FITTING LEADERSHIP FOR STIMULATING LEARNING AND DEVELOPING A LEARNING MINDSET IN A TRANSDISCIPLINARY COLLABORATION CONTEXT

A CASE STUDY OF THE MY DIGITAL TWIN FLAGSHIP OF THE HEALTH & TECHNOLOGY THEME OF THE CONVERGENCE AGENDA OF THE ERASMUS MEDICAL CENTRE, THE ERASMUS UNIVERSITY ROTTERDAM, AND THE DELFT UNIVERSITY OF TECHNOLOGY

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Graduation project to obtain a MSc degree in

Science Communication

at the Delft University of Technology

ABSTRACT

This Master Thesis project was the last assignment in obtaining a MSc degree in Science Communication at the Delft University of Technology. The focus of the project was on finding fitting leadership styles, structures, or behaviors that stimulate learning and help develop a learning mindset in a transdisciplinary collaboration context.

To deal with the increasing complexity and urgency of societal issues – such as the aging population, climate change, and the energy transition – a new collaboration revolution has taken shape. This revolution, also referred to as convergence, is still very new. Articles available on what convergence, and the transdisciplinary collaboration as the new collaboration type therein entail, are rather vague and abstract. The HOW of the matter is not yet clear. Learning is inextricably linked to transdisciplinary collaboration due to its novelty. However, explicit attention has not been given to building in learning and a learning mindset in relation to transdisciplinary collaboration. Leadership and learning have had an existing link in literature, but have not been regarded in a setting of transdisciplinary collaboration. Taking leadership into account will enable the formulation and implementation of more concrete actions to move away from a still rather vague idea of transdisciplinary collaboration and towards actionable steps. Therefore, the combination of transdisciplinary collaboration, learning, and leadership is not only interesting and relevant from a research point of view but it will also directly influence the effectivity of convergence endeavors of the Erasmus Medical Centre (EMC), Erasmus University of Rotterdam (EUR), and Delft University of Technology (TUD) that are currently taking place. Research on the relation between transdisciplinary collaboration, learning, and leadership has not been conducted, and thus forms the main focus of this Master Thesis project. The main research question therefore is:

What leadership styles, structures, or behaviors, suited for the transdisciplinary collaboration context of the Digital Twin project of the Health & Technology branch of the Convergence Agenda of the Erasmus Medical Centre, the Erasmus University Rotterdam, and the Delft University of Technology, stimulate and facilitate learning and help develop a learning mindset?

Based on an extensive literature study, a qualitative study composed of semi-structured interviews with people involved in My Digital Twin – one of the flagships of the Health & Technology theme of the Convergence agenda of the TUD, EUR, and EMC – and analysis of the qualitative data using structural coding in Atlas Ti 9, core elements of transdisciplinary collaboration and core elements of learning in a transdisciplinary collaboration context were found. Based on these elements, a long list of appropriate behaviors for leaders to portray to stimulate learning or work towards transdisciplinarity was established. Appropriate leadership styles and structures were concluded to be rotational distributed leadership consisting of formal and informal leaders. The discussion shows ideas for tools to stimulate learning and help develop a learning mindset, discusses the quality of the research, and provides recommendations for future research.

Key words: transdisciplinarity, transdisciplinary collaboration, learning, leadership, duality, distributed leadership, convergence

VOORWOORD

(Dutch)

Wauw, wat is het een reis geweest! En wat ben ik blij dat deze ten einde loopt. Niet omdat ik er niet van heb genoten (al moet ik zeggen dat het afstuderen mij af en toe wel zwaar is gevallen), maar omdat ik heel erg toe ben aan de volgende stap in mijn leven: mij professioneel verder ontwikkelen in een uitdagende baan en passende werkomgeving. Maar voor ik daar iets over zeg, wil ik een stapje terug doen in de tijd.

Toen mij in groep drie de vraag 'Wat wil je later worden?' werd gesteld, was mijn antwoord 'Juf!'. Dit heb ik verwezenlijkt door (inmiddels alweer elf jaar!) bijles, huiswerkbegeleiding, en later ook examentrainingen te geven. Eerst aan vrienden en vriendinnen, en later via meerdere instanties. En ik doe het nog steeds, met ontzettend veel plezier! Wat ik zo heerlijk vind aan bijles geven is de individuele aandacht die ik iemand kan geven en ik diegene iets kan laten begrijpen. Het moment dat onbegrip overgaat naar begrip en soms zelfs plezier is mij ongelooflijk veel waard. Het gaat mij niet alleen om cognitieve maar ook persoonlijke groei. Het gaat mij erom dat het potentieel benut wordt. Dit stuk van begrip creëren, mensen helpen te groeien, en potentieel te benutten is altijd bij mij gebleven.

In de derde klas van de middelbare school moest ik mijn profiel gaan kiezen. Ik dacht toentertijd psychologie te gaan studeren en koos dus voor een N&G profiel met wiskunde A, scheikunde, natuurkunde, biologie, en aardrijkskunde. Ik had natuurlijk geen idee dat ik uiteindelijk een heel ander pad zou gaan bewandelen. Want ja, wat weet je nou al over wat je wil wanneer je 14 bent.

In de zesde klas had ik besloten naar University College Maastricht te gaan, een internationale universiteit waar je je eigen studieprogramma kon samenstellen. Dit vond ik razend aantrekkelijk aangezien ik nog helemaal niet wist wat ik uiteindelijk wilde gaan doen met mijn leven. Na een kort en oncomfortabel jaar van afzien, deels door te veel hooi op mijn vork door mijn aansluiting bij een studentenvereniging, zei ik het studentenleven in Maastricht vaarwel en keerde weer terug naar Sassenheim. Dan maar even een tussenjaar om rustig uit te pluizen wat ik dan wél wil.

Na een jaar de tijd te hebben genomen was ik eruit: Technische Wiskunde aan de Technische Universiteit van Delft! Ik vond wiskunde immers erg leuk, was er goed in, en gaf er al aardig wat jaren bijles in. Daarnaast gaf wiskunde erg veel mogelijkheden voor masteropleidingen en banen. Er was echter één probleem, ik had de verkeerde wiskunde in mijn pakket. Dus, ik probeerde snel in drie maanden tijd drie jaar aan wiskunde B kennis in mijn hoofd te krijgen. Gelukkig lukte dat en kon ik in 2014 beginnen met de Technische Wiskunde Bacheloropleiding. Maar… In het eerste en tweede jaar waren en er een aantal momenten dat ik toch begon te twijfelen. Gelukkig was daar het derde daar met een fantastisch minor (overigens de minor versie van mijn huidige master), keuzevakken, en een kort afstudeerproject. Yes! Ik had mijn bachelor op zak. Nu begon de volgende uitdaging: welke masteropleiding ga ik doen? Één ding was voor mij zeker: de wiskunde masteropleiding wordt het in ieder geval niet.

Je zou verwachten dat ik de master zou kiezen die ik nu doe. Ik genoot immers zo van de minor versie ervan. FOUT! Voor wat voor reden dan ook zette ik de Science Communication master opzij en zat ik te twijfelen tussen Engineering & Policy Analysis in Delft en Forensic Science in Amsterdam. Ik koos voor de eerste optie, en…stopte na acht weken. Ik herkende het gevoel uit Maastricht en wist dus dat het niet klikte. Stoppen dus, en weer terug naar de tekentafel.

Na eerst een jaar fulltime werken bij twee verschillende start-ups kwam ik dan eindelijk aan bij mijn huidige master: Science Communication. Hè hè. Wat heb ik ontzettend genoten van mijn tijd in deze opleiding! Korte lijntjes met de docenten, een kleine en hechte groep studenten, veel groepswerk, naast theorie meteen real-life praktijk toepassingen, en ruimte voor creativiteit en ideeën voor de opleiding.

En dan zijn we aangekomen bij het heden en daarmee mijn afstudeerproject. Ik kan met volle overtuiging zeggen dat ik trots ben op wat ik neer heb kunnen zetten. Het afronden van dit immense project is echter geen makkelijke opgave geweest en ik heb meerdere obstakels moeten overkomen.

Ten eerste heb ik het mijzelf immens moeilijk gemaakt met de abstractie en grootsheid van de onderwerpen die ik behandel: transdisciplinair samenwerken, leren, en leiderschap. Maar, ik kon het niet laten. Het zijn immers onderwerpen, althans leren en leiderschap, die mij immens interesseren. Initieel had ik bedacht iets met de relatie tussen leiderschap, eigenschap, en verantwoordelijkheid te doen omdat ik het gevoel had dat daar iets interessants tussen plaatsvindt. Echter moest mijn onderwerp natuurlijk relevant zijn voor mijn masteropleiding. Daarom, in overleg met mijn hoofdbegeleider, is het onderwerp geworden wat het nu is. Ik vond het erg lastig de drie termen te bevatten en de condenseren tot iets relevants en begrijpelijks. Dit heeft mij ontzettend veel tijd en moeite gekost.

Daarnaast ben ik erachter gekomen dat ik niet ben gemaakt om in mijn eentje aan een groot, abstract, en lange-termijn project te zitten. Ik heb sparringpartners en brainstormsessies nodig en ik wil het idee hebben dat ik niet de enige ben die een project moet dragen. Ondanks de sessies met mijn begeleiders is dit toch wel degelijk het gevoel wat ik heb gehad tijdens mijn afstuderen, wat ook in wezen klopt met het soort project. Ik ben er in ieder geval achter gekomen dat dit niet is waar ik blij van word.

En natuurlijk niet te vergeten: corona. Nooit had ik van tevoren gedacht een jaar over mijn afstudeerproject te doen. Maar ja, niemand had ook verwacht dat er een pandemie de hoek om zou komen kijken. Niet alleen zorgde corona ervoor dat tentamens werden opgeschoven en vakken uitliepen, maar ook was persoonlijk contact en overleg vrijwel onmogelijk. Dit laatste maakte het voor mij extra lastig om de abstracte onderwerpen waar ik mij mee bezig hield te kunnen bevatten. Zelfs het afstudeerhok was gesloten, waar ik juist had gehoopt veel steun en energie uit te kunnen halen wanneer het mijn tijd was om af te studeren. Aan de andere kant heeft corona, deels door de duidelijke vertraging die ik op zou lopen, mij ook een pas op de plaats laten maken. Ik ben gaan nadenken over wat ik belangrijk vind in mijn leven en waar ik blijdschap uit haal. Sinds corona ben ik meer gaan bakken, staat mijn huis vol met inmiddels alweer 50 planten, heb ik twee fantastisch leuke vogeltjes in huis gehaald, en ben ik aan de slag gegaan met een personal trainer om mijn lijf weer fit te krijgen. Dit zijn allemaal dingen die mijn kwaliteit van leven hebben verhoogd en dus ben ik achteraf stiekem best blij met wat deze pandemie voor mij persoonlijk heeft betekend.

Hoe dan ook is mijn afstudeerproject eindelijk tot een voor mij goed einde gekomen. En dus is de tijd aangebroken om na te denken over die volgende stap waar ik zo aan toe ben: werken! Laat het duidelijk zijn dat ik nooit precies heb geweten wat ik wil, mijn interesse aardig breed is, en ik vaak heb gekozen voor iets waardoor ik nog niet écht hoefde te kiezen: met University College, Technische Wiskunde, én Science Communication kon ik allemaal nog erg veel kanten op. Dat maakte het ook extra lastig voor mij om te bepalen wat ik nu precies wil en waar ik naar op zoek ben. Ik weet alleen wat voor elementen ik belangrijk vind (werken in een team, met begeleiding, uitdaging, en als het even kan mij bezighoudende mensen menselijke processen, leren, en leiderschap) en wat ik graag teweeg wil brengen (begrip, groei, en het benutten van potentieel), maar niet hoe een dergelijke baan dan zou heten. Gelukkig heb ik goed gebruik kunnen maken van mijn netwerk en ben ik flink aan het solliciteren geweest bij wel een stuk of drie ontzettend leuke bedrijven. Bij twee ben ik zelfs al door tot de laatste ronde! Ik ben benieuwd waar ik uiteindelijk terecht zal komen en wat mijn stap erna zal zijn.

Dit was in vogelvlucht de reis die ik de afgelopen 22 jaar heb afgelegd op gebied van institutioneel leren en ontwikkelen. Er liggen ongetwijfeld nog lessen om te leren voor mij in het verschiet en ik heb ontzettend veel zin om aan het nieuwe hoofdstuk van mijn leven te beginnen.

DANKWOORD

(Dutch)

Graag maak ik van deze gelegenheid gebruik om een aantal (groepen) mensen te bedanken. Samengevat: beste begeleiders, PhDer, en geïnterviewden, lieve vrienden, vriendinnen, gezin, en partner. Hartelijk dank voor jullie hulp, ideeën, bijdragen, en steun. Zonder jullie was ik niet tot dit eindresultaat gekomen.

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(English)

The insights presented in this report would not have been obtained if it wasn't for the people I was able to interview. So, to all interviewees, thank you for your time, openness, and honesty. Furthermore, thank you for your permission to use the quotes that I did. Those really made the results sections livelier. Also, an explicit thank you to Régine Steegers and Valentijn Visch for their willingness to cooperate with me and their openness. It was great to see that there was interest in my research. In addition, you enabled me to reach all the postdocs and PIs I interviewed. I am grateful to you for that.

(Dutch)

Mijn lieve vrienden en vriendinnen, ontzettend bedankt voor jullie steun! Jullie begrip en gezelligheid hebben mij immens geholpen deze afstudeerperiode door te komen. Specifiek zijn er een aantal mensen die ik wil benoemen. Angelica Babel, je hebt mij mentaal kunnen voorbereiden op de dieptepunten die ik zou gaan tegenkomen. En die zijn er zeker geweest. Maar dankzij jou had ik altijd het gevoel dat het normaal was en het goed zou komen. Jij gaf mij op die momenten weer een stukje kracht terug. Dank daarvoor. Joey van der Krogt, Menno Looman, Nerine Usman, en Sven Westerbeek, de studiedates met jullie gaven mij dat extra zetje in de rug (en jullie geloof ik ook) om toch nog dat uurtje (of twee) door te pakken. Deze dagen van serieus werken, gezelligheid, en goede gesprekken maakten dat ik niet alleen on track bleef met mijn werk, maar ook met jullie levens. Ik ben mij dieper met jullie verbonden gaan voelen en ben hier heel blij mee. Dank ook aan jullie.

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onze studiedates. Ik heb hier heel veel aan gehad en er altijd van genoten. Een studiedate met jou betekent los van serieus werken ook lekker lunchen, serieuze gesprekken, en dans sessies als pauze. Ultiem genieten! Dank daarvoor.

En last maar zeker niet least, mijn vriend, huisgenoot, partner, buddy, en favoriete persoon: Boaz Venderink. Lief, dank voor het geven van alle knuffels die ik nodig had. Dank voor het verzorgen van het eten zodat ik dat niet hoefde te doen. Dank voor het rekening houden met mij. Dank voor het meedenken over modellen met mij ook al vond je dat immens lastig. Dank voor het mooi maken van modellen in Adobe Illustrator. Dank voor het feit dat je er altijd bent als ik je nodig heb. Dank dat je mij nog steeds niet zat bent (en ik jou ook zeker niet) ondanks dat we elkaar 24/7 zien door corona en het huis door mij inmiddels overvloeit van planten. Dank voor alles.

CONTENT

1 INTRODUCTION

"The more I learn, the more I realize how much I don't know", "The more you know, the more you realize you don't know", "I know that I know nothing". These famous quotes from Albert Einstein, Aristoteles, and Socrates respectively, still ring true to this day. The more we discover about the world, the more we discover we know little of the world. This process is shown in Figure 1.1 below. Figure 1.2 shows how besides knowing what we do not know, there are also unknown unknowns, also referred to as 'deep uncertainty' by Ayas & Zeniuk (2001).

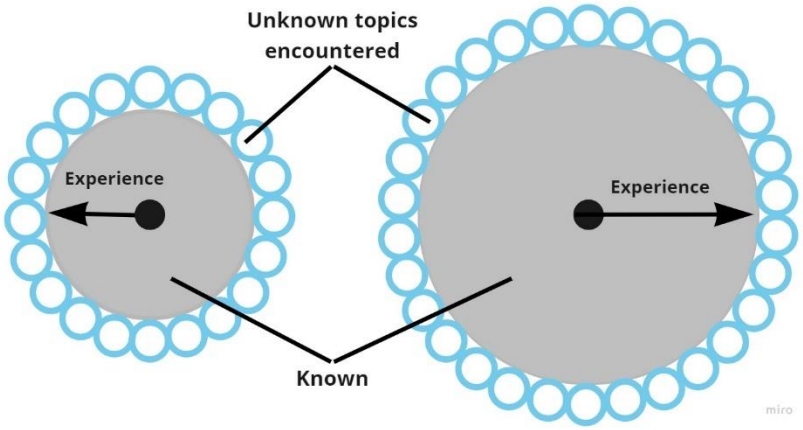


Figure 1.1: The process of the more we discover, the more we discover what we do not know. Based on a figure from https://ardalis.com/the-more-you-know-the-more-you-realize-you-dont-know/

The more we know, the more links between disciplines, communities, and other stakeholder groups we discover, and thus the more all these different groups need to be recognized and taken into account. It would namely be unethical and ignorant not to do so. With our increasing knowledge, we evolve our understanding about societal issues and realize that often times issues cannot be regarded from just one perspective or discipline. In that respect, we increasingly realize the complexity of societal issues and how one discipline can never begin to solely comprise solutions to those issues. In line with that, Nowotney et al. (2003) say how knowledge needs to be increasingly socially robust, since knowledge can no longer be "determined solely, or predominantly, by narrowly circumscribed scientific communities, but by much wider communities of engagement comprising knowledge producers, disseminators, traders, and users" (p. 191-192). Therefore, the more disciplines and stakeholder groups are combined, the greater the chance becomes of being able to tackle the pressing and complex societal issues effectively and in a socially robust way, as is portrayed in Figure 1.3.

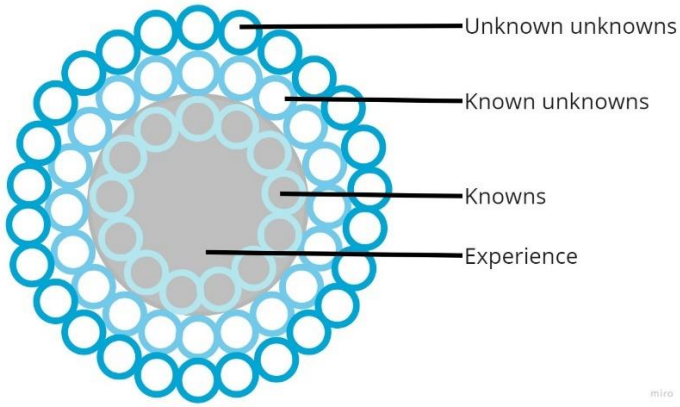


Figure 1.2: A combination of knowns, known unknowns, and unknown unknowns. Based on a figure from https://ardalis.com/the-more-you-know-the-more-you-realize-you-dont-know/

To deal with increasing complexity and face societal challenges that do not belong to any one nation – such as the aging population, climate change, and the energy transition – the previously shown bundling of scientific and non-scientific communities has seen increasing popularity over the past years. This trend, also referred to as 'convergence', provides the starting

point of what this Master Thesis project is about and will be explained in the next sub-section.

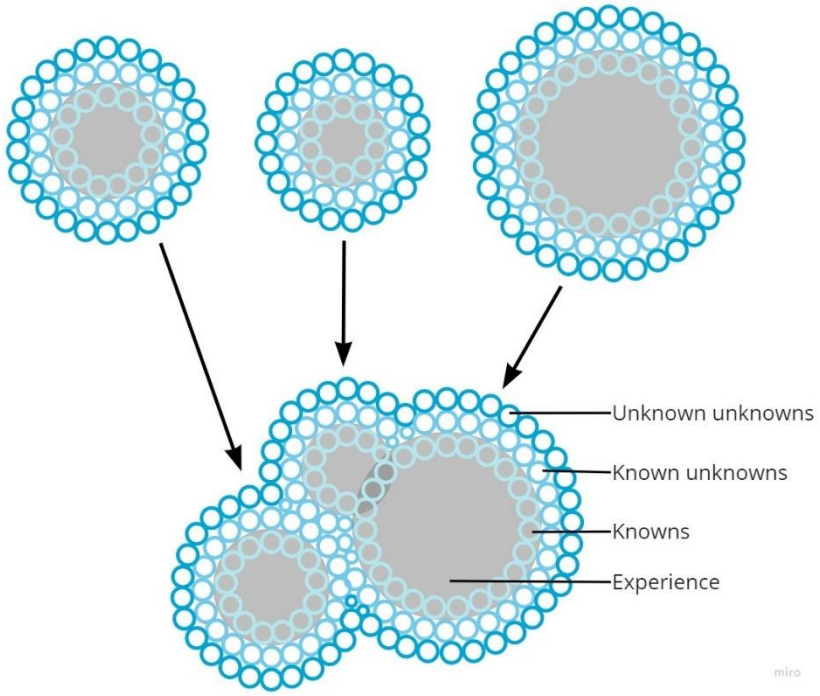


Figure 1.3: Bundling communities' experience, knowledge, and forces results in both fewer known unknowns and unknown unknowns than when each community stands by itself.

1.1 CONVERGENCE

In this section, convergence is and the Convergence Revolution will be elaborated on. Furthermore, the Convergence Agenda of the Erasmus Medical Centre (EMC), the Erasmus University of Rotterdam (EUR), the Delft university of Technology (TUD) as the context of this Master Thesis project will be explained.

1.1.1 WHAT IS CONVERGENCE?

Convergence is the process of the integration of knowledge, expertise, and methods from multiple disciplines and non-scientific domains (Erasmus MC & TU Delft, n.d.; MIT, n.d.; National Research Council, 2014; Sharp et al., 2016). Furthermore, convergence "builds on fundamental progress made within individual disciplines" (National Research Council, 2014, p. 17; Sharp et al., 2016, p. 17) and is at the same time able to cut "across disciplinary boundaries in these fields" (National Research Council, 2014, p. 17; Sharp et al., 2016, p. 17).

1.1.2 THE CONVERGENCE REVOLUTION

Convergence did not just appear out of thin air. It is the logical result of developments in scientific research that happened in the past decades. Nowotny et al. (2003) describe how the paradigm of scientific discovery (Mode 1) – that consisted of theoretical and experimental science, was internally driven by the scientific disciplines, and was characterized by autonomy of both the institutions and their researchers –has in the past years moved to a knowledge production paradigm (Mode 2) which is "socially distributed, application-oriented, trans-disciplinary, and subject to multiple accountabilities" (p. 179). What is called Mode 2 here essentially refers to convergence. The authors also describe how this paradigm shift was not met with enthusiasm by everyone: those that would benefit most from the new paradigm (such as politicians, civil servants and researchers in management) were positive, whereas researchers in established scientific disciplines were mainly sceptic as they feared the quality of research would diminish and their autonomy would be lost. Despite a lack of enthusiasm by some, the Mode 2 paradigm, or convergence, has changed the dynamics within and between research communities (Nowotny et al., 2003). Within the context of life science research, convergence is even considered to be

the third revolution, where the first and second revolution were the molecular & cellular biology revolution and the genomics revolution respectively (MIT, n.d.; National Research Council, 2014). MIT's Koch Institute for Integrative Cancer Research is seen as a leader in the Convergence Revolution (Stoll, 2017). Since their initiative, many convergence-related initiatives have arisen, especially in relation to health care.

1.1.3 THE CONVERGENCE AGENDA OF THE DELFT UNIVERSITY OF TECHNOLOGY, ERASMUS UNIVERSITY OF ROTTERDAM, AND ERASMUS MEDICAL CENTER

The EMC, EUR, and TUD became aware of the necessity to combine their forces, knowledge, and disciplines to deal with the urgent and complex societal issues in our society. According to Tim van der Hagen, Rector Magnificus of the TUD, dealing with these issues is the duty of universities (Van der Hagen, 2020). Therefore, these three institutes decided to follow the Convergence Revolution trend and deepen their already existing collaboration by introducing a Convergence Agenda (TU Delft (b), n.d.). The reason as to why specifically these three institutions decided on this convergence endeavor or whether these institutes are the best combination, is beyond the scope of this Master Thesis project.

