i. Transdisciplinary hub as place of dialogue [6]	“I think the [X] is a great place of dialogue, of belonging, of care” “I feel that a place like [X] is a place where we can sit together and figure out who is talking to each other, who has frictions, and how we can do something about it”
4j. Transdisciplinary hub as place of experimentation [10]	“we even see ourselves much more as an innovation hub, as an ice-breaker, so the ones that experiment” “I think we are a place where if you have ambitions on educational innovation, you can really play around”
4k. Transdisciplinary hub as place of informality [6]	“I mean, the most valuable things come out of these quick conversations” “also the fact that you can really meet people there just spontaneously”
4l. Transdisciplinary hub as place of serendipity [6]	“you can really meet people there just spontaneously” “we had an event going on here [...] and they brought citizens here to talk about, you know, what is your flight experience from booking to coming back home after your trip. [...], in one of the other rooms here, there were researchers working on [Y: a robot helping passengers to get to gates]. [...]. And as that robot was helping here, they were getting in contact with these people, having a different event on the same type of ideas. And after talking to one another, they connected on what can this robot do, and could we not change things that I'm doing in my research while the citizens are here?”
4m. Transdisciplinary hub as place of support [6]	“we actually support teachers much more than students. I mean we facilitate the courses here, but we are there to support teachers and we have developed many tools for doing so” “[X] is not an academic department, but it provides support to academics”
5a. A space build by its users [3]	“when we started, we basically used the old furniture from all faculties, [...], and really made very cheap additional elements with students. But that has also given a kind of signature to [X]” “I participated in the design of the space”
5b. A space displaying its projects [2]	“because the [X] also showcases past projects that have been done before, it’s a good source of inspiration” “things people are building in workshops might spark an idea”
5c. A space that is free to use [2]	“we have large opening hours and all our prototyping facilities are for free” “we still provide the spaces for free to educational programmes”
5d. A space with its own rules [5]	“we have the educational spaces, but they are not part of [Y: university’s facility management] and there, for instance, it’s in the rules that if you use the space [...] you need to leave everything in the place where it was [...]. Whereas in [X] we deliberately choose to have certain spaces where you’re just allowed to make a mess” “there is really more of an attitude like: okay, what is it that you need to do your education instead of making sure that your education fits within these boundaries”
6a. Project-based [9]	“we have a number of projects running with specific questions” “we are aiming to deploy three pilots in which we are [...]”

6b. Student-driven [10]	“we are now [X] people, with half of them being a student assistant” “[X] is also completely student-driven”
6c. Organisation develops organically [4]	“we are organically developing because, in the end, we are also very dependent on the vision of the university” “It [referring to the development of educational innovations] has been very organic, entrepreneurial, sometimes a bit opportunistic”
6d. Organisation is agile [7]	“it’s learning to and trying to stay flexible, to really connect, to stay flat, to keep the culture of trying form the beginning” “we don’t have that much staff directly employed in [X], so we are really lean in terms of structure”
6e. People are the foundation [9]	“it’s the people who make an organisation” “to set it up –because people approached us and asked: can we have a [X]?– it’s nothing without the right people there”
6f. People have multiple roles [17]	“a lot of people within our team, I would say even half of the staff, also works in other departments” “what I found really helpful is that I basically have three positions [in the university] as one person”
7a. Collaborations with other organisations [4]	“some of the partners like the province and municipality have been involved in multiple collaborations at [X]” “we have good links here with the province, with the region, with the city”
7b. Collaborations with other universities [15]	“in some of our courses and student teams there are also students from [Y: a university of applied sciences] and there have been some students involved in the past from [Y: a university of the arts]” “one of the things we’re working on right now is a study abroad program [...], and after this first pilot year, which was very successful, we have three [X] universities that are going to join”
7c. Regional collaborations [4]	“some of the partners like the province and municipality have been involved in multiple collaborations at [X]” “I think what we in general need to do is to create strategic partners that we want to work together with in the region”
7d. National collaborations [4]	“we’re collaboration in [X] with [X] and the tax authorities within a bigger consortium of companies” “the people that bring challenges –and that could be municipalities, NGOs, companies, or [...]– are also involved in some of our events and courses as coaches”
7e. International collaborations [12]	“one of the things we’re working on right now is a study abroad program [...], and after this first pilot year, which was very successful, we have three [Y: international] universities that are going to join” “that’s a European project with nine different partners from eight countries”
8a. Inter-faculty collaborations [27]	“for example, we have created this [X] toolkit. It was initiated here, but later on has been taken over by a team with different other parties” “if you look at the projects that we set up, we also do that with other faculties”
8b. Inter-faculty integration [9]	“that’s something we are trying to do at the moment, to really integrate within the university processes, [...], to integrate with services and departments” “for the [X], we’re now working to integrate it more in degree programs rather than to have it as an extracurricular program”
9a. Science and society should be connected [5]	“we have to tackle very big problems [...] and we need science to step in as well” “I think that it is really a big task or challenge for us as a university to be more in sync with the societal developments”