The Convergence Agenda of EMC, EUR, and TUD, from here on out simply referred to as the Convergence Agenda, consists of three themes: AI & Digitalization, Sustainable Urban Delta, and Health & Technology (Erasmus MC, 2020). Van der Hagen said that the first focus of the Convergence Agenda was on medical technology (TU Delft (a), n.d.), as is also confirmed by several sources from within the Convergence Agenda initiative. Furthermore, it is said that Health & Technology was the first to launch and is furthest along. Additionally, most information online about the Convergence Agenda concerns the Health & Technology theme. Since the Health & Technology theme has existed longest, it has the most experience with the new convergence collaboration and will therefore have the most insights on that front. Therefore, the context of this Master Thesis project is the Health & Technology theme of the Convergence Agenda. To provide a more concrete idea of transdisciplinary collaboration, learning, and leadership in real life, the focus was further specified to one of the flagships of the Health & Technology theme. The flagship that was chosen is My Digital Twin, or simply Digital Twin. Erasmus MC & TU Delft (n.d.) describe it as "a technological framework that, once fully developed, will make it possible to create a digital representation of an individual's health and disease status that is descriptive, interpretive, integrative and predictive (…) The aim of the flagship programme My Digital Twin is to contribute to precision health and precision healthcare from the earliest moment and throughout the course of life, enabling personalized and individual risk assessment, diagnosis, treatment, prediction and prevention of diseases" (p. 23).

1.2 THE FOCUS AND RELEVANCE OF THIS MASTER THESIS PROJECT

In this Master Thesis project, three main themes are focused on: transdisciplinary collaboration, learning (and a learning mindset), and leadership. Why these three themes were chosen and their relevance is explained below.

TRANSDISCIPLINARY COLLABORATION

Convergence is being explicitly linked to a new type of collaboration called 'transdisciplinary' collaboration ("Convergence for Health & Technology", n.d.; Erasmus University & TU Delft, n.d.; Van der Hagen, 2020). Furthermore, this type of collaboration, which will be elaborately discussed later on, (almost) completely encompasses the way convergence has previously been described (National Research Council, 2014). Therefore, transdisciplinary collaboration can be said to provide the lens through which to find the core elements of the 'convergence way of working'.

LEARNING AND A LEARNING MINDSET

In the case of reinvention and renewal, as is undoubtedly the case for the Convergence Agenda, Watkins & Marsick (2021) state that learning and unlearning play a substantial role. Novelty introduces uncertainty but also opportunities to learn. Mutual learning is even mentioned by the National Research Council (2014) to be a key part of transdisciplinary collaboration. Furthermore, incorporating continuous learning is mentioned in relation to the Convergence Agenda ("Convergence for Health & Technology", n.d.). Therefore, explicitly focusing on learning and adopting a learning mindset may ensure the use and implementation of all lessons learned without having to reinvent the wheel. It may speed up the familiarity with and trust in new processes and thus help build transdisciplinary collaboration quicker and more effectively.

LEADERSHIP

Besides having my personal interest, leadership is also relevant to take into account due to the fact that people look towards their leaders for guidance. This is especially true when dealing with uncertainty or novelty, as is the case for the Convergence Agenda. Additionally, Nowotny et al. (2003) state that "the production of knowledge, however widely distributed, however trans-disciplinary, however heterogeneous, however reflexive, has to be 'managed'" (p. 189), thereby implying that a focus on learning would benefit from an additional focus on leadership and how leadership can influence learning.

RELEVANCE

The leads of the Digital Twin project voiced a willingness and necessity to collaborate with me, my main supervisor, and a PhD candidate since they are trying to find out the best way to structure and lead the Digital Twin project and new way of working. Any information that would provide them with insights on how to improve collaboration itself, the outcomes of the collaboration, or leadership were said to be welcome.

Learning is inextricably linked to transdisciplinarity. However, explicit attention has not been given to building in learning and a learning mindset before. Leadership and learning have had an existing link in literature, but have not been regarded in a setting of transdisciplinary collaboration. Taking leadership into account will enable the formulation and implementation of more concrete actions to move away from a still rather vague idea of transdisciplinarity and towards actionable steps. Therefore, the combination of transdisciplinarity, learning, and leadership is not only interesting and relevant from a research point of view but it may also directly influence the Digital Twin project, which is currently taking place. The novelty of both the Convergence Agenda and the combination of transdisciplinary collaboration, learning, and leadership, makes this Master Thesis project an explorative study (Babbie, 2016).

1.3 RESEARCH QUESTIONS

Based on the three previously mentioned themes of transdisciplinary collaboration, learning, and leadership and the links between them, the following main research question can be formulated:

What leadership styles, structures, or behaviors, suited for the transdisciplinary collaboration context of the Digital Twin project of the Health & Technology branch of the Convergence Agenda of the Erasmus Medical Centre, the Erasmus University Rotterdam, and the Delft University of Technology, stimulate and facilitate learning and help develop a learning mindset?

To be able to answer the main research question, the following research questions and research sub-questions were formulated:

1. What are the core elements of a transdisciplinary collaboration context?
    a. What is transdisciplinary collaboration?

   b. What makes it different from well-known types of collaboration such as multi- and interdisciplinary collaboration?
2. What elements are crucial for learning in a transdisciplinary collaboration context?
   a. How does learning relate to the core elements of transdisciplinary collaboration?
   b. What core elements of learning in a transdisciplinary collaboration context can be extracted from this?
3. What type of leadership style, structure, or behavior is appropriate or necessary to enable and stimulate learning within a transdisciplinary collaboration context?
   a. What leadership behaviors are necessary in relation to a transdisciplinary collaboration context?
   b. What leadership behaviors are necessary in relation to the learning elements in a transdisciplinary collaboration context?
   c. What leadership styles or structures do not fit with the identified leadership behaviors?
   d. What leadership styles or structures do fit with the identified leadership behaviors?
4. What are the core elements of transdisciplinary collaboration in the Digital Twin project context?
   a. How is the collaboration perceived by people involved in the Digital Twin project?
   b. How is transdisciplinarity perceived by people involved in the Digital Twin project?
   c. What elements do people involved in the Digital Twin project perceive as important to collaboration?
   d. How do these perceptions and elements relate to the transdisciplinarity core elements found in literature?
5. What are the core elements of learning in the Digital Twin project context?
   a. How do people involved in the Digital Twin project currently learn?
   b. What elements do people involved in the Digital Twin project perceive as important to learning?
   c. How do these elements relate to the learning core elements found in literature?
6. What leadership styles, structures, or behaviors are necessary or appropriate for leadership in the Digital Twin project context?
   a. What elements do people involved in the Digital Twin project perceive as important to or in leadership?
   b. How do these elements relate to the leadership core elements found in literature?
   c. What leadership styles or structures do people involved in the Digital Twin project perceive as important to or in leadership?
   d. How do these styles or structures relate to the leadership styles or structures found in literature?

Research questions 1, 2, and 3 will be answered based on a literature study. Research sub-questions 4a, 4b, 4c, 5a, 5b, 6a, and 6c will be answered based on qualitative research using semi-structured interviews. Research sub-questions 4d, 5c, 6b, and 6d will be answered by contrasting and comparing the answers given to research (sub-)questions 1, 2, and 3 with 4a, 4b, 4c, 5a, 5b, 6a, and 6c.

1.4 OUTLINE OF THE REPORT

The report is divided into six chapters, the first of which is the introduction. Chapter 2 will present the literature study. Within this chapter, the methodology used for the literature study will be elaborated on first. Then, transdisciplinarity, learning in a transdisciplinary collaboration context, and leadership in relation to learning and a transdisciplinary context will be discussed and core elements of each will be extracted. Additionally, for each

of the three themes – transdisciplinarity, learning, and leadership – conceptual visualizations will be given. Chapter 3 will start off with the methodologies used, after which the results of the interviews will be presented. Insights from chapter 2 and 3 will be combined in chapter 4, after which adapted conceptual visualizations of the three themes will be presented. In chapters 2, 3 and 4, answers to corresponding research (sub-)questions will be provided as well. The final conclusion and an answer to the main research question will be given in chapter 5. Finally, a discussion will be presented in chapter 6, noteworthy insights based on interview results, ideas for tools to stimulate learning and help develop a learning mindset, the quality of the research, contributions to the faculty of Science Education & Communication, and recommendations for future research.

2 LITERATURE STUDY

This chapter provides the theoretical understanding of (1) transdisciplinary collaboration, (2) learning in relation to transdisciplinary collaboration, and (3) leadership in relation to learning and a transdisciplinary collaboration context. First, the methods used to perform the literature study on which the theoretical understanding is based will be explained. Thereafter, the three previously mentioned subjects will be discussed from a theoretical point of view in that order. Then, conclusions will be drawn, based on which the first (parts of) research questions will be answered.

2.1 METHODOLOGY – LITERATURE STUDY

The first step of the literature study consisted of gathering literature using specific search engines, search input, and reading the abstracts of the seemingly relevant resulting literature. The sources from where the used literature was obtained is shown below in descending order of frequency. I.e., the source listed at the top is the source that provided most of the used literature.

1. Scopus search engine
2. Literature that was referenced in the literature found using the Scopus search engine
3. Google scholar
4. Literature referred by experts
5. IEEE search engine

The search input contained a combination of Boolean operators, asterisks, and limitations to subject areas to increase the relevance of the search results. An example of a search input in Scopus that was used is: TITLE-ABS-KEY ("leadership" AND "knowledge" AND "learn*") AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "DECI")).

The literature from Google Scholar was selected based on year of publication (at least 2000) and number of citations (at least 100). However, sometimes an article seemed so relevant that the number of citations was not taken into account, but this only happened a maximum of five times.

Some of the articles that are referenced date back to before 2000, which could be seen as outdated. However, this happened only seven times and concerns models that have been proven useful conceptually over the years or have several thousands of citations, and therefore still provide a useful theoretical basis.

The second step of the literature study consisted of a more content-wise selection performed by reading the introductions, headlines, figures, and conclusions. If these proved promising, the literature was read completely.

2.2 UNDERSTANDING TRANSDISCIPLINARY COLLABORATION

As part of their Convergence Agenda initiative, the EMC, EUR, and TUD claim they wish to commence a new type of collaboration referred to as transdisciplinary collaboration (Erasmus MC & Erasmus University, 2019; Erasmus MC & TU Delft, n.d.; Erasmus University & TU Delft, n.d.). What transdisciplinary collaboration entails exactly will be explained, after a basic explanation of multi- and interdisciplinary collaboration is given. Then, an overview and comparison of all three collaboration types will be presented. Finally, a conceptual visual of the core elements of transdisciplinary collaboration and a critical reflection will be provided. However, it is first important to specify what is meant by the construct 'collaboration'. Collaboration is defined as a "mutually beneficial (…) relationship entered into by two or more organisations" (Mattessich & Monsey, 1992, p. 11) to solve common problems or achieve common goals (Ellis et al., 2019; Mattessich & Monsey, 1992).

2.2.1 MULTIDISCIPLINARY COLLABORATION

Multidisciplinary collaboration, or multidisciplinarity, describes a collaboration where people from multiple different disciplines are involved in the same project, but the different elements or components that are contributed by each discipline remain intact (Choi & Pak, 2006; Cooke & Hilton, 2015; Kumar et al., 2019; National Research Council, 2014; Sunarti et al, 2020). I.e., multidisciplinarity entails disciplinary thinking where the boundaries between the disciplines are not blurred (Choi & Pak, 2006; Kumar et al., 2019) and "the results are still formulated from the perspective of scientific disciplines" (Sunarti et al., 2020, p. 2). Multidisciplinarity possesses the awareness of the influence of multiple disciplines in one situation or project, but does not take the whole of those involved disciplines into account (Ramadier, 2004). Multidisciplinary collaboration is a fragmented type of collaboration where the aim is not to view the whole, but only the parts of each discipline that enable consensus and thus maintain coherence (Ramadier, 2004), thereby not challenging the disciplines to think differently or beyond their discipline (National Research Council, 2014).

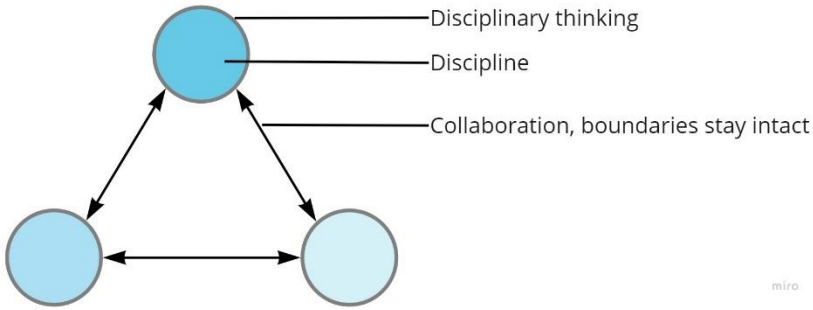


Figure 2.1: Multidisciplinary collaboration, adapted from an image from Kumar et al. (2019, p.3)

In short, multidisciplinary collaboration is characterized by fragmented, disciplinary thinking where the disciplinary boundaries stay intact despite an awareness of the multiple points of view. Figure 2.1 provides a schematic overview of multidisciplinary collaboration.

2.2.2 INTERDISCIPLINARY COLLABORATION

Interdisciplinary collaboration, or interdisciplinarity, consists of integrating elements (such as tools, data, methods, concepts) from the different involved disciplines into a coordinated whole (Choi & Pak, 2006; Cooke & Hilton, 2015; Kumar et al., 2019; National Research Council, 2014; Ramadier, 2004; Sunarti et al., 2020). The coordinated whole, or common model, that is constructed in interdisciplinary collaboration does not belong to any one discipline, but is based on the interactions between the disciplines. Thus, it blurs the boundaries between the disciplines (Kumar et al., 2019). However, since this common model only consists of those parts of the involved disciplines that are compatible with each other, it ignores the multitude of points of view. Furthermore, interdisciplinary collaboration can be described as fragmented (Ramadier, 2004) due to the fact that the parts that do not overlap are not taken into account in constructing the common model, thereby still adhering to the disciplinary boundaries of those parts. Therefore, despite of the blurring of the boundaries between parts of the disciplines that overlap, interdisciplinarity still practices bounded disciplinary thinking (Ramadier, 2004).

So, interdisciplinary collaboration is characterized by the construction of a common model through the blurring of boundaries and integration of knowledge in the overlapping areas of the involved disciplines. In the remaining parts of the disciplines, the boundaries remain, thus still creating a type of collaboration that is fragmented and bounded by disciplinary thinking. Figure 2.2 provides a schematic overview of interdisciplinary collaboration.

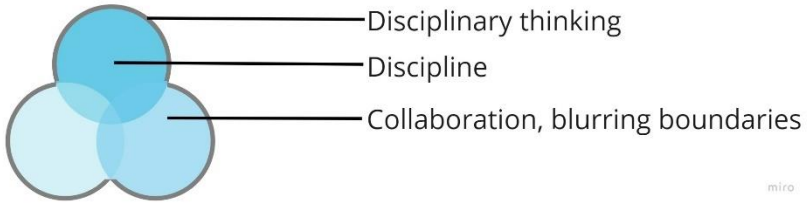


Figure 2.2: Interdisciplinary collaboration, adapted from an image from Kumar et al. (2019, p.3)

2.2.3 TRANSDISCIPLINARY COLLABORATION

Transdisciplinary collaboration, or transdisciplinarity, is described as a collaboration between multiple academic disciplines and non-academic stakeholders in society that results in synergy and transcends disciplinary boundaries (Choi & Pak, 2006; Klein, 2008; Kumar et al., 2019; National Research Council, 2014; Nowotny et al., 2003; Sharp et al., 2016; Sunarti et al., 2020). I.e., transdisciplinarity involves multiple and different communities of society, both academic and non-academic. Diversity is therefore an important part of transdisciplinary teams. Transdisciplinary collaboration integrates approaches and additionally creates "fundamentally new conceptual frameworks, hypotheses, and research strategies" (Cooke & Hilton, 2015, p. 23). To allow for an integration of the expertise from the multitude of diverse communities, a common language is needed (National Research Council, 2014).

Transdisciplinarity is problem-oriented (Klein, 2008), meaning that the urgency to address an existing problem is taken as the starting point of connecting the necessary and involved parties. These problems are often societal and complex and transdisciplinarity is seen as the necessary collaborative type to enable solutions to such problems to be found (Choi & Pak, 2006; Kumar et al., 2019; Ramadier, 2004).

Transdisciplinarity is also referred to as a holistic (Kumar et al., 2019; Ramadier, 2004) or systemic approach, meaning that besides looking for coherence in overlapping parts between the involved parties, the non-overlapping parts are still seen as part of the system and taken into consideration when looking for a solution to a given problem (Kumar et al., 2019; Ramadier, 2004). In trying to find this solution, parties taking part in transdisciplinary collaboration try to develop an overarching system of articulations understandable to all involved (Ramadier 2004), which again necessitates a common language. Developing an overarching system does not, however, mean that transdisciplinary collaboration works towards unity. The reason for this is that trying to find unity would entail eventually choosing one point of view over another to be able to deal with the paradoxical nature of some societal challenges, and thus choosing one discipline over another, which goes back to disciplinarity (Ramadier, 2004). Some paradoxes cannot be lifted and thus ambiguity will always remain a part of transdisciplinarity. Respecting the multitude of realities and trying to find an overarching system necessitates an attitude change to break with disciplinary thinking and accept ambiguity (Ramadier, 2004). Furthermore, accepting ambiguity means relying more on trust when making decisions (Seanor, 2008). Since ambiguity is an inherent part of transdisciplinary collaboration, trust has never been as important as for this type of collaboration.

In short, transdisciplinary collaboration combines a multitude of different and diverse academic and non-academic communities in a holistic way, necessitating a common language. It respects the multitude of realities, looks for coherence instead of unity, and results in synergy. Ambiguity is an inherent part of transdisciplinarity, which makes trust an inherent part of it as well. Since transdisciplinarity is needed to find solutions to complex societal problems, complexity is the theme of the environment in which transdisciplinary collaboration takes place. Transdisciplinarity breaks with fragmented disciplinary thinking which, together with the necessity to be

able to deal with complexity and ambiguity, requires an attitude change. Figure 2.3 provides a schematic overview of transdisciplinary collaboration.

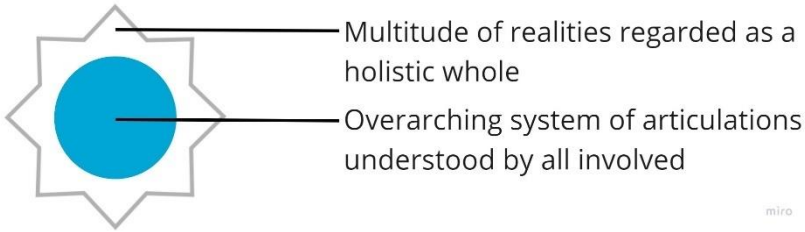


Figure 2.3: Transdisciplinary collaboration, adapted from an image from Kumar et al. (2019, p.3)

2.2.4 COMPARING MULTI-, INTER-, AND TRANSDISCIPLINARY COLLABORATION

Having defined multi-, inter-, and transdisciplinary collaboration, they can now be compared to make the distinction between them even clearer. Table 2.1 provides an overview of the elements of each collaborative form and whether the other forms possess that element as well or to what degree.

Table 2.1: Overview of the differences between multi-, inter-, and transdisciplinary collaboration

Multidisciplinarity	**Interdisciplinarity**	**Transdisciplinarity**
Disciplinary thinking	Mostly disciplinary thinking	Breaks with disciplinary thinking
Fragmented	Mostly fragmented	Holistic
Boundaries stay intact	Partly blurs boundaries	Transcends boundaries, no boundaries can be discerned
Aware of multitude of realities, no common model construction	Construction of common model based on already present common language in overlapping areas, no regard for existence of other realities	Respects the multitude of realities and provides an overarching system understood by all involved
Articulated from points of view of each separate discipline	Coherence in overlapping parts	Coherence of all parts
Collaboration between only academic disciplines	Collaboration between only academic disciplines	Combines a multitude of different academic and non-academic communities
No exchange of models, theories, or concepts	Exchange and integration of models, theories, and concepts between disciplines	Exchange and integration of models, theories, and concepts between disciplines as well as the creation of fundamentally new frameworks, hypotheses, and research strategies
		Enables finding solutions to urgent and complex societal issues
		Ambiguity
		Requires attitude change
		Requires construction of common language

In Table 2.1 it can be seen that transdisciplinarity combines or surpasses elements of multi- and interdisciplinarity and even has additional elements that multi- and interdisciplinarity do not consider. However, it is unfair to say that multi- and interdisciplinarity are outdated or not useful, since they have served the scientific community well for many years (and still do in some instances), and have paved the way for transdisciplinarity to be developed. As Ramadier (2004) put it: "transdisciplinarity simultaneously combines multidisciplinarity and interdisciplinarity in order to rise above these forms of thought. From multidisciplinarity, transdisciplinarity has inherited its awareness of different realities. From interdisciplinarity, it has adopted the effort to reinterpret knowledge in order to readjust the different levels of reality. Thus, (…) multidisciplinarity and interdisciplinarity have contributed to the emergence of transdisciplinarity." (p. 434).

It is recognized that for any type of collaboration some basic common understanding is often necessary. However, in the case of transdisciplinarity, the collaboration consists of exploring uncharted territory and unknown combinations of expert knowledge than before. Therefore, constructing a common language is not only more necessary but also more complex for transdisciplinary collaboration in relation to multi- and interdisciplinary collaboration. This is why it is listed as a separate additional element for transdisciplinary collaboration in Table 2.1.

Perhaps the best description of the difference between multi-, inter-, and transdisciplinary collaboration is provided by Choi & Pak (2006), who state that "multidisciplinary is like a salad bowl (such as a vegetable platter or mixed salad, in which the ingredients remain intact and clearly distinguishable); interdisciplinary is like a melting pot (such as a fondue or stew, in which the ingredients are only partially distinguishable); transdisciplinary is like a cake (in which the ingredients are no longer distinguishable, and the final product is of a different kind from the initial ingredients)" (p. 359-360).

It must be noted that multiple forms of disciplinary collaboration may occur simultaneously in a field of initiative "because of the complex array of activities its participants undertake and diverse institutional contexts" (National Research Council, 2014, p. 46). It is not the wish of the Convergence Agenda to eradicate all other forms of collaboration, but more so to establish a new community that consists of a transdisciplinary collaboration partnership to tackle urgent complex societal issues. To be able to feed transdisciplinary collaboration with the necessary expertise and provide the breadth of focus that is needed to find solutions to the previously mentioned complex problems, disciplinary depth of knowledge is needed.

2.2.5 CONCLUSIONS

Based on the findings from sub-sections 2.2.1-2.2.4, research sub-questions 1a, 1b, and thus research question 1, can be answered. Recall research question 1 with subparts 1a and 1b:

1. What are the core elements of a transdisciplinary collaboration context?
    a. What is transdisciplinary collaboration?
    b. What makes it different from well-known types of collaboration such as multi- and interdisciplinary collaboration?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 1A

Transdisciplinary collaboration is a form of collaboration that combines the strongest elements of both multi- and interdisciplinary collaboration to transcend beyond these forms. From multidisciplinary, it inherited an awareness of different realities. From interdisciplinarity, it adopted the ability to reinterpret knowledge to readjust the perception of reality. It

combines a multitude of different and diverse academic and non-academic communities in a holistic way, necessitating a common language. It respects the multitude of realities, looks for coherence instead of unity, and results in synergy. Ambiguity is an inherent part of transdisciplinarity, which makes trust an inherent part of it as well. Since transdisciplinarity is needed to find solutions to complex societal problems, complexity is the theme of the environment in which transdisciplinary collaboration takes place. Transdisciplinarity breaks with fragmented disciplinary thinking which, together with the necessity to be able to deal with complexity and ambiguity, requires an attitude change.

ANSWER TO RESEARCH SUB-QUESTION 1B

Based on Table 2.1, it can be concluded that, even though transdisciplinarity finds its origin in both multi- and interdisciplinary collaboration, all elements of transdisciplinary collaboration are either a combination of or go beyond the elements of multi- and interdisciplinarity. Examples are holism, trust, and combining academic and non-academic communities. Moreover, transdisciplinary collaboration introduces additional elements to a collaboration that have not been (explicitly) part of multi- or interdisciplinary collaboration. Examples are ambiguity, complexity, attitude change, and the construction of a common language. Therefore, all elements of transdisciplinarity are different from or transcend the elements of multi- and interdisciplinarity.

ANSWER TO RESEARCH QUESTION 1

By combining the answers to research sub-questions 1a and 1b, core elements of transdisciplinary collaboration can be extracted. These core elements are: *complexity, ambiguity, holism, multitude of communities, attitude change, common language,* and *trust*.

2.2.6 CONCEPTUAL VISUALIZATION OF TRANSDISCIPLINARITY BASED ON THEORY

As has previously been stated, the core elements of transdisciplinary collaboration are: *complexity, ambiguity, holism, multitude of communities, attitude change, common language,* and *trust*. These core elements are portrayed in the conceptual visualization of Figure 2.4.

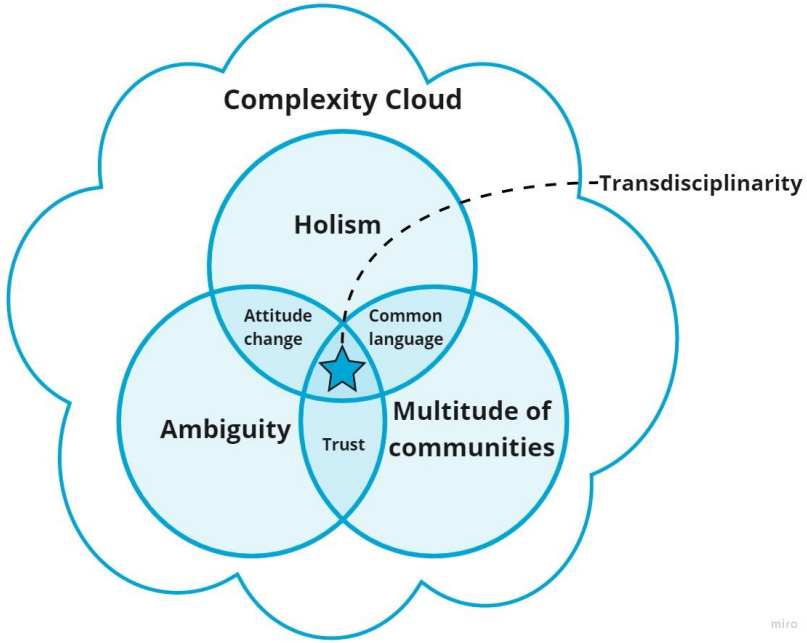


Figure 2.4: A visualization of the core elements of transdisciplinarity where complexity is the context, holism, ambiguity, and a multitude of communities are the defining characteristics, and trust, attitude change, and a common language are the necessities to make transdisciplinarity work.

Complexity provides the context in which the idea of transdisciplinarity was developed. It is the present reality provided by urgent and current complex

societal challenges that need to be tackled. Therefore, the complexity cloud of Figure 2.4 is the stage on which the development of transdisciplinarity takes place. Holism, multitude of communities, and ambiguity are its defining characteristics and are what make it different from other types of collaboration. To enable the transition towards and implementation of transdisciplinary collaboration, trust, a common language, and an attitude change are needed.

2.2.7 A CRITICAL REFLECTION ON TRANSDISCIPLINARITY

A theoretical and rather idealistic image of transdisciplinarity has been formulated and visualized. A critical reflection on this is necessary to not only blindly accept the new way of working, but to also reflect on the practicality of it.

Transdisciplinarity was described to aim towards building an overarching system understandable by all, which necessitates a common language understandable by all involved. This seems like an immense task to fulfill, taking up tremendous amounts of time and effort, that people often do not have or are not willing to invest. Furthermore, enabling a common understanding through a common language may necessitate introducing a lot of simplicity into the overarching system, which will most probably not be sufficient to describe the complexity of the issue at hand. I.e., information and implications may get lost in translation. The other way around is also true, where the knowledge of lay people may not be fitted with scientific knowledge, making integration difficult or even impossible (Cooke, & Hilton, 2015). Additionally, ambiguity was explained to be a part of transdisciplinarity and needs to be accepted. Accepting ambiguity goes against the nature of human beings and may therefore provide an immense challenge to overcome, again taking a lot of time. Ambiguity and an overarching system understood by all involved also sounds rather conflicting and questions whether transdisciplinary collaboration, the way it is described in theory, can even be realized.

The holistic characteristic of transdisciplinarity is a rather vague and challenging one. It is unclear what it means to take everything into account and the question of whether this is even possible remains. Increasing awareness sounds lovely, but it also introduces the question of whether this may actually slow down or even delay decision-making.

Another point of reflection involves whether the institutions of the Convergence Agenda are even able to accommodate transdisciplinarity. These institutions, or universities in general, are not necessarily regarded as the most flexible organizations. The current infrastructure may have to be adjusted, people would have to be (re)educated, and incentives for doing transdisciplinary work will have to be installed since it may not be seen as a true academic achievement yet. Still, since multi- and interdisciplinarity form a basis for transdisciplinarity, learning this new way of working may prove to be doable. However, explicit attention must be given to prevent the relapse into either multi- or interdisciplinary collaboration in the cases where transdisciplinarity is required. This puts additional strain on leadership, especially since transdisciplinary collaboration is new to most people, is very abstract, difficult to chop into actionable steps, and therefore also difficult to communicate and comply to.

Another consideration concerns whether or not transdisciplinary collaboration is truly the way to go when trying to tackle the urgent and complex societal challenges. It is too new to conclusively be able to say that it is truly *the* way of working to find solutions to such challenges.

2.3 LEARNING

From the previous chapter it can be concluded that the core elements of transdisciplinarity are: *complexity, ambiguity, holism, multiple and different communities, attitude change, common language*, and *trust*. As was stated in the introduction, learning is an inherent part of introducing a new way of working and thinking as is the case for the Convergence Agenda and

transdisciplinary collaboration. Therefore, learning, or more specifically learning with regard to the previously mentioned core elements, is taken into consideration in this Master Thesis project. The core elements of transdisciplinarity are either conditions for learning, part of learning processes, or otherwise influence learning as will be explained in the next sub-sections. However, it is first important to specify what is meant by the construct 'learning'. Learning refers to a process of relatively stable (Lachman, 1997) "qualitative change in a person's way of seeing, experiencing, understanding, conceptualizing something in the real world" (Marton & Ramsden, 1988, p. 271) based on "regularities in the environment" (De Houwer et al., 2013, p. 633) processed through interaction with the environment through the senses (Lachman, 1997).

2.3.1 A COMMON LANGUAGE FOR KNOWLEDGE SHARING AND LEARNING

Talebizadeh et al. (2021) mention how knowledge sharing, through the exchange of knowledge experiences and ideas, results in learning. Therefore, any future mentioning of knowledge sharing can therefore be directly linked to (a potential for) learning.

Alavi & Leidner (2001) state that a shared knowledge space created by a common or shared language is needed to enable the communication of, specifically, tacit knowledge. "Tacit knowledge can be thought of as the know-how that is acquired through personal experience (…), is (…) not easily codifiable and cannot be communicated or used without the individual who is the knower. (…) Explicit knowledge, on the other hand, can be easily codified, stored at a single location, and transferred across time and space independent of individuals" (Ipe, 2003, p. 344). The requirement of a common language for tacit knowledge exchange is underscored by Alavi & Leidner (2001) by noting that knowledge is personalized, meaning that the same knowledge is processed differently per individual as they make it their own due to differences in past experiences and opinion, which necessitates a shared group language to enable communication of knowledge.

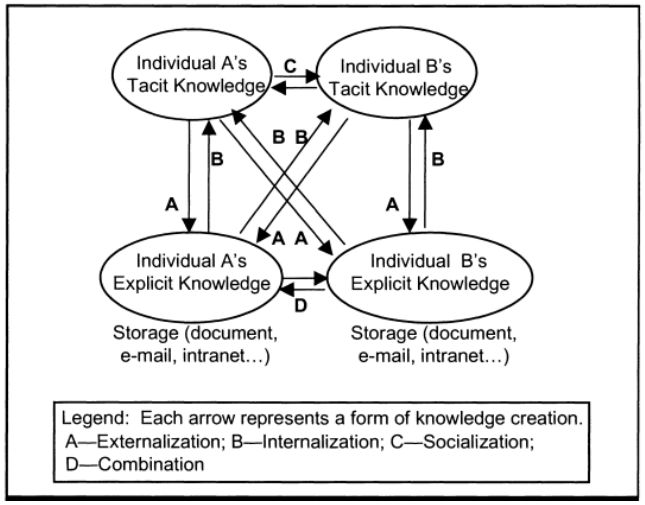


Figure 2.5: Knowledge creation modes as proposed by Alavi & Leidner (2001, p. 117). Externalization (tacit to explicit): articulation of best practices or lessons learned; Internalization (explicit to tacit): through reading and understanding; Socialization (tacit to tacit): through social interactions and shared experience among organizational members; Combination (explicit to explicit): through merging, categorizing, classifying, and synthesizing existing explicit knowledge.

A similar insight was reported by Beers et al. (2006), who stated that "different workers would first negotiate some common ground (i.e., a common frame of reference) to bridge the differences in perspective and be able to share knowledge from their different viewpoints" (p. 530). Additionally, Alavi & Leidner (2001) mention it can be the case that tacit knowledge is needed to understand explicit knowledge. This is not necessarily a problem in teams that have been collaborating for an extended period and have already established a common understanding of things as well as social relationships to enable tacit knowledge exchange, see Figure 2.5. However, in the case of the often newly created transdisciplinary teams

of the Convergence Agenda of the EMC, EUR, and TUD, a shared language does not yet exist.

2.3.2 TRIPLE-LOOP LEARNING TO ACCOMMODATE ATTITUDE CHANGE

Single-, double-, and triple-loop learning are well known learning models that each provide a deeper layer to learning processes. Triple-loop learning is a process that accommodates changing perceptions and attitudes (Salakas, 2017). To understand it fully, however, single- and double-loop learning will be briefly touched upon as well.

Pennington (2008) proposes that single-loop learning provides incremental modifications to the currently employed strategy, see Figure 2.6. She poses that double-loop learning introduces a re-evaluation of the governing variables or assumptions that in turn lead to a new strategy.

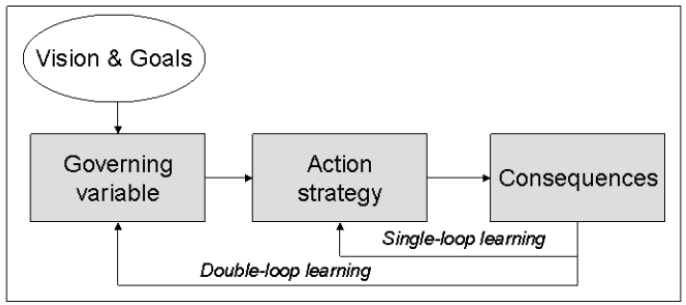


Figure 2.6: Organizational learning processes of single- and double-loop learning through the lens of action research as proposed by Pennington (2008, p. 8)

Flood & Romm (1996) propose that single-, double-, and triple-loop learning all ask the questions 'Are we doing things right?', 'Are we doing the right things?', and 'Is rightness buttressed by mightiness and/or mightiness buttressed by rightness?'. The latter question can also be regarded as 'How do we decide what is right?' (Versluis, 2020). Flood & Romm (1996) pose that single-loop learning regards these questions separately with no reflexivity or regard of the other questions and could even be described as being constituted of obsessive means-end thinking. Double-loop learning introduces some form of reflexivity by regarding both the first and second question. By doing so, double-loop learning weakens means-end thinking (Flood & Romm, 1996). Triple-loop learning goes one step further by "bringing together the three questions from the three loops into one overall awareness" (Flood & Romm, 1996, p. 162) that combines into something more than the sum of its parts and makes the learners more knowledgeable and act more responsibly. Based on what has just been stated, triple-loop learning can be described as holistic. A struggle in both double- and triple-loop learning is to keep iterating and looping through the questions. If this does not happen, a learner can get stuck in the middle and loses their reflexiveness. I.e., double- and especially triple-loop learning are active processes that need continuous looping, reflexivity, and diversity to reap the synergetic fruits. Figure 2.7 shows a visual representation of triple loop learning.

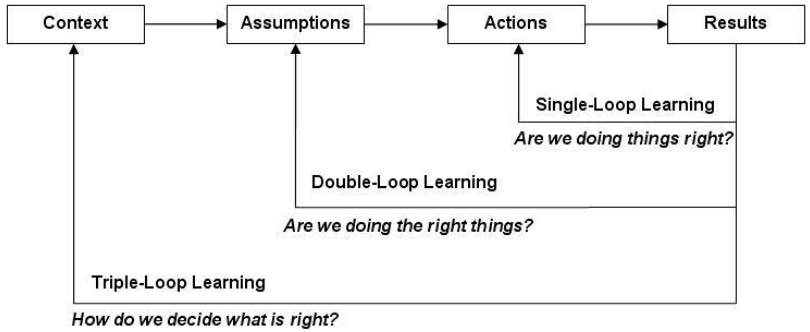


Figure 2.7: Single-, double-, and triple-loop learning based on Argyris' work. Retrieved from http://confocal-manawatu.pbworks.com/w/page/105485889/Triple%20Loop%20Learning

Single-, double-, and triple-loop learning can be linked to the What, How, and Why questions of the Golden Circle introduced by Sinek respectively (Versluis, 2020). The Why question, and thus triple-loop learning, introduces an existential component that reflects on why we hold certain beliefs or assumptions (Peschl, 2007). It therefore holds the potential for behavioral change (Salakas, 2017).

2.3.3 DIVERGENT THINKING AND CONVERGENT THINKING MODES

Ahern et al. (2015) propose that knowledge formation consists of a process of order-chaos-order, marked by a starting point (order), a diverging phase (resulting in disorder), and convergence to an end-state (order) (see Figure 2.8). The authors state that, to get to a higher understanding of things, one must first accept the uncertainty and risk that comes with the exploration and experimentation of the diverging or chaotic phase. Trust influences the ability to accept this uncertainty and risk. The chaotic phase, marked by an increase in entropy, emerges due to differentiation where new information is sought to understand the current situation and actual problem. The converging phase in Figure 2.8 marks a period of order and decreased entropy, where the obtained information is integrated to form a better and fuller understanding of the situation when compared to the start.

Converging and diverging phases can also be seen in the processes portrayed in the double-diamond process of Design Thinking (see Figure 2.9), where a diverging phase of gathering information and exploring the numerous factors that might influence the initial problem statement, is followed by a converging phase in which the essence of the problem (which is often different from the initial problem) is formulated. A similar process of diverging and converging follows wherein the solution space is explored. Leifer & Steinert (2011) propose a comparable model where divergent and convergent thinking are applied iteratively throughout the whole design process to “accelerate learning and to open up the solution space” (p. 171). Divergent and convergent thinking is also mentioned by Pennington (2008) to be a part of each iteration in both single- and double-loop learning, where divergent thinking is used to generate ideas and convergent thinking combines those ideas into a pragmatic format.

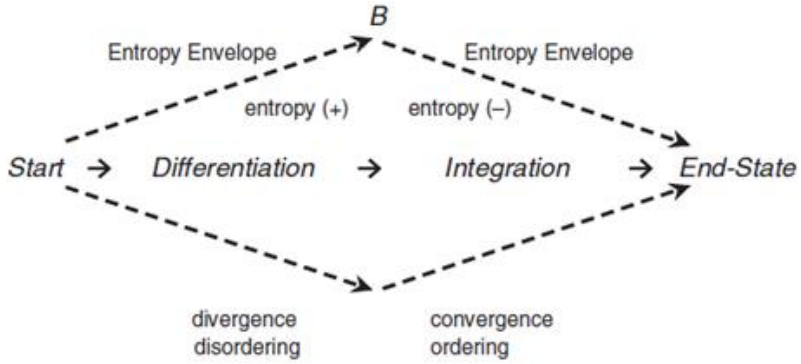


Figure 2.8: The Entropy Envelope: the logical structure of knowledge formation (Ahern et al., 2015, p. 741).

It is important to note that exploration and experimentation as a part of divergent thinking – as portrayed in the Entropy Envelope of Ahern et al. (2015) in Figure 2.8 and the diamond of Design Thinking in Figure 2.9 – are not the only source for knowledge acquisition. Ahern et al. (2015) mention a body of literature that reports a duality of project-led exploration and business-led exploitation to be effective means for knowledge acquisition. Therefore, besides setting out on explorative endeavors, organizations should also exploit existing resources and processes (Lee et al., 2012). I.e., there should be a balance between uncertain expeditions and certain endeavors. In any case, learning in and from projects should not just encompass the factual knowledge or experiences (the what), but also the activities or actions (the how) that facilitated them, so that these activities and actions can be duplicated in future projects (Ahern et al., 2014; Ahern et al., 2015).

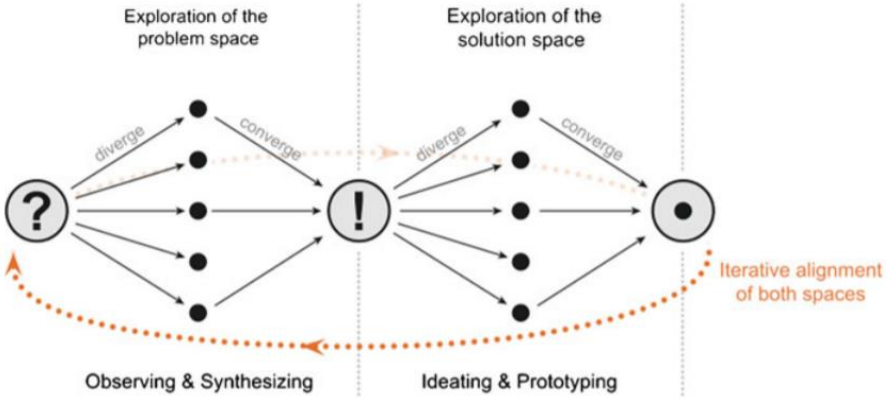


Figure 2.9: A double-diamond iterative alignment process representing the problem and solution space in design thinking (Plattner et al., 2009, p. 5).

Csermely (2017) describes divergent thinking as holistic and flexible. The author describes how divergent thinking and convergent thinking, the latter being systematic and focused thinking, are combined in deep thinking (Csermely, 2017). Deep thinking starts with questioning the initial idea or problem statement, followed by the introduction of (emergent) ambiguities that weaken the initial starting point. This uncertain and ambiguous state can, according to Csermely (2017), be overcome through true deep thinking, combining divergent and convergent thinking modes, so that the initial idea can be reframed into a "new conceptual consensus at a higher level" (Csermely, 2017, p. 1). During this process, social networks can play a crucial role: they can introduce more diverse and novel information, leading to both more ambiguity as well as more originality in the final rephrasing (Csermely, 2017). More ambiguity might intuitively feel as something undesirable, but in the process of learning it is actually an asset. Ambiguity should be seen as a tool, not a burden or obstacle (Sanders & Stappers, 2012). Incompleteness is a form of ambiguity and compels people to fill in the gaps (Sanders & Stappers, 2012). However, this obstructs the fact that ambiguous things, such as ideas, can hold multiple meanings. Thus, not allowing for ambiguity means not allowing for different interpretations and creative thinking of which the latter will later be explained to contribute to learning.

2.3.4 INFORMAL AND INCIDENTAL LEARNING, TRUST, AND (SELF)CARE

Watkins & Marsick (2021) name informal and incidental learning as the way to break through disruption (of routines), uncertainty, and unpredictability. Informal learning concerns learning that happens 'in the moment' and outside of scheduled learning situations, or, in other words, in informal situations. With informal learning, there is still an awareness that learning is taking place, whereas incidental learning is learning that takes place whilst doing an activity where learning was not the primary objective (Watkins & Marsick, 2021). Araujo (1998) mentions informal relationships to contribute to learning as well by providing "opportunities for exchange of ideas, information, favours, etc., (…) and search opportunities for new knowledge" (p. 331). The author also states that informal relationships help pinpoint shared problems and create consensus on the space in which to explore solutions to those problems. According to Watkins & Marsick (2021), conditions for dealing with unpredictability, uncertainty, and disruption of routines and increasing the outcomes of incidental and informal learning are, amongst others, experimentation, critical reflectivity, openness (to new ideas), self-awareness, and creativity.

The uncertainty and risk that have previously been explained to contribute to a higher understanding of a situation or problem statement, introduce the need for trust to be a part of the learning system as well, since trust and risk, and thus uncertainty and ambiguity, are related: a person who puts their trust into someone or something is demonstrating a willingness to be vulnerable and thus also a willingness to be at risk (Chen & Wang, 2008; Mayer, 1995). The possibility namely exists that, if you put yourself in a vulnerable position by for example opening up, you are not met with good intentions or are disappointed with the outcome of the process. Therefore,

trusting is risky business, especially when you do not know the person/process or their/its track record. The necessity of introducing trust into the learning system is also explicitly mentioned by Talebizadeh et al. (2021), who state that a culture of trust, risk-taking, and support leads to "effective professional learning" (p. 4). The authors explain how trust leads to the development of collegial relationships in which colleagues happily work together. These relationships enable knowledge sharing, which in turn leads to the exchange of experiences and, with that, to learning. Building onto that, Ipe (2003) reports a study in which it was found that "in the absence of trust, formal knowledge-sharing practices were insufficient to encourage individuals to share knowledge with others within the same work environment" (p. 347). Talebizadeh et al. (2021) additionally state that the trusting person needs to be confident that the trustee will be respectful, honest, reliable, and benevolent. To increase this confidence in others' intentions and make sure people trust without fear and with a sense of (psychological) safety, a supportive environment is needed (Talebizadeh et al., 2021).

Trust should not only be concerned in relation to others or processes: trust in oneself is also of great importance. "Our limbic brains are smart and often know the right thing to do. It is our inability to verbalize the reasons that may cause us to doubt ourselves or trust the empirical evidence when our gut tells us not to" (Sinek, 2009, p. 5). In today's society, especially in higher education and research, people are trained to mainly if not only trust scientific facts and to be able to debate their every decision. However, people's lives are dictated by much more than just hard facts, especially when it concerns social interactions where past experiences, emotions, and behaviors come into play. Therefore, trusting in oneself is a crucial part in feeling confident and thus sharing one's mind and experiences, which in turn has a positive effect on learning through knowledge sharing.

Eradicating, whether it concerns trusting someone or a process, or facing novel situations where one might fear feeling or looking incompetent, can be done through humility, calmness, and acceptance (Watkins & Marsick, 2021). We need to be humble when learning to fully appreciate the novelties we are presented with; we need to stay calm when the inevitable pitfall appears; and we need to accept our limitations and see the moments of uncertainty or 'incompetence' for what they are, namely opportunities for us to learn (Watkins & Marsick, 2021). Self-awareness, self-reflection, and proper self-care pave the road towards humility, calmness, and acceptance. Meditation is a well-known tool to ease one's mind and body. Another powerful tool is systemic work, which employs a phenomenological perspective. This means that systemic work takes the whole instead of just the parts into account and lets situations, things, or people speak for themselves without wanting to add to or change anything about them (Bakker & Steeghs, 2015). It accepts things as they are. Inclusion is one of the three pillars of systemic work (Bakker & Steeghs, 2015) and revolves around acknowledgment and acceptance. You do not necessarily have to agree with something (whether it is a person, situation, opinion, or feeling), but you can recognize that it is there and part of the system, thereby making it easier to listen to others and value their contribution. Inclusion means showing respect for everyone and everything in the system, it inspires an open-mindset as everything is allowed to just be, it helps people accept that things present themselves as they are, and allows people to calmly assess a situation and their role therein. Inclusion includes humility since no one is seen as more or less important than someone else. "You enclose with your heart, not with your head" (Bakker & Steeghs, 2015, p. 52). Inclusion is explicitly mentioned by the National Research Council (2014) to be necessary to "build a sustainable convergence ecosystem" (p. 8). Furthermore, inclusion has a positive effect on psychological safety (Cooke & Hilton, 2015) and increases feelings of trust. One puts one's trust in the system and trusts that what is necessary will come to light. The team members are truly heard and included in decision-making which increases their trust in the course of action that is eventually chosen. In line with inclusion, silence allows for a calm assessment of new information without jumping to conclusions and immediately sharing these conclusions as well. Silence helps show respect and provides room for those who would

normally not be heard or are afraid to speak up, to share their ideas. Consequently, silence contributes to diversity of input and creativity and thus learning (Verouden, 2018). Introducing silence makes people truly listen to each other and puts team members at ease because they know they will be listened to and will be provided the opportunity to speak their mind calmly without anyone interrupting them. However, introducing too much silence, for example to spare others' feelings or protect reputations, can be detrimental to knowledge sharing and to learning as it leads to a lack of feedback and questioning (Verouden, 2018). Therefore, silence in that regard may be more related to inclusion and respect than actual silence in itself. Still, silence can be a useful tool to train a team to openly and attentively listen to each other. Figure 2.10 shows what inclusion entails based on the insights mentioned previously.