9b. Science and society collaborations should involve multiple perspectives [19]	“we think it’s important in transdisciplinary work that you also see different perspectives from society, the ones that are further away from you” “it means that this approach is not only about transdisciplinarity, so to [...], but also about having an ethical, socially oriented, and critical perspective”
9c. Science should make an impact [4]	“we have to tackle very big problems [...] and we need science to step in as well” “what do we want to achieve as a university? Clearly, what stands out is the societal impact”
9d. Society should be the starting point [13]	“We need to spend a lot more time doing that and understanding what are the challenges that the local people are really facing [...]. I still feel, but that's my personal meaning, that we're still pushing our own research agendas [...] and not what society is pushing towards us.” “The most important thing is that we go out to society and to indicate what are the issues at stake. That it really comes from them as well”
10a. Transdisciplinary hub impact can be hidden [6]	“there are clear indicators that there is value, that there is impact, but how big is it, how long lasting is it, how does it really show?” “it can sometimes be the small ones where you... you know [...] where [X] is working with the father on an electric wheelchair for his son. It's a small thing, but there you can see how makerspaces and digital fabrication help on a personal level.”
10b. Transdisciplinary hub name can be misleading [3]	“it’s a very personal opinion, but maybe we’re working very much with the name [X] and not the purpose. And then people seeing: ‘oh, [X] again got a price’ but they don’t have a clue what happens in [X]” “I think the term [X] is misleading because it’s not a [X] about [X]. We do [X]. We use [X]. [...]. But the place is not about [X]. It’s a futures lab [...], that’s I think something that maybe would be a bit clearer”
10c. Transdisciplinary hub role can be difficult to know [5]	“from the staff side, [...] it’s less understandable what they can do here and why they should be here” “it’s a very personal opinion, but maybe we’re working very much with the name [X] and not the purpose. And then people seeing: ‘oh, [X] again got a price’ but they don’t have a clue what happens in [X]”
11a. Challenging to develop inter-faculty collaborations [10]	“this connection to the departments is one of the biggest challenges” “it’s not formalised in a way. I think in that sense, it’s still dependent on the people that are actually coming into [X] and going back to the faculties. Therefore, we also see that we reach certain faculties or certain parts of faculties better than others, because people are already more integrated into [X].
11b. Challenging to balance differing speeds of the university and transdisciplinary hub [8]	“sometimes we run too fast, as the university is slower and has its ways, its protocols, its processes” “that does make it for us as [X] now the challenge, okay, now that the rest of the university is coming along in this way of working, how can we make sure that we still stay that one step ahead? That we remain that source of inspiration and that centre of expertise. It's wonderful if the whole university is going to act in this way, but for the reason of existence of [X], we should also go one step beyond”
11c. Challenging to connect to society [4]	“somehow we have a disconnection and a cognitive dissonance between everybody outside, inside, and around the university” “in some of the conversations we've had with companies, they say: ‘well, how interesting is it to work with all these internationals? My staff doesn't speak English very well, they can't communicate with them in the way that they would like to”
11d. Challenging to keep up with the fast-changing society [7]	“we cannot keep educating our students in the same way we did ten years ago” “the purpose is to innovate education in a very rapidly changing world. Like everything changes and needs to be adapted all the time.”

12a. Challenging to deal with time scarcity [14]	“you always have the challenges of timing and availability of people” “I think one of our biggest challenges is that time is becoming more valuable to people”
12b. Challenging to deal with information quantity [4]	“we're still using very basic ways of gathering the information, mainly word files and excel sheets, so it still is very artisanal. So, especially when you grow in number of students, the quantity of information that you have to manage starts becoming something really unmanageable” “I think that sometimes there is a kind of delay in the quantity of information that we have available, like written information versus the quantity of information in terms of people's expertise”
12c. Challenging to deal with formalisation necessity [8]	“you cannot formalise the process. You can only formalise it once you completely know the process. You can only formalise it [...] once it's implemented so that the majority of people have adopted this way of working [...]. But as long as you're still at the forefront, [...], you cannot formalise the process” “the challenge is writing the story, you know. Because I think that today there is a lot of knowledge in people's heads, but not too many things are written because it takes a lot of time”

Table 9: Inductive Codes & Exemplary Quotes