Figure 2.10: What constitutes inclusion based on theory

"Fears, anxieties, and doubts are very common emotional experiences in processes of learning" (Vince, 1998, p. 310). Accepting and acknowledging and thus including, for example, feelings of frustration or anxiety when faced with uncertainty, allow you to stay calm and look at the situation without being overwhelmed. This allows you to steer clear of judgement, keep an open mind, and let your creativity flow. Since creativity has previously been mentioned as a tool to deal with the uncertainty and ambiguity that the learning process brings with it, inclusion can be said to strengthen the learning process from within yourself. Furthermore, inclusion also enables others to be and think more freely and without fear, since they and their thoughts are being acknowledged and accepted without judgement. Therefore, inclusion contributes to a safe environment and thus creates more opportunities for knowledge sharing and, with that, learning.

In line with the systemic ideology, Mea & Sims (2019) state that creativity flourishes when human dignity, consisting of, amongst others, respect, care, and benevolence, has become part of an organization's culture. These traits do not just concern one's behavior towards others, but, maybe even more importantly so, towards oneself.

2.3.5 SOCIAL LEARNING, COMMUNITIES OF PRACTICE, AND LEARNING COMMUNITIES

It has previously been mentioned that social networks can contribute to a learning process by introducing novel information, thereby increasing diversity. Therefore, learning, or at least an important part of it, is a social endeavor. This is emphasized by Araujo (1998), who states that relationships with third parties as well as a variation of physical settings result in new and unexpected links and associations between practices, thus providing opportunities for learning.

Learning in a social context can be referred to as social learning. Wenger (2000) describes how social learning is "an interplay between social competence and personal experience" (p. 227). Verouden (2018) states that "The essence of social learning is that diverse actors interactively work towards acceptable solutions for complex social issues or problems" (p. 104). Furthermore, social learning is said by Bos et al. (2013) to be "nurtured through the process of experimentation" as well as being considered "very important in overcoming stable and difficult-to-change socio-technical systems" (p.398). Since universities can be argued to be socio-technical systems of which the change potential is not very big and the Convergence Agenda focuses on finding solutions to complex societal issues, it can be said that universities may benefit from experimentation and social learning in helping the new form of collaboration of the Convergence Agenda to succeed.

Watkins & Marsick (2021) also underscore the notion that more effective learning efforts result from social interaction. They base this on the non-linearity of learning which calls for iterative assessment cycles to refine an initial problem statement, as was portrayed in the double-diamond of Design Thinking as well as the Entropy envelope proposed by Ahern et al. (2015). In Watkins & Marsick's (2021) opinion, these assessments are performed better if information and viewpoints from multiple stakeholders are gathered, again insinuating that effective learning is a social endeavor. However, the fruitfulness of such interactions also depends on actor involvement (Bos et al., 2013).

Social learning is mentioned by Wenger (2000) to be a byproduct of communities of practice. A community of practice is a group that forms naturally and consists of people that share a common practice, interest, or concern, and learn from and with each other through regular social interaction and reflection so as to improve their practice (Wenger, 2000). In line with that, reciprocity is mentioned by Ipe (2003) to be "a motivator of knowledge sharing in communities of practice" (p. 346). Talebizadeh et al. (2021) also state that "the utilization of communities of practice facilitates (…) knowledge sharing by creating opportunities for members to interact and exchange best practices" (p. 3).

Dohaney et al. (2020) mention communities of practice to be beneficial to learning and provide support to learners which is especially important during a crisis. The authors also state that a community feel, for example stimulated by shared activities, helps people feel normal again after a crisis or disruption. Since the Convergence Agenda strives for a type of collaboration that is new to the three institutes EMC, EUR, and TUD, it can be seen as disruptive. Therefore, creating strong communities (of practice) is beneficial for learning and the success of the Convergence Agenda.

In their article, Talebizadeh et al. (2021) describe how professional learning, which concerns practitioners expanding and deepening their knowledge and ensuring their practice is up-to-date, "is increasingly conceptualized as a dynamic, ongoing, interactive, developmental process, rather than as a series of isolated activities" (p. 3). This means the institution itself is becoming, or needs to become, a learning community (Talebizadeh et al., 2021). Ayas & Zeniuk (2001) emphasize the necessity of a learning community by stating that projects do not automatically result in learning. Making learning an integral part of projects by adopting a learning mindset is a way to ensure that learning takes place (more explicitly) within every project. This could also be formulated as implementing a learning agenda besides a research agenda for research teams. An initial focus on learning was even found by Talebizadeh et al. (2021) to have a positive effect on trust and knowledge sharing, which in turn led to better engagement in professional learning activities and thus increased learning. See Figure 2.11 for a visual of this relationship. Additionally, Wenger (2000) states that "Communities of practice deepen their mutual commitment when they take responsibility for a learning agenda, which pushes their practice further" (p. 232). Examples of activities that can increase the learning mindset is "exploring the knowledge domain, finding gaps in the community practice, and defining projects to close these gaps" (Wenger, 2000, p. 232).

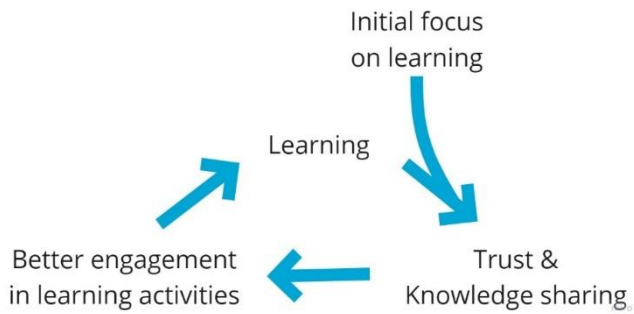


Figure 2.11: The enforcing learning loop that can be initiated through an initial focus on learning (Talebizadeh et al., 2021).

That a learning community contributes to learning is clear, but the question of how to build such a community remains. Ayas & Zeniuk (2001) state that "Culture awareness increases the likelihood of learning becoming a natural process in the organization" (p. 62). This awareness consists of individuals being able to reflect on their own perceptions, biases, assumptions, and contributions to problems, so that an overall "commitment to truth and inquiry" (p. 62) can be built. Examples of reflective exercises are story-telling, dialogue, the ladder of inference, left-hand column, and system archetypes.

Building the capability to learn and reflect takes time and practice, and can be stimulated through what Ayas & Zeniuk (2001) term "insider/outsider collaboration" (p. 74), which brings in new information and a broader perspective to situations. This type of collaboration concerns spanning boundaries between research groups internally as well as externally (Wenger, 2000). According to Wenger (2000), to be able to learn at boundaries, the following four conditions must be met: (1) something of interest to interact about, (2) open engagement constituting both differences and common ground, (3) a willingness to interact without judgement and with objectivity, and (4) a shared language or other way to translate between repertoires so that actual interaction can take place. Boundaries are a primary source of progress as it provides novelties and diversities in presented knowledge (Wenger, 2000). However, if two communities are too diverse, no common ground or interests can be found which impedes knowledge sharing and thus has a negative effect on learning opportunities (Cooke & Hilton, 2015). Therefore, a balance between bridging (where different, but not too different, communities are linked providing new sources of information) and bonding (where there are high levels of similarity, trust, and frequency of interaction thereby enabling social learning) needs to be established. This relates to the previously mentioned insight that both experimentation and exploitation are needed to safely explore learning opportunities. Additionally, Cooke & Hilton (2015) state that the "boundaries of science teams and larger groups are often permeable, reflecting changes in the project goals and needs over time" (p. 35). For this reason, reflexivity is once again important to be aware of the changing boundaries of a team as well as where those boundaries are at a given point in time. This awareness and the knowledge of where the boundaries are makes looking for learning opportunities at boundaries more efficient and fruitful.

2.3.6 HOW COMPLEXITY INFLUENCES LEARNING

Based on Watkins & Marsick's (2021) logic, the Convergence Agenda of the EMC, EUR, and TUD can be placed in the complicated and complex quadrants of the Cynefin framework designed by Snowden & Boone (2007). Furthermore, transdisciplinary collaboration, which is the type of collaboration sought after in the Convergence Agenda, has previously been mentioned to be necessary to find solutions to complex societal problems. To deal with complicatedness and complexity, Snowden & Boone (2007) propose critical reflection, interaction, diversity, and experimentation. In line with that, Watkins & Marsick (2021) state that "Learning within complexity calls for experimentation, taking calculated risks, and flexible, frequent adaptation based on sensing and responding to the environment" (p. 2). Ahern et al. (2015) argue that single- and double-loop learning are not enough to accommodate complex problem solving learning. Instead, the authors propose what they term "open-loop discovery learning with a problem space that is unstructured and non-linear" (p. 740). Additionally, Swanson et al. (2010) state that "principles of omnivory (the use of multiple approaches) and redundancy are important under conditions of complexity and deep uncertainty" (p. 934). In the authors' description, variation in essence means deploying several experiments parallel to each other that are all working towards the same end goal but use different approaches (Swanson et al., 2010).

Ahern et al. (2014, 2015) state that for complex problems, only the end-state can be known in advance and no individual is able to grasp the totality of the

complexity from the start. To be able to deal with complex projects successfully, knowledge needs to be continuously generated over the life cycle of a project (Ahern et al., 2014, 2015). What this implies is that, for dealing with complexity, the end goal needs to be kept in mind as the project members adapt a mindset of continuous learning with regards to the project and the project members. To accommodate this process, the project team needs to become a "community of learners" (p. 1424), of which the learners learn about the project as they engage in it. This community of learners is not so different from a community of practice as introduced by Wenger (2000), where social learning is an integral part of belonging to the community and improving it. When combining both types of communities, it could be said that the practitioners should view themselves as learners as well as practitioners, to accommodate a mindset of continuous learning for themselves and their practice. In that sense, introducing a separate learning project within each project itself (Ahern et al., 2014) seems a good start to develop a mindset of continuous learning, as was stated before.

2.3.7 CONCLUSIONS

Based on the findings from sub-sections 2.3.1-2.3.6, research sub-questions 2a, 2b, and thus research question 2, can be answered. Recall research question 2 with subparts 2a and 2b:

2. What elements are crucial for learning in a transdisciplinary collaboration context?
    a. How does learning relate to the core elements of transdisciplinary collaboration?
    b. What core elements of learning in a transdisciplinary collaboration context can be extracted from this?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 2A

Everything that has previously been described concerning learning can now be more concisely linked to the core elements of transdisciplinary collaboration as described before. These core elements are: *complexity, holism, ambiguity, multitude of communities, common language, trust,* and *attitude change*. How learning relates to those elements and the essential elements that can be taken from those relations are presented in Table 2.2.

Table 2.2: How learning relates to the core elements of transdisciplinary collaboration and the resulting essential elements for learning in a transdisciplinary context

Trans-disciplinarity elements	Relation to learning	Essential elements of learning in transdisciplinary context
Complexity	Dealing with complexity necessitates reflection, interaction, diversity, and experimentation. Furthermore, one needs to be able to adapt to the changing boundaries, conditions, and environment of the problem, which can only be done well by being reflexive to increase awareness. Additionally, taking calculated risks by carrying out several experiments helps deal with complexity.	• Reflexivity • Interaction • Diversity • Multiple experiments
Holism	Inclusion introduces a holistic point of view. Furthermore, triple-loop learning was also linked to holism and is stimulated by	• Inclusion • Reflexivity • Iteration • Diversity

	reflexivity, iteration, and diversity. Divergent thinking is another process that helps to adopt a broader perspective and is improved through diversity and social networks and thus social interaction. Additionally, experimentation is mentioned as an inherent part of divergent thinking. It must be noted, however, that to come to a higher understanding of things one must implement convergent thinking as well, which translates to exploitation. Divergent thinking and experimentation include uncertainty and taking risks, which necessitates a solid basis of trust.	• Social interaction • Experimentation & exploitation • Trust
Ambiguity	Divergent thinking is mentioned as a way to deal with ambiguity and is improved by diversity and social networks and thus social interaction. Additionally, experimentation is mentioned as an inherent part of divergent thinking. It must be noted, however, that to come to a higher understanding of things one must implement convergent thinking as well, which translates to exploitation. Divergent thinking and experimentation include uncertainty and taking risks, which necessitates a solid basis of trust. Trust was also mentioned by itself to be necessary to face ambiguity. Furthermore, ambiguity and inclusion were mentioned to increase creativity, which in turn helps deal with ambiguity. Additionally, informal and incidental learning were named as ways to deal with ambiguity. For these types of learning to be as fruitful as possible, experimentation, critical reflectivity, openness, self-awareness, and creativity are needed. Critical reflectivity translates to reflexivity which in turn enables (self-)awareness.	• Diversity • Social interaction • Experimentation & exploitation • Trust • Inclusion • Creativity • Reflexivity • Openness
Multitude of communities	A multitude of communities introduce multiple social networks which increases diversity. The highest potential for diversity can be found at and beyond the borders of a community. To know where these boundaries are, reflexivity is needed. Social learning is a byproduct of communities of practice and can be	• Diversity • Reflexivity • Experimentation & exploitation • Social interaction • Trust

	nurtured through experimentation. However, here it must also be noted that experimentation needs to be coupled with exploitation. Communities are also characterized by regular social interaction, regular reflection, and high levels of trust. Building a learning community with a learning mindset was mentioned specifically as a useful way to support learning as well as the development of trust.	
Common language	To enable the formation of a common language and keep it updated, respect and open communication are necessary. Open communication in this context consists of continued social interaction and a continued iteration of assumptions, of which the latter can be translated to reflexivity (due to the link with double-loop learning) and iteration.	• Reflexivity • Iteration • Continued social interaction • Respect
Trust	Humility, calmness, and acceptance, or in other words inclusion, helps build trust. Furthermore, an initial focus on learning, and thus a learning mindset, has been mentioned to have a positive effect on trust. Additionally, a supportive environment helps reduce fear and build trust.	• Inclusion • Learning mindset • Supportive environment
Attitude change	Triple-loop learning is a process that is known to be useful for changing attitudes and is stimulated by reflexivity, iteration, and diversity.	• Reflexivity • Iteration • Diversity

ANSWER TO RESEARCH SUB-QUESTION 2B

From Table 2.2 it can be concluded that the core elements of learning in relation to a transdisciplinary collaboration context are: *reflexivity, (informal) social interaction, diversity, experimentation (multiple at a time) and exploitation, inclusion, trust, creativity, learning mindset,* and *a supportive environment.* Note that *openness* and *respect* are mentioned in Table 2.2 but are not in the just mentioned summation of core elements of learning. The reason for this is that *openness* and *respect* are subparts of *inclusion*, as can be seen in Figure 2.10.

ANSWER TO RESEARCH QUESTION 2

Based on the answers to research sub-questions 2a and 2b, it can be concluded that the core elements of learning in relation to a transdisciplinary collaboration context are: *reflexivity, (informal) social interaction, diversity, experimentation (multiple at a time) and exploitation, inclusion, trust, creativity, learning mindset,* and *a supportive environment*.

2.3.8 VISUALIZATION OF LEARNING IN A TRANSDISCIPLINARY COLLABORATION CONTEXT BASED ON THEORY

Figures 2.12 and 2.13 combined encompass all the core elements of learning in a transdisciplinary collaboration context mentioned previously. Figure 2.12 shows a conceptual visualization of the learning community that would

be beneficial in and for transdisciplinary collaboration. This learning community is situated in a learning field, which encompasses all the potential opportunities for learning to take place, including inside the learning community itself. The learning community is characterized by a learning mindset, a supportive environment, high levels of trust, and inclusion. It implements a combination of exploitation and experimentation where the latter introduces more risk than the first. Multiple experiments are deployed at once to increase the learning opportunities as well as the chances of success. These experiments do not steer away from the community too much so as to not increase the risk too much and make people feel too uncomfortable. Diversity and social interactions are part of the internal workings of the learning community, but they are also enhanced through interaction with communities outside of their own community. For these reasons, social interaction and diversity are placed both inside and outside of the learning community. Creativity is enhanced through inclusion and diversity, the latter of which results in creativity being placed both inside and outside of the learning community as well.

Only one of the core elements of learning in relation to transdisciplinarity remains to be discussed: reflexivity. Due to the complex context in which transdisciplinary collaboration takes place, new insights will come to light along the way that change the goals of the project, the community, and its boundaries. Reflexivity plays a special role in this process. Figure 2.13 shows how reflexivity is needed to ensure that the actual learning community and the perceived learning community are one and the same. This means that the boundaries of the community are clear and true, which is needed to increase learning opportunities since these are most plentiful at and beyond the boundaries of a community. Knowing where the boundaries of a community are enables more effective deployment of both exploitation and experimentation efforts. For if the boundaries are not known, what would be perceived to be experimentation could very well be exploitation, thereby decreasing the learning opportunities. Therefore, reflexivity is constantly needed to get the most (out of) learning opportunities.

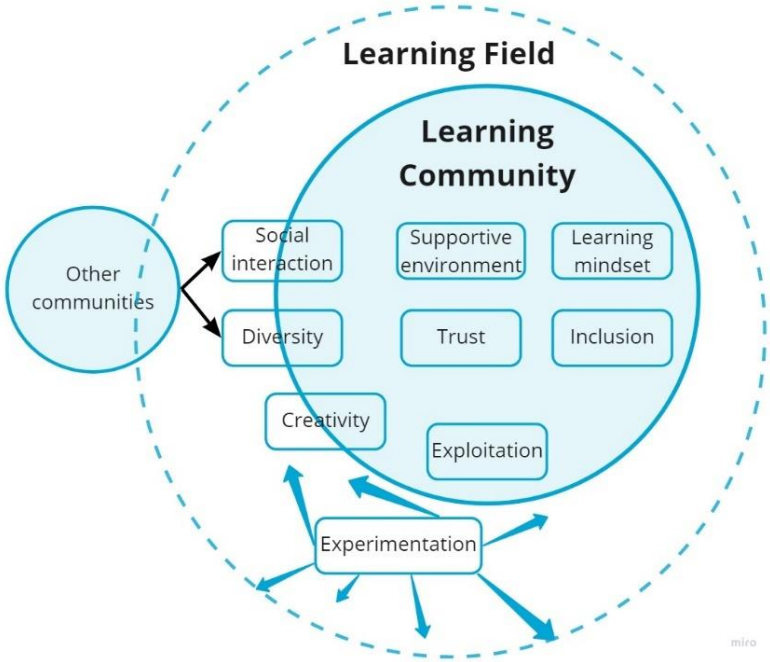


Figure 2.12: A simplified visualization of the core elements of learning in the context of transdisciplinary collaboration based on theory, where the potential for learning is highest in the Learning Field and the border of the Learning Community

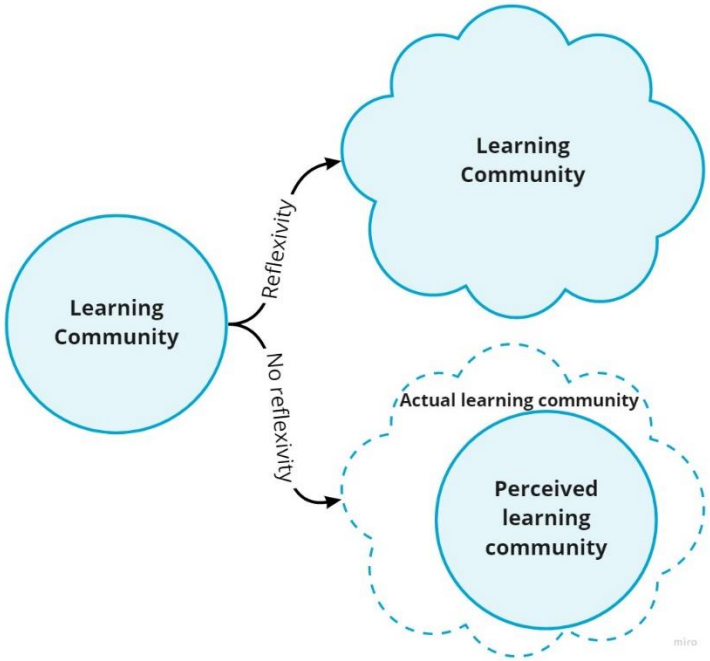


Figure 2.13: A simplified visualization of how reflexivity is needed to enhance the learning opportunities by making the boundaries of the community clear and updated

2.3.9 CRITICAL REFLECTION OF THE CORE ELEMENTS OF LEARNING IN RELATION TO TRANSDISCIPLINARITY

It is important to note that learning is extremely contextual and what is and is not effective differs per person. For example, in the same type of situation conflict could be detrimental for learning for group A while providing many learning opportunities for group B. This difference can come from varieties in past experiences, moods, character, and so on. Therefore, there is never one correct way to learn something and there is never one perfect environment for learning. However, the elements mentioned in sub-section 2.3.7 have been found to have a positive effect on learning and can therefore be said to increase the chances of learning taking place. Still, some of these elements need some more nuance, as will be provided next.

Diversity has been said to increase opportunities for learning. However, too much diversity may result in increased tensions among team members (Cooke & Hilton, 2015) and have detrimental effects on "developing goal interdependence and a sense of trust" (National Research Council, 2014, p. 48). Furthermore, there are different types of diversity that can each influence collaboration differently. For example, identity diversity can be detrimental for collaboration, where functional diversity can contribute to creativity (National Research Council, 2014). Additionally, diversity does not automatically result in better performance. If it is supported by an environment in which diversity is valued and people can openly express their opinion, then diversity increases creativity and team performance. If not, increased diversity can lead to troubles concerning communication and collaboration (National Research Council, 2014). Increasing diversity also often means either creating larger teams, communicating with a larger number of different stakeholders, or collaborating with several teams. All three of these options takes up time and effort to coordinate them effectively. Additionally, the larger the group the more difficult it is to build familiarity and trust (Cooke & Hilton, 2015). Even though larger teams also allow for the distribution of tasks to divide the workload thereby increasing productivity, this again necessitates more communication and coordination (Cooke & Hilton, 2015). Increasing diversity can also lead to more potential for conflict. So, balance must be found in including diversity, but where this balance is perfect or still beneficial is unclear and can only be truly found out by experimenting which takes time and effort.

Experimentation is often said to be beneficial for learning. However, no clear guidelines concerning the direction or scope of experimentation are given. It is unclear how one can ensure that experimental endeavors do not stray away from the learning field and stay beneficial. Additionally, making people more comfortable with experimentation needs time and successes to prove it is a viable way of working. If these successes do not exist, are not

expressed, or cannot be shown on the short-term, commitment to experimentation will most likely fade.

Developing a learning mindset takes time and effort. It will also necessitate consistent, regular, and explicit attention by leadership making it labor intensive. Since oftentimes leaders, or people in general, already have a busy schedule, committing to the process of developing a new mindset can be met with much adversity and resistance if not properly introduced. It could even mean that people need to be retrained. Additionally, incentives could change, meaning that things that would previously have been regarded as desirable may no longer be desirable. This in turn may deem much work that has been done as a waste of time and therefore poses a potential blow for morale if not handled properly.

Being not only reflective after the fact but building in reflexivity as a regular check-up will take up additional time that people might not be willing to 'sacrifice'. Building trust takes time as well and is often based on repeated interactions with the same people. However, it has also been said that the community changes over time, which may mean that the community members or connections change over time. This in turn may result in relationships that had just developed a basic level of trust to be separated, which will most likely have a negative effect of the willingness of people to invest in building relationships.

2.4 LEADERSHIP

In sub-section it 2.3.8 it was concluded that the core elements of learning in a transdisciplinary collaboration context are: *reflexivity, (informal) social interaction, diversity, experimentation (multiple at a time) and exploitation, inclusion, trust, creativity, learning mindset,* and *a supportive environment*. In this section, leadership will be discussed in relation to these core elements and the transdisciplinary collaboration context. Taking leadership into account can increase the chance of building in the conditions for a learning mindset to be adopted. This in turn enables continuous learning and increases the chances of transdisciplinary collaboration being implemented and leading to successful results. Leadership namely ensures the implementation of new ideas and is needed to provide support and guidance in continuing to develop and improve the new mindset.

First, what leadership should do in relation to the core elements of learning in a transdisciplinary collaboration context will be will be discussed. Second, the relation between leadership and the transdisciplinary context of complexity will be considered. Then, leadership structures or styles that do or do not fit with previously mentioned conditions and behaviors will be discussed, so that an assimilation of a fitting leadership style or structure for transdisciplinary collaboration stimulating learning can be found. However, it is first important to specify what is meant by the construct 'leadership'. Leadership is a process whereby one or more people influence one or more followers to achieve common objectives and bring about change for the organization, the common good, or the people involved (Sethuraman & Suresh, 2014; Summerfield, 2014; Winston & Patterson, 2006).

2.4.1 HOW LEADERSHIP RELATES TO THE CONTEXT OF LEARNING WITHIN TRANSDISCIPLINARY COLLABORATION

DIVERSITY

Diversity has previously been mentioned to contribute to learning by introducing new insights and information. Besides developing novel insights, the input from a diversity of actors is thought by Bos et al. (2013) to also develop relational capacity, meaning the trusting relationships that help people feel safe in working together, and in turn facilitate learning. To increase (the diversity of) input, an open governing style that stimulates actors in the social-technical system in question to "engage, interact, negotiate, and collaborate" (Bos et al., 2013, p. 400) can be adopted. An open network structure provides a lower threshold for individuals to join a

project or weigh in since it allows for their engagement at a later stage in the process and also not continuously (Bos et al., 2013). The diversity can be further increased by experimenting with "formal and informal interactions among core and non-core stakeholders at horizontal and vertical levels within, across and beyond organisations" (Bos et al., 2013, p. 409). Leaders should therefore steer towards openness and an open network structure., and facilitate a combination of formal and informal interactions with a diversity of people concerning organizational level, involvedness in the project, and level of expertise.

CREATIVITY

Plasticity, relatable to divergent thinking, brings creativity, a flat hierarchy, dynamic, and a greater repertoire of possible solutions or responses. Too much plasticity, however, results in an unreliable, inefficient, and inaccurate system. Therefore, plasticity needs to be balanced with rigidity, relatable to convergent thinking. I.e., to reach optimal outcomes of creativity, alternating between plastic and rigid mindsets is necessary (Csermeley, 2017). Rotating leadership was found to be beneficial for team creativity, which in essence relates to changing the leader mindset from plastic, to rigid, to a combination of both (Csermeley, 2017), since every person has a different personality and preferred way of working. So, changing leader positions every now and then is beneficial for team and network creativity. Additionally, individuality and autonomy are mentioned by the National Research Council (2014) to be essential for creativity. This implies that leaders should provide initial guidance or a clear vision (which will be discussed later) and then trust their team members to take it on themselves, thereby leaving room for some autonomy and individuality.

COMMUNITIES

Wenger (2000) states that "a community needs multiple forms of leadership: thought leaders, networkers, people who document the practice, pioneers, etc." (p.231). These forms of leadership can be performed by one individual or be spread among several individuals and will change over time (Wenger, 2000). Similarly, Javadi et al. (2018) say that the role of the leader of a community changes over time as the community changes over time. This is also supported by Snowden & Boone (2007), who state that "Effective leaders learn to shift their decision-making styles to match changing business environments" (p. 7). So, what kind of leadership is needed changes over time as the community or circumstances change, thereby changing the role of the leader and therefore possibly also who fulfill(s) the leadership role(s) at a given time.

It has just been explained that, ideally, the leadership role changes with the community. That may sometimes also mean that it is ideal if the person or people fulfilling the leadership role(s) change over time. However, the ability to take on leadership roles or feeling one could be fit to take on such a role is not necessarily present within every community member. Increasing this ability is therefore beneficial for the more natural and organic functioning of a community as well as for the ability to react to changing circumstances. Leader ability, or a perception thereof, is partly influenced by the current leaders or people highest up the hierarchy sharing their personal stories (Berman, 2015). That way, leaders become more human and personal and, consequently, less intimidating, making leadership seem less intimidating as well. Furthermore, as understanding of team members and the project as well as intimacy increase over time, team members will increasingly take on leader roles (Chen & Wang, 2008). Intimacy entails open communication about beliefs, feelings, and thoughts, and is "the willingness to pass on honest information" (Senge, 2014, p. 70). It encompasses a respectful and open way of communicating, and entails a true interest in the other and what they have to say, which reminds of inclusion. It does not, however, mean violating someone's privacy or pressuring someone to reveal secrets or deeply personal information. It merely enables people to get to the essence of an opinion or statement, so that people can truly understand each other (Senge, 2014), thus improving collaboration (Mea & Sims, 2019). A way of increasing intimacy is through what Senge (2014) calls shared vision

exercises: “when we deeply care about the realization of a common purpose, we recognize the need for each other’s contributions” (p. 71). Intimacy introduces vulnerability and therefore necessitates trust, which will be discussed later on.

Individuals are often a member of multiple communities (Cooke & Hilton, 2015; Javadi et al., 2018), meaning multiple communities and their different contexts can influence a person and their learning processes simultaneously. Learning and learning processes are influenced by their context, including history, culture, and involved individuals (Bos et al., 2013). Therefore, experimental endeavors initiated by leadership should focus not just on stakeholder interaction, but also respect the context (Bos et al., 2013). To be able to respect the contexts of multiple communities, leaders need to have short links between and close communications with these communities (Purcell, 2019). This is underscored by Mea & Sims (2019), who describe the necessity of solving problems at the lowest level possible, which means appealing to and respecting the specific knowledge, creativity, and autonomy of the individuals experiencing that problem, thus taking into account their context. Furthermore, moving between communities helps develop a culture of “healthy debate and healthy decision-making” (Purcell, 2019, p. 258), which is beneficial to learning.

Building a learning community was previously said to contribute to learning. This learning community needs to be built and stimulated by leadership through three actions: (1) moral support, (2) a common vision, and (3) the communication of that common vision so that every day activities can be performed with the vision in mind (Talebizadeh et al., 2021). The latter implies that leaders need to have a vision for the future but also make it concrete enough to allow for daily implementation. I.e., leaders should provide both a long-term vision and opportunities for short-term implementation.

DEALING WITH AMBIGUITY, UNCERTAINTY, AND RISK THROUGH RELATIONSHIP BUILDING AND REFLEXIVITY

Previously, risk, uncertainty, and ambiguity were mentioned as elements that provide learning opportunities. Risk-taking is mentioned by Berman (2015) to be a quality that benefits leaders and involves “trying new approaches (…), often challenging the status quo” (p. 298). Naturally, taking risks will involve facing challenges, which can be better tackled by inspiring solidarity and agreement (Berman, 2015). This solidarity and agreement can be reached through relationship-building (Berman, 2015) which in turn necessitate social- and interpersonal skills. These skills are mentioned by Blackwell et al. (2007) to be essential for a leader to possess. Relationship-building can be improved through empathy (Berman, 2015), which in turn enhances social relationships and thus increase solidarity. Solidarity can also be increased by ensuring the achievement and celebration of small wins and showing how these contribute to the overall (future) goal (Bos et al., 2013). These small wins also positively contribute to confidence and self-esteem, which make it easier to deal with the adversities of risk (Blackwell et al., 2007), as higher self-esteem and increased confidence diminish the chances of paralysis and enable people to continue working even if it seems to not be going well at that moment. What has previously been said implies that a leader should be able to not only communicate the future goal or vision (National Research Council, 2014), but also be able to generate and formulate small and concrete short-term goals. I.e., leaders should possess and be able to communicate both a long-term vision and short-term concrete goals.

Detrimental for relationship-building is for a leader to view people as “means to an end rather than ends in themselves” (Mea & Sims, 2019, p. 5). This means-ends thinking was previously mentioned to be related to single-loop learning. Therefore, encouraging double- and triple-loop learning through continuous looping and introducing reflexivity can help leaders to

connect to people in a more significant way. This will in turn help build the solidarity that is needed to deal with ambiguity, uncertainty, and risk.

Self-awareness and reflection are named by Berman (2015) as valuable and necessary qualities of leaders. For a leader to be as reflective as possible, they must be committed to finding the truth (Ayas & Zeniuk, 2001). This also includes making sure people around them tell them the truth, not only about the problems they are facing but also about the leader (Ayas & Zeniuk, 2001). For this to happen, trust is needed as a secure basis for communication.

TRUST AND FOLLOWERSHIP

Trust is best influenced by leaders (Talebizadeh et al., 2021). To build trust, interaction with the team and community members is important. However, it is more effective for leaders to target their efforts to developing and nurturing a supportive environment (Talebizadeh et al., 2021) that provides a practical and emotional safety net (Sinek, 2009). As Sinek (2009) said, "Earning the trust of an organization doesn't come from setting out to impress everyone, it comes from setting out to serve those who serve you" (p. 10), which underscores the necessity to focus on providing a comfortable environment or secure basis for the 'servers' to work in. This can be done through stimulating and facilitating open and honest dialogue, discussion, and engagement within and between communities (Purcell, 2019). The leader must therein provide a proper example and be the first to take part in such dialogue to set the right tone. For if the leader does not portray a certain behavior, then why should anyone else.

Trust provides the basis for confidence in leadership (Chen & Wang, 2008). Similarly, Nordbäck & Espinosa (2015) stated that "perceiving each other as an eligible source of leadership is vital for the influence attempt to be effective" (p. 409). Additionally, "Those who lead are able to do so because those who follow trust that the decisions made at the top have the best interest of the group at heart. In turn, those who trust work hard because they feel like they are working for something bigger than themselves" (Sinek, 2009, p. 8). All statements relate to the notion of followership, without which leadership does not exist. I.e., leadership is only possible if those being led have given their consent to be led (Fombrun, 2007). Inspiring people is a way to create willing followers instead of manipulating them into action. This inspiration comes from answering the Why of the Golden Circle (Sinek, 2009) and relates to triple-loop learning. Inspired people are deeply and personally motivated, and will go to greater lengths to attain the set goals. Therefore, having an inspiring leader will have a positive influence on learning and creating a learning mindset.

2.4.2 EFFECTIVE LEADERSHIP FOR COMPLEX CONTEXTS

Postposing decision-making until the situation is well understood is detrimental for progress, especially in the face of complexity and deep uncertainty, as is the case for the Convergence Agenda. In such circumstances, deploying "policy instruments that will be effective across a range of plausible futures, and can handle anticipated and unanticipated circumstances" (Swanson et al., 2010, p. 935) increases the willingness of individuals to commit to proposed policy adaptation, thereby freeing up the road to progress. Experimentation and employing multiple possible solutions or prototypes parallel to each other are useful ways to ensure effectivity across a range of plausible futures.

Effective leadership in a complex context is said by Snowden & Boone (2007) to consist of five actions:

1. Opening up the discussion to initiative "democratic, interactive, multidirectional" (p. 6) conversations.
2. Setting boundaries helps indicate the limits so that "the system can self-regulate within those boundaries" (p. 6).
3. Stimulating attractors, which are "phenomena that arise when small stimuli and probes (whether from leaders or others) resonate with people" (p. 6), to increase coherence, provide structure, and

gain momentum and support. Experimentation helps increase the chance of finding such attractors.

4. Encouraging dissent and diversity to "encourage the emergence of well-forged patterns and ideas" (p. 6).
5. Managing starting conditions and monitoring for emergence to create a supportive and creative environment to stimulate the emergence of (unexpected) ideas "rather than trying to bring about predetermined results and possibly missing opportunities that arise unexpectedly" (p. 6).

The fifth action is underscored by Ahern et al. (2015), who say that the nature of complex problems inhibits specifying them fully at the onset and therefore call for a discovery-driven approach that enables continuous learning over the entire duration of the project (Ahern et al., 2015). For leaders, this means they need to facilitate and mentor the project members to be a community of learners and can learn about the project along the way (Ahern et al., 2014; Ahern et al., 2015). Additionally, leaders must introduce a non-hierarchical structure in teams and increase commitment of the team members to the team for the long-term, not just the achievement of short-term tasks (Ahern et al., 2015). The necessity for a non-hierarchical structure to better deal with complexity relates to a concern Snowden & Boone (2007) expressed concerning leadership in a complex context. The authors say that their "primary concern is the temptation to fall back into traditional command-and-control management styles—to demand fail-safe business plans with defined outcomes" (p. 5), which goes directly against the experimental mentality that is beneficial for complex contexts. It is furthermore said that tolerating failure is an important skill for a leader to have in dealing with complexity, and leaders should set up experiments that are safe to fail (Snowden & Boone, 2007). "Leaders who try to impose order in a complex context will fail, but those who set the stage, step back a bit, allow patterns to emerge, and determine which ones are desirable will succeed" (Snowden & Boone, 2007, p. 5). Therefore, leaders must be patient, trust in their followers, employ a discovery-driven approach, experiment (safely), and steer towards a learning mindset.

2.4.3 FITTING LEADERSHIP BEHAVIORS, STYLES AND STRUCTURES FOR LEARNING AND TRANSDISCIPLINARY COLLABORATION

To make a good indication of what leadership styles and structures fit with the conditions of learning and transdisciplinary collaboration that have been mentioned previously, the necessary leadership behaviors that can be concluded from previous sub-sections will be assimilated. Based on that, leadership styles and structures with a lower and higher chance of success in the context of the Digital Twin project will be presented. It must be said that every leadership style has its use and being listed as having a lower or higher chance of success means it is (in)appropriate specifically for the behaviors that are mentioned below.

NECESSARY LEADERSHIP BEHAVIORS FOR LEARNING AND TRANSDISCIPLINARY COLLABORATION

Leaders need to employ an open governing style to increase diversity. This can be done through engagement, interaction, negotiation, and collaboration. Diversity can be further increased through experimentation, by facilitating a combination of formal and informal interactions with a diversity of people concerning organizational level, involvedness in the project, and level of expertise. Experimentation, together with deploying multiple possible solutions parallel to each other, is also an effective way for leaders to deal with complexity. Preferably, these experiments should be safe to fail. Therefore, tolerating failure is an important skill for a leader to have to deal with complexity, as well as being patient and trusting in their followers. It should be noted, however, that exploitation should be taking place next to experimentation to safely explore learning opportunities.

Rotating leadership increases creativity through switching between plastic & rigid, or divergent and convergent, mindsets. Furthermore, having multiple leaders and forms of leadership was said to be necessary in a community. Additionally, these forms of leadership were said to change over time as the community or circumstances change over time, thereby changing who fulfills the leadership role(s) and how. To accommodate the necessity of having multiple leaders in a community, increasing the ability to take on leadership roles is beneficial for the community. Increasing this ability can be done by current leaders or people highest up the hierarchy sharing their personal stories as well as developing intimacy within the community through shared vision exercises and repeated respectful and open conversation. Additionally, individuality and autonomy are essential for creativity. This implies that leaders should provide initial guidance or a clear vision (as will be explained later) and then trust their team members to take it on themselves, thereby leaving room for some autonomy and individuality.

To be able to best respect the contexts of the different communities the individuals are a part of, the leaders should preferably possess short links to these communities and thus be well- and closely connected. Furthermore, moving between communities helps develop a culture of healthy debate, which is beneficial for learning. Building a learning community can be stimulated by leadership by providing moral support, formulating a common vision, and communicating that vision in a way so that it can be implemented on a daily basis.

Inspiring solidarity and agreement helps leaders deal with risk, uncertainty, and ambiguity. Building solidarity and agreement can be done through relationship-building, which necessitates social and interpersonal skills, such as empathy. Moreover, creating and celebrating small wins and clarifying how these contribute to the overall future goal not only help build solidarity but also increase the self-esteem of the team members, which makes dealing with risk and its adversities easier. Thus, leaders should possess and be able to communicate both a long-term vision and short-term concrete goals. Additionally, relationship-building can be stimulated through continuous looping through the What, How, and Why questions of single-, double-, and triple-loop learning respectively and building in reflexivity.

To increase reflexivity, trust is needed. Trust can be built through repeated (respectful) interactions, practicing inclusion, and building a nurturing and supportive environment, or secure basis, with practical and emotional safety nets. Stimulating and facilitating open and honest dialogue and connecting communities is an important step therein, where leaders should be the first to portray this behavior and set the right tone.

Leaders can deal with complexity by (1) opening up the discussion, (2) setting boundaries, (3) stimulating attractors, (4) encouraging dissent and diversity, and (5) managing starting conditions and monitoring for emergence. The third point can be increased through experimentation. The fifth point implies a discovery-driven approach that enables continuous learning. Therefore, building a community of learners is important in dealing with complexity. Furthermore, leaders need to implement a non-hierarchical structure to steer clear of command-and-control leadership, which is detrimental for flexibility and dealing with ambiguity.

Interestingly, five dualities in the necessities of leadership can be identified. Namely, (1) convergent thinking & divergent thinking, (2) giving direction & autonomy of team members, (3) internal & external focus concerning the community, (4) practical short-term goals & long-term vision, and (5) experimentation & exploitation.

LEADERSHIP STYLES WITH LOWER CHANCES OF SUCCESS FOR STIMULATING LEARNING AND TRANSDISCIPLINARY COLLABORATION

Based on the previously summarized necessary leadership behaviors for learning and transdisciplinary collaboration, leadership styles and structures that are not appropriate could be identified and are mentioned below. It should be noted that the leadership styles and structures discussed here are not exhaustive and are highly contextual. The latter means that these styles

and structures may in some contexts or in some situations work well and in other instances not so well. Furthermore, the fact that several dualities were found important in leadership increases the ambiguity and complexity of finding one style or structure that completely or always fits. That being said, in the case of a transdisciplinary collaboration context and a focus on stimulating learning and developing a learning mindset within that context, the below-mentioned leadership styles and structure can be said to have a lower chance of success.

Command-and-control leadership

Command-and-control leadership is based on a hierarchical structure, meaning it imposes a top-down approach, and does not bode well in a network (De Bruijn & Ten Heuvelhof, 2018). This leadership style has previously been specifically mentioned to be detrimental for, amongst others, dealing with ambiguity. Ambiguity is a big part of transdisciplinarity as well as the process of learning, which makes command-and-control a style that will most likely not be beneficial for learning or transdisciplinarity. There are, however, specific conditions for when command-and-control can be useful in a network, also termed "smart command and control" (De Bruijn & Ten Heuvelhof, 2018, p. 86). However, these conditions are so specific and not overall applicable to the necessary leadership behaviors mentioned before that smart command-and-control will not be taken into consideration in this master thesis project.

Pacesetting leadership

Pacesetting leaders are known to set the pace ambitiously high and push their team members to the extreme (Martinuzzi, 2019). It is a leadership type that is not meant for the long-term as it is too focused on results (Martinuzzi, 2019). Not only was a long-term focus mentioned to be necessary for a leader to have and provide, but a focus on results may be detrimental for stimulating learning and working towards transdisciplinary collaboration. The latter is due to the uncertainty and ambiguity of transdisciplinarity as a new collaboration type as well as the learning process. Only focusing on results does not give credit to the process, which may in the case of developing a learning mindset and trying to get acquainted with a new way of working may be just as important. Furthermore, pushing team members to the extreme may in itself not be durable in the long run.

Autocratic and benevolent autocratic leadership

Autocratic leaders assume a hierarchical role wherein the decisions, which are made entirely by themselves, have to be followed since they are the boss (Aronson, 2001; Martinuzzi, 2019). It is a command-and-control type of leadership of which the catchphrase could be said to be "Do as I say" (Martinuzzi, 2019). Benevolent autocratic leaders are only different in that they impose their decisions on others since they think it is what is best for everyone involved (Aronson, 2001). Since they are command-and-control types of leadership, both autocratic and benevolent autocratic leadership have lower chances of success in the context of the Digital Twin project, as explained previously.

Laissez-faire leadership

This type of leadership may not even be called leadership, since it basically puts all trust in the team members and employs (almost) no oversight (Martinuzzi, 2019). In dealing with complexity and uncertainty, having a leader that provides no general guidance or oversight will most likely only induce more uncertainty and nothing will get done. A leader is needed to remind people of the overall vision and help them make this vision concrete and daily implementable. Therefore, laissez-faire leadership is most likely not suited for the Digital Twin project context.

Transactional leadership

Transactional leadership is focused on a transaction between leader and follower, where the leader provides rewards to or adheres to preferences of the follower in exchange for good performance of the follower (Aronson,

2001; Nanjundeswaraswamy & Swamy, 2014). Providing rewards in itself is not problematic. However, this achievement-reward system focuses too much on short-term goal attainment and relies too much on "organizational rewards and punishments to influence employee performance" (Nanjundeswaraswamy & Swamy, 2014, p. 58). As has previously been said, leaders need to not only have a short-term but also a long-term focus for the Digital Twin project context. Furthermore, inspiring people makes them move from within and makes them more willing to work hard and long to achieve the common goals. This is much more fruitful than solely relying on external incentives. Therefore, purely transactional leadership is most likely not beneficial for the Digital Twin team.

Leadership styles with higher chances of success for stimulating learning and transdisciplinary collaboration

Based on the previously summarizes necessary leadership behaviors for learning and transdisciplinary collaboration, leadership styles and structures that are appropriate can be identified and are mentioned below. It should be noted, however, that the leadership styles and structures discussed here are not exhaustive and are highly contextual. The latter means that these styles and structures may in some contexts or in some situations work well and in other instances not so well. Furthermore, the fact that several dualities were found important in leadership increases the ambiguity and complexity of finding one style or structure that completely or always fits. That being said, in the case of a transdisciplinary collaboration context and a focus on stimulating learning and developing a learning mindset within that context, the below-mentioned leadership styles and structure can be said to have a higher chance of success.

Transformational leadership

"Transformational leadership style concentrates on the development of followers as well as their needs" (Nanjundeswaraswamy & Swamy, 2014, p. 58). It tries to evolve people's mindset, attitude, and drive (Aronson, 2001; Nanjundeswaraswamy & Swamy, 2014), thereby introducing triple-loop learning and thus reflectivity, towards a more complete awareness (Nanjundeswaraswamy & Swamy, 2014). This makes it a holistic approach and makes the team members act beyond their own interest for the good of the team (Aronson, 2001; Nanjundeswaraswamy & Swamy, 2014). It is a visionary type of leadership that inspires followers (Aronson, 2001; Nanjundeswaraswamy & Swamy, 2014). Attitude change, triple-loop learning, a holistic approach, and inspiring followers have all previously been linked to either transdisciplinary collaboration or learning. This implies that transformational leadership is a style of leadership that is beneficial for the Digital Twin project context.

Authoritative leadership

Authoritative leaders are confident, have a vision, set a clear path and expectations, and are able to inspire followers (Martinuzzi, 2019). These leaders are open to ideas and communicate their own thinking, making them fit for helping people deal with uncertainty (Martinuzzi, 2019). All these behaviors have previously been linked to either transdisciplinary collaboration or learning. This implies that authoritative leadership is a style of leadership that is beneficial for the Digital Twin project context.

Democratic leadership

Democratic leaders involve their followers in decision-making and are open and honest in their communication (Martinuzzi, 2019). This type of leadership inspires trust, sparks intrinsic motivation in the follower, and allows room for creativity (Martinuzzi, 2019). All these behaviors have previously been linked to either transdisciplinary collaboration or learning. This implies that authoritative leadership is a style of leadership that is beneficial for the Digital Twin project context.

Coaching leadership

Coaching leaders assume that every individual is capable and full of potential (Martinuzzi, 2019). These leaders gently guide people and provide insights with which the followers themselves can put the pieces together so that it

'clicks' for them (Martinuzzi, 2019). This type of leadership provides both direction and autonomy, which is one of the dualities of leadership that has previously been mentioned to be beneficial for leaders to have in the context of the Digital Twin project. Furthermore, assuming that every individual is capable and full of potential implies a focus on evolution and development and not so much on results right away. This may allow for more exploration and creativity, which is beneficial for learning. Therefore, a coaching leadership style can be said to most likely be successful in stimulating learning and working towards transdisciplinary collaboration.

Affiliative leadership

This type of leadership is focused on relationship-building and ensuring that the emotional needs of team members are met (Martinuzzi, 2019). Affiliative leaders are especially useful for making people feel at ease in times of stress or uncertainty (Martinuzzi, 2019). Since stress and uncertainty are inescapable when learning and working towards transdisciplinary collaboration, affiliative leadership is likely to be beneficial for the context of the Digital Twin project.

Authentic leadership

A shift towards authentic leadership is said to be necessary to deal with the increasing complexity of leadership challenges (Van Droffelaar & Jacobs, 2017). Van Droffelaar & Jacobs (2017) mention the four core elements of authentic leadership to be "self-awareness, an internalized moral perspective, balanced processing of information, and relational transparency" (p. 2). The latter is underscored by Alok (2014), who states that authentic leaders have a high self-esteem which "helps them to be open and truthful in relationships, i.e. achieve relational transparency" (p. 268). The author furthermore mentions that authentic leaders inspire high levels of trust, but does so with a warning. The more followers trust a leader, the less they are inclined to get involved in decision-making or let their voice be heard, which may be detrimental for the organization (Alok, 2014). Therefore, authentic leaders should steer clear of dependence and stimulate autonomy and dialogue. Relational transparency and trust have previously been mentioned to be beneficial for learning. In combination with autonomy, which has previously been stated to be beneficial for learning as well, authentic leadership can therefore be beneficial for the Digital Twin project context.

Humble leadership

"Humble leaders know they cannot do it all, and that they must delegate and call on the contributions of others to build what is great and of benefit to society. Humble leaders bring out the best in others in the service of the wider enterprise" (Mea & Sims, 2019, p. 11). Additionally, leaders should strive for success through using one's natural talents (Mea & Sims, 2019), which also comes down to recognizing one's own talents and that of others, and being smart about how to use them, which is what humble leaders are able to do. From the above it can be said that humility and reflectivity are linked and are both qualities that a leader should have to stimulate learning and enable transdisciplinary collaboration. Therefore, humble leadership can be said to be beneficial for the context of the Digital Twin project.

Informal leadership

Having a strong leader role identity is not enough to be a successful leader; the behavior portrayed by this individual must also be seen by the followers as desirable leadership behaviors (Kwok et al., 2018). I.e., to be accepted as a leader, and thus more successful as a leader, the leader behaviors must match with the followers' implicit leadership theories. Therefore, having teams select their leader themselves or letting informal leaders emerge themselves, might result in the best and most successful leader for teams and thus increase team performance (Kwok et al., 2018). Additionally, what informal leader emerges may differ per situation as different situations need different skills to handle them (Kwok et al., 2018) and is based on performance over time (Nakayama et al., 2019). Therefore, leader

emergence is a social process and should be able to change over time to adhere to the needs of the situation and the team. Rotating leadership has previously been mentioned to be beneficial for creativity and thus learning. Furthermore, allowing for leadership to emergence and change based on how the community changes has also been mentioned to be beneficial for a community. Therefore, informal leadership is likely to be effective in the context of the Digital Twin project.

Distributed or shared leadership

In distributed or shared leadership, "leadership responsibilities are distributed over more than one person in the team, without neglecting the possibility of having a person in a designated leader position as well" (Nordbäck & Espinosa, 2015, p. 403). This type of leadership encourages involvement, thereby providing opportunities for people to learn new skills as well as reducing the time needed for directing (Nordbäck & Espinosa, 2015). However, distributed leadership is only effective if there are some boundaries and a clear common goal, since otherwise people might get too much off track or might reinvent the wheel (Nordbäck & Espinosa, 2015). Therefore, coordination between leaders is needed. Additionally, the effectiveness of distributed leadership also depends on whether people are viewed as leaders (Nordbäck & Espinosa, 2015), whether team members accept them as leaders, and whether the leaders have been given a systemic place as a leader (Bakker & Steeghs, 2015). Furthermore, the role you take on in a system (whether it is formally or informally) influences the value of what you say (Bakker & Steeghs, 2015). Other conditions that need to be met are mutual trust and open communication (Chen & Wang, 2008). As understanding of team members and the project and intimacy increase over time, team members will increasingly take on leader roles, thereby increasing the total amount of distributed leadership (Chen & Wang, 2008). It has previously been said that multiple leaders are needed in a community. Furthermore, distributed leadership allows for more and parallel exploration of what leadership styles do and do not work which helps to better deal with uncertainty and ambiguity. If the above-mentioned conditions are met, distributed leadership may be said to be a type of leadership that is likely to be beneficial for the Digital Twin project.

Ambidextrous leaders

It has previously been mentioned that leaders should possess short links and close communication with several communities. These can be provided by what Purcell (2019) terms "'ambidextrous' leaders" (p. 251), who are adaptive, part of multiple systems, and can move between them freely. Purcell (2019) explains that ambidextrous leaders play a significant role in building "shared understanding and trust, creating ownership and developing a coalition of support, enabling people to bridge from the old to new ways of working" (p. 258), through stimulating dialogue, discussion, and engagement between the two systems. Possessing short links and close communications with several communities, moving between communities, shared understanding, trust, support, and bridging towards a new way of working are either beneficial to learning or part of moving towards transdisciplinary collaboration. Therefore, ambidextrous leaders are likely to be effective for the context of the Digital Twin project.

Open governing style

An open governing style was previously said to stimulate actors to engage, interact, negotiate, and collaborate (Bos et al., 2013). It provides transparency and lowers the threshold for people to weigh in (Bos et al., 2013), thereby increasing diversity. Diversity has been said to be beneficial to learning, which makes an open governing style likely to be beneficial for the Digital Twin project context.

Learning-centered leadership

Learning-centered leadership is a perspective where learning is seen as the key outcome of leadership. Talebizadeh et al. (2021) describe the four dimensions of learning-centered leadership to be: (1) building a learning vision and being able to communicate it, (2) supporting openness, risk-taking, and collaboration through their behavior, (3) providing learning

support, and (4) managing, monitoring, and developing the learning program. Naturally, leadership that focuses on learning is beneficial for learning and developing a learning mindset. Specifically, openness, risk-taking, and support have previously been mentioned to be beneficial to learning. Therefore, learning-centered leadership can be said to most likely be effective for the context of the Digital Twin project.

2.4.4 CONCLUSIONS

Based on the findings from sub-sections 2.4.1-2.4.3, research sub-questions 3a, 3b, 3c, and 3d, and thus research question 3, can be answered. Recall research question 3 with subparts 3a, 3b, 3c, and 3d:

3. What type of leadership style, structure, or behavior is appropriate or necessary to enable and stimulate learning within a transdisciplinary collaboration context?
    a. What leadership behaviors are necessary in relation to a transdisciplinary collaboration context?
    b. What leadership behaviors are necessary in relation to the learning elements in a transdisciplinary collaboration context?
    c. What leadership styles or structures do not fit with the identified leadership behaviors?
    d. What leadership styles or structures do fit with the identified leadership behaviors?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 3A

Based on the previously mentioned necessary leadership behaviors for learning and transdisciplinary collaboration, a causal diagram was made and can be seen in Figure A in Appendix A. Based on this figure, core elements of leadership that influence core elements of learning or transdisciplinarity were identified. An element was regarded a core element if it was only an influencing factor and not being influenced by anything itself. I.e., if A→ B → C, then A can be said to be the source of influence for C. For example, in Figure A it can be seen that dealing with uncertainty, risk and ambiguity can be done through building solidarity and agreement. Solidarity and agreement can in turn be built through relationship-building. In turn, social- & interpersonal skills help build stronger relationships. Therefore, social- & interpersonal skills can be said to be at the source of dealing with uncertainty, risk, and ambiguity, and it can thus be seen as one of the core elements of leadership when it comes to transdisciplinary collaboration. It is important to note that the other elements portrayed in Figure A are still of importance to leadership, but they should logically follow from the core elements.

From Figure A, it can be concluded that the core elements of leadership in relation to transdisciplinarity are: *encouraging diversity, encouraging dissent, deploying multiple solutions, tolerating failure, having patience, having social- & interpersonal skills, creating & celebrating small wins, linking small wins to overall goal, connecting communities, setting boundaries, stimulating & facilitating open & honest dialogue, facilitating formal & informal interactions with a diversity of people, iteration of What, How, Why, a duality of exploitation & experimentation, a duality of practical short-term goals & long-term vision,* and *a duality of autonomy & direction.*

ANSWER TO RESEARCH SUB-QUESTION 3B

From Figure A, it can be concluded that the core elements of leadership in relation to learning in a transdisciplinary context are: *applying an open governing style, having close connections to communities, moving between communities, connecting communities, portraying wanted behavior, tolerating failure, trusting followers, stimulating & facilitating open & honest dialogue, facilitating formal & informal interactions with a diversity of people, iteration of What, How, Why, rotating leadership, a duality of*

exploitation & experimentation, a duality of internal focus & external focus, a duality of practical short-term goals & long-term vision, a duality of autonomy & direction, and *a duality of convergent thinking & divergent thinking*.

ANSWER TO RESEARCH SUB-QUESTION 3C

As was noted before, the styles and structures previously mentioned to have a lower chance of success for transdisciplinary collaboration and a focus on learning therein are highly contextual. This means that these styles and structures may in some contexts or in some situations work well and in other instances not so well. Additionally, the list provided below is not exhaustive. Therefore, the answer provided to research sub-question 3c is more of a proposition or suggestion than any hard science.

That being said, the following leadership styles or structures can be said to have a lower chance of success in a transdisciplinary collaboration context and a focus on stimulating learning and developing a learning mindset within that context:

- Command-and-control leadership
- Pacesetting leadership
- Autocratic and benevolent autocratic leadership
- Laissez-faire leadership
- Transactional leadership

ANSWER TO RESEARCH SUB-QUESTION 3D

As was noted before, the styles and structures previously mentioned to have a higher chance of success for transdisciplinary collaboration and a focus on learning are highly contextual. This means that these styles and structures may in some contexts or in some situations work well and in other instances not so well. Additionally, the list provided below is not exhaustive. Therefore, the answer provided to research sub-question 3d is more of a proposition or suggestion than any hard science.

That being said, the following leadership styles or structures can be said to have a higher chance of success in a transdisciplinary collaboration context and a focus on stimulating learning and developing a learning mindset within that context:

- Transformational leadership
- Authoritative leadership
- Democratic leadership
- Coaching leadership
- Affiliative leadership
- Authentic leadership
- Humble leadership
- Informal leadership
- Distributes or shared leadership
- Ambidextrous leaders
- Open governing style
- Learning-centered leadership

ANSWER TO RESEARCH QUESTION 3

To know what a leader should do to stimulate learning in a transdisciplinary collaboration context, it is not just important to consider how leaders can directly influence learning. It is also of great value to take the context in which this learning is taking place into account and portray the behaviors that are appropriate in that context to be more effective as a leader.

The core elements of leadership in relation to transdisciplinarity are: *encouraging diversity, encouraging dissent, deploying multiple solutions, tolerating failure, having patience, having social- & interpersonal skills, creating & celebrating small wins, linking small wins to overall goal, connecting communities, setting boundaries, stimulating & facilitating open & honest dialogue, facilitating formal & informal interactions with a diversity of people, iteration of What, How, Why, a duality of exploitation &*

experimentation, a duality of practical short-term goals & long-term vision, and *a duality of autonomy & direction.*

The core elements of leadership in relation to learning in a transdisciplinary context are: *applying an open governing style, having close connections to communities, moving between communities, connecting communities, portraying wanted behavior, tolerating failure, trusting followers, stimulating & facilitating open & honest dialogue, facilitating formal & informal interactions with a diversity of people, iteration of What, How, Why, rotating leadership, a duality of exploitation & experimentation, a duality of internal focus & external focus, a duality of practical short-term goals & long-term vision, a duality of autonomy & direction,* and *a duality of convergent thinking & divergent thinking*.

Notice that there are several core elements that are necessary for leadership both in relation to transdisciplinarity and in relation to learning in a transdisciplinary collaboration context. These are: *tolerating failure, connecting communities, stimulating & facilitating open & honest dialogue, facilitating formal & informal interactions with a diversity of people, iteration of What, How, Why, a duality of exploitation & experimentation, a duality of practical short-term goals & long-term vision,* and *a duality of autonomy & direction.* These core elements are therefore extra important.

There is not one unambiguous answer to what type of leadership style or structure would always work in any given situation, as was explained before. So, a definitive answer concerning styles and structures does not exist. However, several dualities were identified to be important for leadership. , which influence the type of leadership style or structure used. Furthermore, there is an indication as to what styles and structures of leadership may have more success than others in the transdisciplinary collaboration context and with a focus on learning. Examples are:

- Transformational leadership
- Authoritative leadership
- Democratic leadership
- Coaching leadership
- Affiliative leadership
- Authentic leadership
- Humble leadership
- Informal leadership
- Distributes or shared leadership
- Ambidextrous leaders
- Open governing style
- Learning-centered leadership

2.4.6 VISUALIZATION OF LEADERSHIP IN RELATION TO TRANSDISCIPLINARY COLLABORATION AND LEARNING IN A TRANSDISCIPLINARY COLLABORATION CONTEXT BASED ON THEORY

Based on the previously defined core elements of leadership, the overlap therein, and the dualities, a visualization of leadership in relation to learning and transdisciplinarity was made. This visualization is shown in Figure 3.13 and in essence consists of two sets of discs: one concerning transdisciplinarity and one concerning (continuous) learning. Each set of discs consists of four layers. The inner layer, also referred to as layer 0 or the core, displays the goal of a set of discs. The first layer, layer 1, consists of the core elements of that goal as defined in sub-sections 2.2.5 and 2.3.8. The second layer, layer 2, contains the core elements of leadership that have been identified to have a specific relation to layer 1 based on Figure A and previously mentioned in sub-section 2.4.5. As can be seen, there is some overlap and some difference between these core elements. The third and final layer, layer 3, contains the dualities corresponding to that specific set of discs. Again, here is some overlap between discs. The dualities are in the outer layer since they have an influence on every core element and

introduce restraints and tensions to the system, making it less unambiguous. For example, having an internal focus & external focus puts a strain on facilitating open & honest dialogue (necessitating more of an internal focus) on the one hand, and facilitating interactions with a diversity of people (necessitating more of an external focus) on the other hand. The first is needed to build trust and a supportive environment and practice inclusion. The latter is needed to introduce diversity and more learning opportunities. Even though they both have positive effects on learning, they may put a strain on each other: increasing diversity too much can decrease a community feel and feelings of trust, whereas putting too much focus on the community may result in decreased diversity and may eventually result in confirmation bias.

There are several things to note about Figure 3.13. First, even though the core elements defined for learning in this Master Thesis project have been found in specific relation to transdisciplinarity, there is no explicit relation between the first layer of both sets of discs in Figure 3.13 (except for trust and diversity which are elements of both layers 1). The reason for this is that Figure 3.13 was made from the perspective of leadership to transdisciplinarity and learning (in a transdisciplinary collaboration context), not from the perspective of learning in relation to transdisciplinarity. Second, it can be seen that reflexivity, iteration on What, How, Why, and rotating leadership are blue. This is because they all introduce some sort of renewal or updating mechanism to all levels of the system, as is portrayed by the arrows near reflexivity. This relates not only to the changing of the communities, but also to a necessity to see leadership as being in development itself. Third, note how some (parts) of the elements in Figure 3.13 are bold. This relates to the core element *portray wanted behavior* and shows what behaviors leaders must portray to stimulate this behavior in others. Note how this has only been done for elements in the discs of learning, since *portray wanted behavior* is only part of those discs and not of the transdisciplinarity discs. Fourth, there are several forms of influence taking place between the layers of the discs: the first layers contain the elements that all have a direct link to their corresponding core; the second layers contain elements of which some have direct links to elements in the corresponding layer 1, but some have no direct link; the third layer has an effect on the core, layer 1, and layer 2. There was the option to, for example, color the text of elements to indicate a direct influence. However, this resulted in a rather clownish image that was not aesthetically pleasing whatsoever. Therefore, the choice was made to leave them out and go for simplicity instead. Figure A can be consulted if the reader finds themselves curious about the direct links.

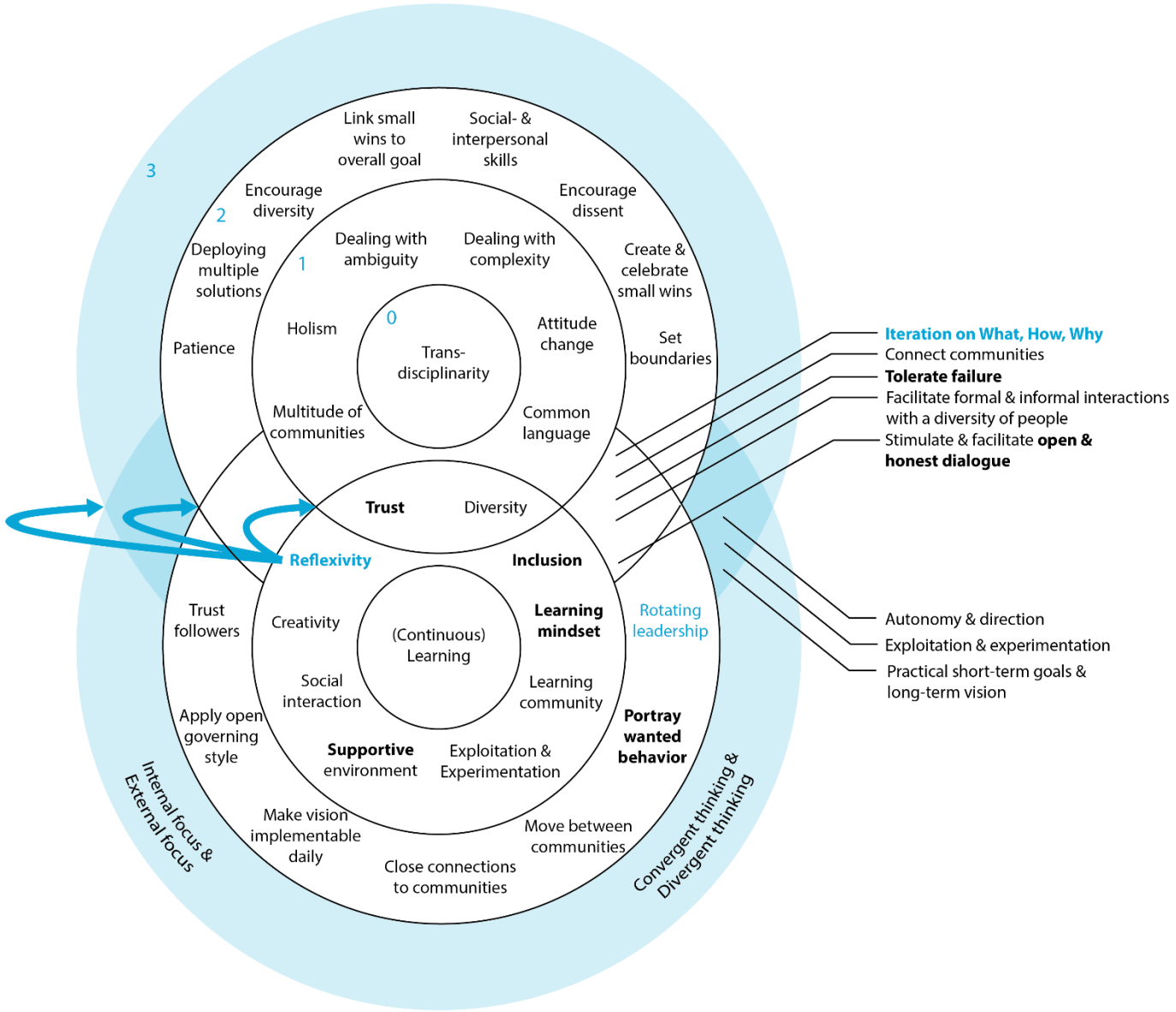


Figure 3.13: The Omni-Discs of Leadership for Transdisciplinarity and Learning. The figure portrays what is needed from leadership to work towards transdisciplinarity and (continuous) learning (within a transdisciplinary collaboration context). Layer 0: the goal of a set of discs – transdisciplinarity or (continuous) learning. Layer 1: core elements of transdisciplinarity or learning. Layer 2: core elements of leadership that support (parts of) layer 1. Layer 3: dualities of leadership, they have an influence on all other layers. Reflexivity, rotating leadership, and iteration on What, How, Why: influence all layers and help keep up with changes in the community. Bold elements: the behaviors that leaders need to portray as part of the 'portray wanted behavior' element.

2.4.5 CRITICAL REFLECTION OF LEADERSHIP IN RELATION TO LEARNING AND A TRANSDISCIPLINARY CONTEXT

It is important to note that leadership is extremely contextual and what is and is not effective differs per person and per situation. One indication for this is the list of lesser and more effective types of leadership for the Digital Twin project context and the list is not nearly exhaustive. Furthermore, many styles overlap or may be used at the same time, making it almost if not completely impossible to make an unambiguous claim about what leaders should always or never do. Additionally, even if certain types of behaviors may be more effective than others, the people in leadership positions may not be able to portray them. Installing a new leader as well as offering possibilities for training or development takes time, effort, and often money.

Besides the leadership styles, team composition as well as the relation between the team and the leader have tremendous influence on the effectiveness of leadership. This is currently not taken into account. For example, learning-centered-leadership may in theory work very well, but if the team consists of old hands in the trade that may very soon retire, the willingness to accept a new type of leadership, attitude, or way of collaborating may be nonexistent.

Duality has been said to be an important part of leadership. However, this poses a great challenge to leaders since it literally asks them to be able to perform tasks or portray behaviors on the opposite sides of a spectrum. It is rather naïve to think one person is able to do so, thereby implying that there needs to be a shared or distributed leadership to enable the execution of the dualities. The benefits of distributed leadership are clear. However, it is unclear how one can implement it when there are no people willing or capable to take on leader roles. Willingness can be changed through incentives, but this may not provide the internal motivation that would be beneficial for leaders to have. In case of capability, training and coordination are needed, which costs time, money, and effort. These are valuable resources and institutions, faculties, or leaders may possibly rather spend them elsewhere. Being not only reflective after the fact but building in reflexivity as a regular check-up will take up additional time that people might not be willing to 'sacrifice' either.

Rotating leadership was previously said to stimulate learning. It is however unclear when or based on what metrics or situations leadership should rotate. Furthermore, it is a possibility that there are no people available to rotate to or the people that are available are not willing to take on a leader role. Additionally, it is a possibility that people are not willing to give up a leader position once they have one, thereby only creating more tension and stress in the team if rotating leadership is pressed upon.

It has previously been said that leaders should portray the behavior they want to see in others, such as open and honest dialogue, and also be the first to do so. Leaders are example figures, which means others use their behavior as a criterion for their own. This implies that if leaders do not set the right tone or fail to correct their own unwanted behavior, there is a strong probability that others will portray that unwanted behavior as well. This is particularly challenging since some of the behaviors necessary by leaders to stimulate learning and work towards transdisciplinary collaboration are new and will therefore most likely not go correct on the first try. Therefore, leadership needs to be seen, treated as, and communicated to be a learning process in itself as well so that people help the leader reflect on what is and is not working. This poses two challenges. First, seeing leadership as a learning process itself is not something that is already being done by all leaders and may therefore necessitate an attitude change from leaders and possibly also followers. Second, seeing leadership as a learning process insinuates leaders do not always know best and may also be unsure some (if not most) of the time. This goes against the clarity and certainty that followers often look to receive from leaders.

Experimentation has previously been said to be beneficial to learning, therefore making it an activity that leadership should undertake or at least

stimulate. However, no clear guidelines concerning the direction or scope of experimentation are given. It is unclear how one can ensure that experimental endeavors do not stray away from the learning field and stay beneficial. Additionally, making people more comfortable with experimentation needs time and successes to prove it is a viable way of working. If these successes do not exist, are not expressed, or cannot be shown on the short-term, commitment to experimentation will most likely fade.

3 QUALITATIVE RESEARCH

In this chapter, the results of the qualitative research on (transdisciplinary) collaboration, learning, and leadership in relation to the Digital Twin project context will be presented. First, the methodologies used will be elaborated on. Second the results of the qualitative research will be given. Third, conclusions will be drawn and the corresponding research questions will be answered. This sequence will be presented for each of the three themes – (transdisciplinary) collaboration, learning, and leadership – in that order.

3.1 METHODOLOGY - QUALITATIVE RESEARCH THROUGH SEMI-STRUCTURED INTERVIEWS

During and after the literature study and during the final formalizations of the core concepts of the three main themes – transdisciplinary collaboration, learning, leadership – the research was conducted in five stages, some of which took place parallel to each other: (1) the development and iteration of interview protocols, (2) the identification and approaching of participants, (3) data collection through semi-structured interviews, and (4) data processing consisting of full transcripts and structural coding (Saldaña, 2021) in Atlas Ti 9, and (5) data analysis using descriptive statistics. These stages will be elaborated on below.

3.1.1 SEMI-STRUCTURED INTERVIEWS AND INTERVIEW PROTOCOLS

Since the concepts around which this Master Thesis project revolves cannot be quantified or at least are immensely challenging to quantify, qualitative research was conducted (Babbie, 2016). This was done in the form of qualitative interviewing. There are several reasons why interviews were chosen as the format for the qualitative interview instead of, for example, a survey or structured interviews. The reasons are listed below:

1. Interviews diminish the chance of influencing the opinion of the interviewees and allows them to speak openly and freely (Babbie, 2016).
2. Interviews allow for interaction with the interviewee, which enables reacting to their answers and going more into depth.
3. Interviews allow for the interviewer to provide additional information if needed to enable the interviewee to answer a question or ensure the intended interpretation of a question. This again adds to the validity of the research as well as to the usefulness of the results.
4. Interviewing allows for immediate reflection of the interviewer on what questions seem relevant to ask. This (internal) iteration on the relevance of questions ensures that interviewees do not have to spend time on irrelevant questions but can spend that on relevant ones instead.
5. Semi-structured interviews do not have to adhere to a certain order of questions, thereby making the interview even more relaxed and natural.
6. Since semi-structured interviews do not have to adhere to a certain order, the order of the questions do not have to be tested beforehand or relate to each other in a certain way.

For number three on the list, concepts from the theoretical framework were kept on hand in case an interviewee would have difficulty coming up with concepts themselves. This concerned questions about characteristics or circumstances.

Interview protocols were made for the interviews and were adapted to the specific type of people that were to be interviewed. More information about the target groups can be found in the next sub-section. The interview protocols can be found in Appendix B. It should be noted that the order in which the questions are listed in the protocol are not necessarily the order in which they were asked. The order and whether the questions were asked

depended on the flow of the conversation and the answers of the interviewee.

The interview protocols were iterated on several times in consultation with my main supervisor as well as a PhD candidate of the faculty of Science Education & Communication (SEC). The questions were formulated in such a way that it made it easier for interviewees to answer them, as they relate to their own experiences and perceptions. Only after such a first introduction to a subject was made through their own experience would more abstract questions about the topic at hand be asked.

Before an interview took place, an email containing general information about the interviewer, the context of the interview, how the interview and the data would be used and safely stored, and the request by the interviewer to record the interview and why was explained. The actual text can be found in the interview protocols in Appendix B. The general information was shared beforehand to free up more time for the actual interview. At the start of the interview, the interviewee was provided the opportunity to ask questions about the general information. Furthermore, permission to record the interview was asked explicitly before actually recording to ensure the (ethical) safety of the interviewee.

The request to record the interviews was made to enable the interviewer to get all the details but at the same time have an attentive conversation with the interviewee and react to their answers. Furthermore, recording the meeting enabled for the complete transcription of the interviews, which on the one hand was beneficial for coding and the results, and on the other hand for the research of the PhD candidate of the faculty of SEC.

3.1.2 TARGET GROUPS

In the introduction it was already explained that the context of this Master Thesis project is the Digital Twin flagship of the Health & Technology theme of the Convergence Agenda. There were several reasons for selecting the Digital Twin flagship for the case study. The reasons are listed below:

1. The 'trekkers', from now on referred to as leads, were very open to and enthusiastic about involvement of SEC.
2. My main supervisor has a (close) connection with them
3. Digital Twin is the flagship that is furthest along and the people working in this flagship will therefore be able to provide more insights concerning the collaboration, learning, and leadership that they have experienced thus far.

Several categories of people were interviewed. What these categories are, how many of them were interviewed, what institution they are from, and why they were interviewed is mentioned below:

1. People from a governance level of the Convergence Agenda; 2; both from TUD but one has a history at EMC as well; these people have a lot of experience with leadership, have a more general knowledge of the Convergence Agenda and the vision of Health & Technology and the flagships, and have insights in what is currently being done and what can or should be done on a governance level or in leadership.
2. The leads of Digital Twin; 2; 1 EMC, 1 TUD; they are in leadership positions, have some overall knowledge about the inner workings of Digital Twin, and have insights in what is currently being done and what can or should be done in leadership.
3. Principal investigators (PIs) from Digital Twin; 2; 1 from EMC, 1 from TUD; they can be somewhat considered to be in leadership positions but also have knowledge about the inner workings of Digital Twin on a collaboration level, how they view leadership, what they deem necessary from leadership, and are closer to their learning phase than the leads and governance people.

4. Postdocs from Digital Twin; 3; all from EMC; they have knowledge about the inner workings of Digital Twin on a collaboration level, how they view leadership, what they deem necessary from leadership, and are closer to their learning phase than the leads and governance people.
5. Philosophers affiliated with Digital Twin; 3; 1 from EMC, 2 from TUD; they provide a different perspective and are able to think more abstractly about concepts.

For groups 1, 2, and 5 the selection and introduction were done by my main supervisor. The selection of groups 3 and 4 was based on voluntary registration of people after one of the leads asked about it during a meeting. The introduction to these people was done by this same lead. The diversity in people's role and differences in institution was beneficial as it provided different perspectives, which added to the validity of the research.

3.1.3 PROCESSING THE INTERVIEWS

FULL TRANSCRIPTION OF THE INTERVIEWS

The interviews were fully transcribed in the instances where the interviewee agreed to recording. In the other case, a summary of the notes that were taken during the interview was used. With 'fully transcribed' is meant that all words that were spoken (and understood) were noted. The time it took to answer or the pauses were not noted, since it was not the purpose of this Master Thesis Project to analyze answering time or struggle in answering. Another reason for fully transcribing the interviews was the knowledge that a PhD candidate of SEC would benefit from it for their own research. An example of a full transcript can be found in Appendix C, to which the person concerned granted permission.

STRUCTURAL CODING IN ATLAS TI 9

For the further processing of the interviews, Atlas Ti 9 was used since it is a tool specifically designed for qualitative analysis of large bodies of, for example, textual data. It provided a systematic and yet still flexible way to code and manage the material.

The textual data, or transcripts, were processed using structural coding. Coding essentially means labelling the data to make analyzing, summarizing, and concluding easier. Structural coding entails going through the data, finding meaningful words, sentences, or even paragraphs, and labelling them with a code that seems appropriate. Structural coding provides space for nuance and additional insights that could not be coded if all codes would have been pre-determined. The structural codes were each divided into one of the following groups: Collaboration, Learning, Leadership, Background, or Extra. Next to a group label, the codes were often also given a specification to make the future analysis easier. Examples are Collaboration: transdisciplinary, Learning: social interaction, Leadership: informal, and Extra: convergence. The codes that were used in the structural coding were mainly based on concepts from the theoretical framework, but also on words used by the interviewees. The codes of the groups Collaboration, Learning, and Leadership aided in answering the research questions. The codes of the group Background helped determine reasons for clear discrepancies between answers of people with different backgrounds, should they occur. The codes of the group Extra provided additional insights that may provide interesting perspectives for future research.

3.1.4 ANALYZING THE INTERVIEWS

DESCRIPTIVE STATISTICS

After the pieces of text related to the structural codes were transferred to tables and the concluding statements were formulated from those pieces of text (see Appendix D), it was summarized how many people said certain statements and who they were (see Appendix E). Who they were relates to a combination of the role the interviewees have and the institutions they

represent. From these summarizations, ratios could be constructed and results could be presented.

3.2 RESULTS ON (TRANSDISCIPLINARY) COLLABORATION

The results that will be discussed in this chapter are based on Table D.1 in Appendix D. The information in this is based on the full transcripts of the interviews and the structural coding used in Atlas Ti 9. From this table, concluding statements and their significance were subtracted and put in Table E.1 in Appendix E. Significance refers to the number of people that said a statement or something along those lines (1 to 12) as well as their role (G, L, PD, PH, PI) and institution (EMC, TUD). These are listed in numerical or alphabetical order.

Several quotes used in the interview results mentioned next will in Dutch. The reason for this is that those interviews were conducted in Dutch. Furthermore, no quotation marks will be shown when a 'quote' from person [2] is shown. The reason for this is that this person did not consent to the interview being recorded. Consequently, any examples from that interview were based on notes and are thus no actual quotes.

3.2.1 INTERVIEW RESULTS ON (TRANSDISCIPLINARY) COLLABORATION

THE COLLABORATION AND ITS CHALLENGES

The collaboration with(in) the Digital Twin team is perceived by 11/12th of the interviewees to be going well. Despite this, four challenges were identified. The most prominent of these challenges, with 6/12th of the interviewees mentioning it, is caused by differences in expectations. This challenge was experienced by all postdocs and also acknowledged by two philosophers. The online environment was said by 4/12th to pose a challenge to collaborating more effectively. This challenge was put forward by people from the EMC only. Institutional boundaries were mentioned by 4/12th of the interviewees to make collaboration more difficult despite people's willingness to collaborate, as can be concluded from the quote below.

"(…) als je dan soms vraagt aan een wetenschapper of aan de support staff van 'Joh regel dat is even', dat ze onderling… Het is niet eens onwil maar ook zo niet georganiseerd dus dat breekt wel eens op in ongeduld, onbegrip. Soms komt het door de cultuur van de organisatie waardoor, ook al willen mensen, ze het niet helemaal voor elkaar krijgen en dat zie je nu dus ook voorkomen." [1]

Finally, cultural differences were mentioned by 3/12th to make collaboration more challenging. These cultural differences concern differences between disciplines and institutions, which in turn influences for example the way research is done and what the incentives are. The quotes below support this.

"Enerzijds cultuurverschillen in disciplines maar ook cultuurverschillen in hoe de universiteit of de instelling georganiseerd is financieel (…) waar de incentives zijn" [1]

"(…) vanuit onze discipline, als je onderzoek doet, dan heb je eerst een vraagstelling en dan ga je kijken welke data je kan verzamelen" [3]

"(…) what I understood is that they have a different culture of doing research" [7]

Specifically, one person mentioned that the incentives for the type of new collaboration, such as that within the Digital Twin project, are not motivating enough or non-existent. The quote below illustrates this.

"(…) not super motivating to do too many of these projects (…) typically you don't really get a lot of recognition out of these projects" [5]

BENEFICIAL OR NECESSARY FOR COLLABORATION

A common language or common understanding of things was mentioned by 9/12th of the interviewees as a necessity for collaboration. Furthermore, open discussions and (informal) social interactions were also prominently mentioned by 7/12th to be beneficial for collaboration. From the quotes below it can be concluded that the open discussions concern talking about expectations, a willingness to contribute, and discussing biases and assumptions. Specifically, iterating on assumptions and expectations was mentioned by someone to be necessary for effective collaboration. Open discussions were even mentioned to be necessary to be able to take steps towards building a common language.

"So, there was some open discussion just about people's expectations, and also about how willing and how much they want to contribute to this administration. Everyone was talking also about what their expectations were at the beginning and where their disappointment was" [8]

"(…) it is a very new area and we don't really know what to anticipate. (…) often the things I really want to have are not there, but you do know that it is because people don't really know the expectations you have. And, you can only, like, have more discussion and then see how to make the adjustment." [9]

"I think that's what needs to be opened up, because what happens when you come from a specific research culture, you have a cultural bias right (…) People don't always understand what it is that they're misunderstanding because they're not going down to that level. They're both trying to solve a problem at this level but there's conflicts happening down here that are affecting the way they're talking about it up here. So, I think it's more a matter of getting to those conflicts before we can get to a language where that comes into play." [12]

Furthermore, 4/12th of the interviewees mentioned clarity and concreteness, people being open to sharing, and a connection between people, projects, and the institutions to be beneficial for collaboration. Additionally, knowing what others can contribute, shared goals, and creativity were mentioned by 3/12th to be beneficial for collaboration. Based on the quotes provided below it can be said that the connection between people, projects, and the institutions means that the focus of people, projects, and institutions should not just be on themselves but also on the others. The communities of the projects need to be interlinked as they are interrelated. The necessity for the connection between people, projects, and institutions as well as creativity were only mentioned by people from the TUD and people in leadership positions or a philosopher.

De projecten binnen Digital Twin stemmen tussen en binnen projecten veel af [2]

"Digital Twin bestaat uit vier projecten die met elkaar samenhangen. Dat is de enige manier om samen te werken en om ook grote stappen te kunnen maken en dat betekent dus ook dat de acht postdocs, twee op elk project, ook moeten samenwerken binnen het project maar ook tussen de projecten" [3]

"I have a very very tight link with my direct partner (…), so I'm very frequently connected with him" [5]

"(…) alleen als je die openheid hebt in de samenwerking kan het tot synergie leiden in plaats van allemaal losse projectjes die wellicht her en der raakvlakken hebben. Dat is te weinig denk ik. Je moet echt streven naar die synergie" [11]

Trust, reciprocity, and daring to speak up were mentioned by 2/12th of the interviewees as important. Specifically, one person described how short links or strong relational bonds influence reciprocity, as can be concluded from the quote below. Furthermore, one person mentioned that calmness and a willingness to listen to others as well as getting out of one's comfort zone is beneficial for this collaboration.

"(…) makkelijk schakelen met korte, informele lijntje. Dus even bellen of een soort loyaliteit van 'Weet je als jij nou dit doet of dit, of als je nu tijd hebt om even hieraan bij te dragen dan doen wij het de volgende keer weer'" [10]

THE TRANSDISCIPLINARITY OF THE COLLABORATION

Interestingly, from the three types of collaboration described in section 2.2 the collaboration was referred to by 5/12th as multidisciplinary, by 3/12th as interdisciplinary, by 2/12th as transdisciplinary, and by 4/12th believed the collaboration to be partly transdisciplinary or be moving towards transdisciplinarity. One person even mentioned all of the types of collaboration. It is clear that there is confusion about what the types of collaboration entail and which applies to the collaboration within the Digital Twin team. This confusion was also mentioned by 4/12th of the interviewees and is further illustrated by the quotes below. The second quote even poses the question whether it is necessary to put a label on the collaboration. The third quote raises the question whether transdisciplinarity is even something that should be strived for and addresses the fact that even though transdisciplinarity may build towards an overarching model, disciplinary expertise is still at the root of the knowledge that is put into a collaboration.

"I'm not really sure to be honest, because there's a very difficult taxonomy between these things like interdisciplinary, multidisciplinary, transdisciplinary. It always confuses me, which is which, and also different people seem to be finding a different definition" [5]

"Het heeft ook echt een meerwaarde in de samenwerking met Delft. Echt een evidente meerwaarde. Of je dat nou in hokjes van multi- en trans-… Ik zou niet weten hoe ik dat zou moeten beoordelen." [6]

"(…) weet ik eigenlijk niet of transdisciplinariteit überhaupt mogelijk en wenselijk is. Het klinkt ook wel een beetje als een utopie. (…) En als je de suggestie wekt dat je weer terug kan naar een theorie van alles waar alles in meegenomen wordt dan denk ik… Ja volgens mij kan dat helemaal niet. Dus ik weet niet precies wat het ideaalbeeld nou eigenlijk is en of dat een realistisch een wenselijk ideaalbeeld is. (…) het idee van dat het ideaal transdisciplinair is (…) dat veronderstelt toch nog steeds dat je moet vertrekken vanuit iets van kennis vanuit een discipline (…) Ja en ik denk dus eigenlijk dat je juist wel al best heel veel van een discipline moet weten om vruchtbaar met anderen samen te kunnen werken" [10]

Descriptions of transdisciplinarity were (1) that it involves both academic and non-academic stakeholders (5/12th), (2) that it involves holistic thinking and introduces a broader perspective (4/12th), (3) that it leads to synergy (3/12th), (4) it means letting go of boundaries (2/12th), and (5) it concerns building bridges (2/12th). The latter is portrayed by the first quote below. The second quote portrays how one person specified that people need to think of their own knowledge and approach as not being fully formed, so that it becomes possible to be open to other ideas and approaches to form new approaches in a transdisciplinary way. The descriptions of transdisciplinarity were only mentioned by people in a leadership position or philosophers and mainly by people from the TUD.

"Nou ik zou het anders zien bij Digital Twin. Juist niet dat er een overlap is maar dat de ruimte tussen disciplines wordt gevuld en dat is behoorlijk uniek aan dit project (…) Die ruimtes of disciplines nu die liggen nu nog wat uit elkaar en (…) de verbindende bruggen ertussen, die bestaan nog niet. En die Digital Twin zit wel heel duidelijk daarbinnen, dus die verbindt echt disciplines (...) In die zin is het transdisciplinaire niet met een overlap maar juist de ruimte die wordt opgevuld en dat is wel heel leuk aan dit onderzoek" [4]

"(…) rather than two well-formed approaches coming together, what you want to do is conceive of your own approach as being in formation.

Therefore, something new can promote that transdisciplinary attitude towards research methods and prioritizations" [12]

ADDITIONAL INSIGHTS CONCERNING THE COLLABORATION

Diversity in the background of team members seemed to be a prominent characteristic of the Digital Twin collaboration as it was mentioned by 8/12th of the interviewees. Furthermore, 7/12th described the collaboration as time consuming. Additionally, the collaboration was experienced as vague, unclear, or ambiguous by 5/12th. Of the interviewees, 2/12th referred to the collaboration as complex.

The overall goal of the Digital Twin project was said by 5/12th of the interviewees to be to learn to work together and bring people from the two institutions closer together. Someone even specified the Digital Twin project as a learning project. In line with that, it was said by 3/12th that taking part in collaboration makes (future) collaboration easier.

Additionally, the collaboration was said by 3/12th to be more bottom-up than top-down, which is not what most people are used to. Bottom-up collaboration means starting with the collaboration itself and moving towards clarity as you try to collaborate instead of everything being clear from the beginning, as can be concluded from the following two quotes:

"(…) vager algemeen idee van Digital Twin. Het is wel een heel breed concept en hier moet je dan in (…) toch wat brede vraagstelling als ware bottom-up je samenwerkingen zoeken met anderen. Dus het is in die zin echt een omgekeerd traject en dat is wel anders ja" [6]

"Usually, you start collaborating with a group of people you have something in common with (…) for example, you want to work in this field. And this group, for example, has expertise in conducting this kind of work. And (…) you don't have expertise in everything. So, you would ask another group that they know has expertise in that field. So, you invite them to collaborate (…) We have just started to collaborate and so, now we are saying 'Okay, what are we going to do together and how can we use the knowledge that we have in both sides to make a common project?'. I think that's the difference." [7]

3.2.2 CONCLUSIONS

Based on the findings from sub-section 3.2.1, research sub-questions 4a, 4b, and 4c can be answered. Recall research question 4 with its subparts 4a, 4b, and 4c:

4. What are the core elements of transdisciplinary collaboration in the Digital Twin project context?
    a. How is the collaboration perceived by people involved in the Digital Twin project?
    b. How is transdisciplinarity perceived by people involved in the Digital Twin project?
    c. What elements do people involved in the Digital Twin project perceive as important to collaboration?
    d. How do these perceptions and elements relate to the transdisciplinarity core elements found in literature?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 4A

The collaboration is perceived as follows:

- It is going well
- It is challenging. Four challenges were identified: (1) differences in expectations, (2) the online environment, (3) institutional boundaries, and (4) cultural differences resulting in, for example, differences in how research is done and incentives.
- It is time consuming
- It is vague, unclear, and ambiguous
- It is complex

- It consists of team members with diverse backgrounds
- It is new and introduces a new way of working, namely bottom-up instead of top-down
- It is seen as a learning project
- It is seen as multi-, inter- and (partly or working towards) transdisciplinary

ANSWER TO RESEARCH SUB-QUESTION 4B

The people who were able to make sense of transdisciplinarity mentioned the following characteristics:

- It involves both academic and non-academic stakeholders
- It introduces holistic thinking or a broad perspective
- It results in synergy
- It means letting go of boundaries
- It means building bridges between disciplines
- It involves building onto disciplinary expertise

Furthermore, the necessity of transdisciplinarity was questioned by some.

ANSWER TO RESEARCH SUB-QUESTION 4C

The following elements were said to be important or beneficial for collaboration:

- A common language
- Open discussion (including talking about expectations, a willingness to contribute, and discuss biases and assumptions and iterate on them)
- (Informal) social interaction
- Clarity & concreteness
- People being open to sharing
- A connection between people, projects, and the institutions (interrelatedness)
- Knowing what others can contribute
- Shared goals
- Creativity
- Trust
- Reciprocity
- Daring to speak up
- Calmness
- A willingness to listen
- The installation of incentives for this type of collaboration

3.3 RESULTS ON LEARNING

The results that will be discussed in this chapter are based on Table D.2 in Appendix D. The information in this is based on the full transcripts of the interviews and the structural coding used in Atlas Ti 9. From this table, concluding statements and their significance were subtracted and put in Table E.2 in Appendix E. Significance refers to the number of people that said a statement or something along those lines (1 to 12) as well as their role (G, L, PD, PH, PI) and institution (EMC, TUD). These are listed in numerical or alphabetical order.

Several quotes used in the interview results mentioned next will in Dutch. The reason for this is that those interviews were conducted in Dutch.

3.3.1 INTERVIEW RESULTS ON LEARNING

HOW LEARNING IS TAKING PLACE

Learning was said by 6/12th of the interviewees to currently not being given explicit attention. Of the interviewees, 6/12th said learning is taking place implicitly and 3/12th even said learning is an inherent part of doing research.

Furthermore, learning on a theoretical basis often involving self-study as well as a practical basis where people try to apply the newly acquired knowledge were both mentioned by 6/12th of the interviewees as ways of learning something new. However, what method works best was said by 2/12th to depend on the context and the nature of what needs to be learned.

BENEFICIAL FOR LEARNING

Despite the perception that learning is currently not being given (enough) explicit attention, 9/12th thought making learning explicit would be beneficial for learning. Making learning explicit was even said by someone to contribute to the development of a common understanding, as is portrayed in the following quote:

A: "Do you think learning should get explicit attention?" B: "Oh, yes, I think. (…) Now I have some ideas of this neural networks but I'm not the expert at all. But before I would not be able to collaborate with anyone on this at all if I wouldn't have some small basic knowledge. So, I think it is necessary to go to some level to be able to collaborate." [8]

(Informal) social interaction was mentioned by 7/12th of the interviewees to be beneficial to learning. Failure and openness were mentioned by 4/12th. Interestingly, failure was mentioned only by people from the TUD and people either in a leadership position or philosophers. Openness refers to openness to others and other disciplines, as well as openness to the unexpected, as can be concluded from the quotes below.

"(…) ik zou ook hier weer zeggen dat je open moet staan voor het leren van totaal andere inzichten uit de andere vakgebieden. Dus ja die flexibiliteit intellectueel, die is denk ik heel belangrijk" [11]

"You won't learn the things you need to learn unless you're willing to open yourself up to ideas you didn't expect, because then you've already pre-determined what you're going to learn" [12]

Additionally, experimentation and getting feedback were mentioned by 3/12th of the interviewees to be beneficial to learning. Diversity was mentioned by 2/12th to be beneficial. Furthermore, 2/12th mentioned that the relevance of what is to be learned influences the commitment to learning it. Additionally, creativity, trust, respect, and a humble attitude were mentioned as beneficial for learning, but only once. One person pointed out that one must expand one's boundaries or go beyond their comfort zone to learn. In line with that, this same person explained how clear boundaries make it easier to seek out learning opportunities, as is portrayed by the quote below.

"Er is altijd gewoon meer mogelijk. Ook binnen zo'n onderzoeksvraag (…) In het begin weet je dat nog niet zo goed waar die [grenzen] liggen. Die worden steeds concreter. En vervolgens, als ze concreet zijn, kan je ze steeds een beetje gaan verschuiven" [4]

3.3.2 CONCLUSIONS

Based on the findings from sub-section 3.3.1, research sub-questions 5a and 5b can be answered. Recall research question 5 with its subparts 5a and 5b:

5. What are the core elements of learning in the Digital Twin project context?
    a. How do people involved in the Digital Twin project currently learn?
    b. What elements do people involved in the Digital Twin project perceive as important to learning?
    c. How do these elements relate to the learning core elements found in literature?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 5A

Learning is currently mainly taking place implicitly and is seen as an implicit part of doing research. It is not being given explicit attention. Furthermore, learning is taking place through the methods of theoretical self-study and practical application possibly involving social interaction.

ANSWER TO RESEARCH SUB-QUESTION 5B

The following elements were said by interviewees to be important or beneficial to learning:

- Making learning explicit
- (informal) social interaction
- Failure
- Openness (to others, to other disciplines, and to the unexpected)
- Experimentation
- Getting feedback
- Relevance of what needs to be learned
- Creativity
- Trust
- Respect
- Humble attitude
- Going beyond your comfort zone

3.4 RESULTS ON LEADERSHIP

The results that will be discussed in this chapter are based on Table D.3 in Appendix D. The information in this is based on the full transcripts of the interviews and the structural coding used in Atlas Ti 9. From this table, concluding statements and their significance were subtracted and put in Table E.3 in Appendix E. Significance refers to the number of people that said a statement or something along those lines (1 to 12) as well as their role (G, L, PD, PH, PI) and institution (EMC, TUD). These are listed in numerical or alphabetical order.

Several quotes used in the interview results mentioned next will in Dutch. The reason for this is that those interviews were conducted in Dutch. Furthermore, no quotation marks will be shown when a 'quote' from person [2] is shown. The reason for this is that this person did not consent to the interview being recorded. Consequently, any examples from that interview were based on notes and are thus no actual quotes.

3.4.1 INTERVIEWS RESULTS ON LEADERSHIP

WHAT LEADERS NEED TO DO

It was mentioned by 8/12th of the interviewees that leaders must follow up on people and stay on top of things, have the ability to adapt to changing circumstances, and have a facilitating role. Specifically, the ability to respond to changing circumstances goes beyond the leader themselves. As the quote below portrays, it is important to increase the leader role ability of team members so they can take up a leader role and step up if their specific skills are needed to deal with a new situation.

"In response to changing situations, but also to contribute their unique perspective and experience and expertise. Because in these kinds of situations [this new project], you're never actually quite sure beforehand what's going to be important. So, you have to be prepared to pick up on cues and for people to step up when they have something to offer" [12]

A facilitating role concerns facilitating processes for people to meet, facilitating processes needed to achieve goals, and facilitating opportunities for open discussion as well as for collaboration, as can be concluded from the quotes below. Open discussion was also linked to the development of a common language.

"(…) van onderaf is het is echt de wetenschappers die elkaar gaan vinden. Ja dan gaat er iets ontstaan en dat kan je natuurlijk faciliteren met support staff en daar hen in helpen en ook in activeren" [1]

"I mean leadership is typically somebody or who is here to organize and structure stuff so that the goal can be achieved with higher reliability or something like that" [5]

"(…) wat we ook wel in het Digital Twin proberen is dat wij met de postdocs zulke soort seminars (…) lezingen (…) houden. Als je kan beginnen met een soort dialoog van 'Kennen jullie deze problemen?' of 'Hebben jullie heel andere problemen?' (…) een serie van een aantal bijeenkomsten gepland, daar geweest, en door maar gewoon concreet over dingen te gaan praten en uitleg te geven hopen dat je daar gaandeweg wat meer van die common language gaat ontwikkelen" [10]

Providing clarity was prominently mentioned by 7/12th to be essential for a leader to do. Furthermore, providing team members with autonomy was said by 6/12th to be important for leaders to do. The need for autonomy may, however, be related to the sciences as portrayed by the quotes below.

"(…) you're kind of your own leader right. Academia is not a strictly hierarchical thing anyway (…) this is how it kind of always works. You're always responsible for your own things and making up your own plans." [5]

A: "Because scientists like to be more autonomous, or not?" B: "Yes, they like to be more autonomous" [5]

Being concrete or providing concreteness and being open to different backgrounds and interests was mentioned by 5/12th to be necessary for a leader to do. The latter was mainly mentioned by people from the EMC. Additionally, having the ability to connect people and taking values and interests of individuals into account was mentioned by 4/12th to be important for leaders. Based on the quotes below, connecting people is not only about helping to make connections between people (from different communities) but also for leaders to be connected to the communities themselves. Furthermore, connecting people is also about connecting people to the overall vision or goal.

Je moet verbinding met de community zoeken en bottom-up vanuit die community ophalen wat daar leeft [2]

"Ik vind dat wel soort van, ja soort perspectief, een soort route en een soort mensen samenbrengen vanuit een idee. 'Dit is waarvoor we staan' of 'Dit is waar we heen willen' of 'Dit is het gezamenlijke doel en hoe gaan we dat doen'" [10]

"(…) the team leaders did some work to explicitly reach out in their process and ask for advice but also she, she made connections among the postdocs" [12]

Making connections between people and making sure people stay connected to the overall goal may be especially important in the scientific context of the Digital Twin project, as is portrayed by the following quote:

"Ja wij wetenschappers in het algemeen… Ik ben niet de enige die het druk heeft. Er zijn er meer die het druk hebben dus (...) de focus gaat al heel snel liggen op het eigen op de eigen interesse, of in ieder geval zorgen dat je dat het eigen stukje wat je uit een project wil halen goed afsluit en iets minder oog hebt voor de samenwerking" [4]

Leaders were mentioned by 3/12th to have to provide support, be proactive, provide vision, be able to deal and communicate with a diversity of people, be open in their communication, be aware of what is going on in the community, inspire and engage others, and invest time and effort. Providing vision, inspiring and engaging others, and investing time and effort were mainly if not only mentioned by people in leadership roles. One of them specifically mentioned that it would have been more beneficial for this project to have had less people to decrease the time spent on getting to know each other and to increase the time spent on exploration, as can be concluded from the quote below.

"(…) eigenlijk vind ik het project een beetje groot moet ik zeggen. Ik was als katalysator liever begonnen met de helft van alle medewerkers omdat je

dan iets minder tijd kwijt bent aan het projectmanagement en aan elkaar leren kennen en iets meer tijd kan steken in het ontdekken van nieuwe richtingen" [4]

Of the interviewees, 2/12th mentioned leaders should be brave and have guts, allow for failure, provide others with feedback, and provide a safe and inclusive environment. Helping people get out of their comfort zone, having social skills, adopting a learning mindset to their own leadership, valuing diversity, and being humble were mentioned, but only once. Interestingly, more diversity was mentioned by one person to necessitate more direction from leaders. Based on the quote below, humility includes an awareness of the struggles and failures one has had to overcome to be where they are now.

"I think it's a recognition that you also went through all of that at one point. You also had to learn all of these things and you were also wrong many times. When we are living in a world created by our successes, we forget about how the failures actually allowed us to get there too, that we had to make those mistakes and do those things wrong. So, yeah, it's humility in your own development of skills. So, an awareness of the fact that you had to develop these skills that you have that they were not innate and or blessed upon you because you were born into the right family right. So, there's definitely a leadership potential to forgetting the ladder that you climbed" [12]

TYPES OF LEADERSHIP

Duality in leadership was recognized by 10/12th of the interviewees as necessary. Several types of dualities were mentioned explicitly – explicitly in the sense that the duality was mentioned in the same part of the conversation and by the same person. The most prominent ones, mentioned by 5/12th of the interviewees, were (1) a duality of balancing between the overall goal (overview) and the individual goals of institutions/individuals (detail), and (2) a duality of providing autonomy and giving direction. Furthermore, 2/12th mentioned the importance of an internal and external focus of a leader. This duality can also be concluded from has been stated previously to be important for a leader to have or do. One person mentioned that leaders should have both a short-term and long-term focus.

Another duality that can be concluded from what has previously been stated is bottom-up and top-down leadership. The first is about facilitation and the latter about providing clarity of and connection to the overall goal, as can be concluded from the quote below. However, this duality relates to the duality of autonomy & direction: facilitation in essence means giving people the tools to do something themselves and direction is needed to provide clarity concerning the overall goal and to ensure the overall goal is kept in mind. Therefore, the duality of top-down & bottom-up leadership will not be seen as a separate duality.

"Tuurlijk het moet snelheid hebben maar convergentie is het belangrijkst (…) dus daar hebben we qua proces even wat scherp paaltjes gezet en heeft de bestuurder dus ook de wetenschapper aangesproken van 'Je doet het hartstikke goed, maar convergentie is het uitgangspunt'. Dat is dan even van bovenaf. Van onderaf is het is echt de wetenschappers die elkaar gaan vinden. Ja dan gaat er iets ontstaan en dat kan je natuurlijk faciliteren met support staff en daar hen in helpen en ook in activeren" [1]

Distributed leadership is clearly present as portrayed by 7/12th of the interviewees. One person even experienced distributed leadership as an opportunity to experiment and as a contribution to learning, as can be concluded from the quote below. In line with distributed leadership, 2/12th of the interviewees mentioned diversity in leadership as well as an interplay between different leaders and styles of leadership to be important. Someone even explicitly said leaders should consult with each other.

"Ja dat vind ik wel leuk om te leren en ook belangrijk om te weten. Ik gebruik het een klein beetje als een test punt van 'Hoe ga ik er nou mee om voor mezelf zeg maar in de andere projecten' en dan vind ik het juist wel

heel erg fijn omdat ik het samen met other leader person *doe, want anders zou het mij veel te veel tijd kosten. Dan zou ik het misschien niet waard vinden om te doen. Wat ik verder ook wel leuk vind is de rolverdeling bij ons zelf.* Other leader person *die zit er veel inhoudelijk erin dan ik. Ik wil het gewoon toepassen. (…) heel prettig dat* other leader person *eigenlijk inhoudelijk betrokken is en ik kan een beetje dingen uitproberen over projectmanagement en interdisciplinaire samenwerking en een klein beetje over data" [4]*

Both formal and informal leadership, mentioned by 6/12th and 5/12th of the interviewees respectively, are present forms of leadership in the Digital Twin project. The combination of these types provides another duality in leadership. Both forms were mainly mentioned by people from the EMC. Interestingly, formal leadership was said to be able to influence the formation of informal leadership, as can be concluded from the quotes below.

"So, my counterpart was very willing to do things, but then his supervisors were breaking him. They were saying 'No, you should not invest so much time into writing this proposal. (…) You can do better something else'. So then, I think he went a little bit more in the background." [9]

A: "And that just evolved?" B: "I think that his supervisor pushed him also. So, at the first meeting I wouldn't say that he was immediately taking the lead by himself, but I think it was also from his supervisor. But it fits. It fits him. So, now I know him better. I think he's very good at it also." [9]

BENEFICIAL FOR LEADERSHIP

Three things were mentioned by several people to be beneficial for leaders to have. Namely (1) status, prestige, or expertise (5/12th), (2) trust (3/12th), and (3) experience in leadership (3/12th). The first and third were even said to be specific to the scientific context. The first is illustrated by the quotes provided below. Furthermore, one person mentioned that a willingness to lead is beneficial for the effectiveness of leadership.

"(...) is wel een boegbeeld. Dit moet wel een wetenschapper met bepaald aanzien zijn op dat vlak" [1]

"Ik denk in zijn algemeenheid dat als je wetenschappers bij elkaar zet, dan moet de leider op basis van kennis geaccepteerd worden als leider door zijn collega's" [6]

"We only had one medical doctor working there, so only he has some expertise with what data is relevant. Even while I work as a statistician, I cannot formulate clinically relevant research questions. (…) It's just not possible. So, then this one medical doctor took the lead and arranged things with the data" [9]

LEADERSHIP IN RELATION TO THE DIGITAL TWIN PROJECT CONTEXT

Several leadership behaviors were explicitly mentioned by interviewees to be important in relation to the Digital Twin project context. These were as follows:

1. The leader must have a particular status, prestige, or expertise
2. Leaders should be able to adapt to changing circumstances
3. Leaders should be aware of differences in backgrounds or disciplines
4. Leaders should give autonomy to scientists
5. There should be an interplay between scientific formal director and an informal secretary or operational support
6. The leader should be connected to the community
7. In a research environment, leaders should clarify that the process is not linear
8. A leader must ensure that team members focus on the collaboration instead of on just their own interests and goals
9. Besides a content-focused leader, a leader that keeps the overview would be beneficial
10. It would be beneficial for leaders to have experience in leading

11. It would be beneficial for leaders to have experience in working in multidisciplinary projects
12. Leaders must be willing to lead
13. Leaders must be practical and help find the next step
14. Leaders play a role in in establishing stronger incentives or more recognition for these types of collaboration
15. Leaders should have a vision
16. Leaders have a facilitating role
17. Leaders should provide direction
18. Leaders should tolerate failure
19. Leaders should be open-minded
20. Leaders should establish a safe and inclusive environment
21. Leaders should value diversity
22. Leaders should connect people to the overall goal
23. Leaders should not impose things in a top-down way

Numbers 1-4 were mentioned by 2/12th of the interviewees in specific relation to the Digital Twin project context. The rest was only mentioned once. Note that numbers only 7, 11, and 14 are insights that have not been stated earlier.

LEADERSHIP IN RELATION TO LEARNING

Leadership was said by 3/12th of the interviewees to play a role in making learning explicit. Developing a learning mindset was also mentioned by 3/12th to be something leadership has an influence on. Specifically, one interviewee remarked that leaders should adopt a learning mindset towards their own leadership.

Some leadership behaviors were explicitly mentioned by interviewees to be important in relation to learning. These were: tolerating failure, getting people out of their comfort zone, being supportive, being vigorous, having vision, setting clear goals, linking what needs to be learned to the project or individual needs, being future-oriented, providing opportunities for people to learn (for example by facilitating social interaction with people with specific expertise), and making learning explicit (for example by mentioning it or initiating a 'lessons learned' report for future projects). Only tolerating failure was mentioned by 2/12th of the interviewees. The rest was only mentioned once.

3.4.2 CONCLUSIONS

Based on the findings from sub-section 3.4.1, research sub-questions 6a and 6c can be answered. Recall research question 6 with its subparts 6a and 6c:

6. What leadership styles, structures, or behaviors are necessary or appropriate for leadership in the Digital Twin project context?
    a. What elements do people involved in the Digital Twin project perceive as important to or in leadership?
    b. How do these elements relate to the leadership core elements found in literature?
    c. What leadership styles or structures do people involved in the Digital Twin project perceive as important to or in leadership?
    d. How do these styles or structures relate to the leadership styles or structures found in literature?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 6A

Based on the interviews, it can be said that leaders need to:

1. Stay on top of things and provide direction
2. Adapt to changing circumstances
3. Facilitate
    a. Opportunities for scientists to meet

    b. Processes needed to achieve goals
    c. Open discussion
    d. Opportunities for collaboration
    e. Opportunities for learning
4. Provide clarity
5. Be concrete and provide concreteness
6. Provide team members with autonomy
7. Be open to and aware of different backgrounds and interests
8. Be able to connect people
    a. Connections between people
    b. Be connected to communities
    c. Connect people to the overall vision or goal
9. Take values and interests of individuals into account
10. Provide support
11. Be proactive
12. Provide vision
13. Be able to deal and communicate with a diversity of people
14. Be open in their communication
15. Be aware of what is going on in the community
16. Inspire and engage others
17. Invest time and effort
18. Be brave and have guts
19. Allow for failure
20. Provide others with feedback
21. Provide a safe and inclusive environment
22. Help people get out of their comfort zone
23. Have social skills
24. Adopt a learning mindset to their own leadership
25. Value diversity
26. Be humble (be aware of struggles and failures)
27. Have status, prestige, and expertise
28. Trust and have trust
29. Have experience
    a. In leadership
    b. In working in or with multidisciplinary teams
30. Be vigorous
31. Set clear goals
32. Link what needs to be learned to the project or individual goals
33. Be future-oriented
34. Make learning explicit
35. Clarify that the research process is not linear
36. Willing to lead
37. Be practical
38. Introduce incentives for such collaboration types
39. Ensure a focus on collaboration and not just on personal interests
40. Not impose things in a top-down way

Numbers 1, 2, 3, 6, 7, 8bc, 12, 19, 21, 25, 27, 29ab, 35, 36, 37, 38, 39, 40 were mentioned specifically to be important for a leader to do in the Digital Twin project context. Furthermore, the duality of overview & detail was also mentioned in specific relation to the Digital Twin project context. Numbers 3e, 10, 12, 19, 22, 30, 31, 32, 33, and 34 were mentioned specifically to be important for a leader to do to stimulate learning.

ANSWER TO RESEARCH SUB-QUESTION 6C

From the interviews, the following leadership styles or structures can be extracted:

- A duality in leadership. Dualities that were mentioned explicitly are: (1) a duality of balancing between the overall goal (overview) & the individual goals of institutions/individuals (detail), and (2) a duality of providing autonomy & giving direction, (3) a duality of an internal focus & an external focus, and (4) a duality of a short-term focus & a long-term focus. An additional duality that could be extracted implicitly from the interviews is a duality of formal leadership & informal leadership.

- Distributed leadership (which also allows for experimentation within leadership). Specifically, an interplay between leaders as well as different styles of leadership were said to be important.

4 COMBINING THEORY AND PRACTICE

In this chapter, the insights from chapters 2 and 3 will be combined. This chapter consists of three sections. In each section, insights from the literature study and the qualitative study concerning one of the three main topics – transdisciplinary collaboration, learning, leadership – will be contrasted and compared, and answers to the corresponding research (sub-)questions will be given. Furthermore, updated visualizations based on these answers will be provided.

4.1 COMBINING THEORY AND PRACTICE – (TRANSDISCIPLINARY) COLLABORATION

4.1.1 CONTRASTING AND COMPARING INSIGHTS FROM THE LITERATURE STUDY AND QUALITATIVE STUDY ON (TRANSDISCIPLINARY) COLLABORATION

In sub-section 2.2.5 it was concluded that, from a theoretical point of view, the core elements of transdisciplinary collaboration are (1) complexity, (2) ambiguity, (3) holism, (4) multitude of communities (in the form of non-academic and academic fields and stakeholders), (5) attitude change, (6) common language, and (7) trust. Of these mentioned seven elements, all but one (attitude change) was named explicitly, either in relation to transdisciplinary collaboration specifically or in relation to the experienced collaboration in the Digital Twin project. However, the necessity of an attitude change can still be concluded from the interviews. Namely, it was mentioned in relation to collaboration that new incentives would need to be installed to make contributing to projects such as that of Digital Twin more attractive. This means that what is currently perceived as important or valuable in contributing to science needs to be adjusted. Furthermore, the collaboration of Digital Twin introduced a new bottom-up approach to the collaboration. This approach was said to be different from what people in science are used to and thus necessitates a different mindset towards collaboration. Additionally, the idea of knowledge and approaches being in formation, and thus never truly finished and therefore dynamic, was posed to be needed for the formation of approaches in a transdisciplinary way. Seeing existing expert knowledge as dynamic introduces a new way of looking at knowledge and knowledge sharing. Finally, the goal of the Digital Twin project was said to be to learn to work together and bring people from the two institutions closer together. It was even once described as a learning project. Not having a certain number of publications or scientific breakthroughs as the goal of a project is a novelty in the scientific community and therefore necessitates a change of attitude towards the project and what entails a success.

Besides a multitude of communities and holistic thinking, synergy, letting go of boundaries, and building bridges were mentioned in descriptions of transdisciplinary collaboration. Synergy and letting go of boundaries are elements of transdisciplinarity that were found in theory as well. However, synergy can be seen as a product of transdisciplinarity and is therefore not a core element of it. Letting go of (disciplinary boundaries) again relates to the attitude change as well as to a holistic approach, and is therefore already incorporated in the core elements. An interrelatedness was mentioned where a connection between people, projects, and the institutions is necessary for the Digital Twin project context, which relates to holism as well.

Interestingly, building bridges is a slightly different approach to transdisciplinarity than was described from a theoretical point of view. These bridges were said to be built through the formulation of shared goals and shared goals were named as being beneficial to the collaboration as well. Additionally, one interviewee remarked that the knowledge contributed to a transdisciplinary collaboration would still originate from disciplinary expertise. Building bridges together with disciplinary expertise being the building blocks of transdisciplinarity somewhat weakens the theoretical approach to transdisciplinarity as transcending boundaries to the extent that no boundaries can be discerned. It was mentioned in theory

that disciplinary depth of knowledge is needed, but the transcending of boundaries somewhat blurred this specificity. This should be rectified as it was specifically mentioned in the interviews. So, even though transdisciplinarity ideally results in new knowledge and a new approach to complex problems, this knowledge and these approaches will be based on disciplinary knowledge. Therefore, completely fading the disciplinary boundaries is not possible and is therefore substituted by building bridges between disciplines, formed by formulating shared goals, and a slight blurring of the disciplinary boundaries to make this formulation possible.

Despite the fact that the theoretical core elements of transdisciplinary collaboration were also mentioned in or could be extrapolated from the interviews, most of the elements were not mentioned explicitly in relation to *transdisciplinary* collaboration. In fact, there was confusion about the different types of collaboration (multi-, inter-, and trans-) and some people even expressed some criticism towards the need for either labelling the collaboration or the need for transdisciplinarity altogether. Furthermore, descriptions of transdisciplinarity were only given by people in leadership positions. All this implies that a common understanding of what transdisciplinarity is, why it is needed for the Convergence Agenda, and how it relates to the Digital Twin project and the collaboration therein have come up short. On the bright side, the collaboration is clearly perceived to be going well, which provides a good basis for future collaboration. Furthermore, based on the links that were drawn between transdisciplinarity elements based on theory and descriptions of the collaboration in the Digital Twin project context, there is some indication that the collaboration taking place within the Digital Twin project is indeed transdisciplinary. However, this cannot be said with certainty. Therefore, only the elements from the interviews that can be linked to core elements of transdisciplinarity were taken into account in the re-evaluation of what transdisciplinarity is. The elements from the interviews concerning the collaboration that were not taken into account are:

- It is challenging. Four challenges were identified: (1) differences in expectations, (2) the online environment, (3) institutional boundaries, and (4) cultural differences resulting in, for example, differences in how research is done and incentives.
- It is time consuming
- Open discussion (including talking about expectations, a willingness to contribute, and discuss biases and assumptions and iterate on them)
- (informal) social interaction
- Clarity & concreteness
- People being open to sharing
- Knowing what others can contribute
- Creativity
- Reciprocity
- Daring to speak up
- Calmness
- A willingness to listen

4.1.2 CONCLUSIONS

Based on the findings from sub-section 4.1.1, research sub-question 4c, and thus research question 4, can be answered. Recall research question 4, with its subpart 4c:

4. What are the core elements of transdisciplinary collaboration in the Digital Twin project context?
    a. What elements do people involved in the Digital Twin project perceive as important to collaboration?
    b. What elements do people involved in the Digital Twin project perceive as important to collaboration?
    c. How do these perceptions and elements relate to the transdisciplinarity core elements found in literature?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 4C

Complexity, ambiguity, holism, multitude of communities, common language, and trust relate directly to core elements of transdisciplinarity from literature. The necessity to install incentives for the type of collaboration of the Digital Twin project together with the new bottom-up approach, seeing expert knowledge as dynamic, and the goal of the Digital Twin project to be getting to know each other better and learning, was linked to attitude change.

Synergy is indeed related to transdisciplinarity, but it a result of it and therefore not a core element. Letting go of boundaries relates to the holistic approach and the attitude change. Interrelatedness can be connected to holism.

Building bridges through the formulation of shared goals together with the notion that newly created knowledge would still be based on disciplinary expertise, weakened the idea that transdisciplinarity involves indiscernible boundaries. Therefore, boundaries are not completely faded and an emphasis on knowledge originating from disciplinary expertise is added.

In the end, the core elements of transdisciplinarity are still *complexity, ambiguity, holism, multitude of communities, attitude change, common language,* and *trust*. The structure of transdisciplinarity, however, is not one of indiscernible boundaries. Rather, it is a gathering of communities with blurred boundaries from which expert knowledge is drawn. The communities are connected through bridges formed by shared goals. The expert knowledge is applied to the realization of these shared goals, which in turn results in new knowledge and thus a new (perception of) reality.

ANSWER TO RESEARCH QUESTION 4

The core elements of transdisciplinary collaboration in the Digital Twin project context are: *complexity, ambiguity, holism, multitude of communities, attitude change, common language,* and *trust*. Transdisciplinarity can be seen as a gathering of communities with blurred boundaries from which expert knowledge is drawn. The communities are connected through bridges formed by shared goals. The expert knowledge is applied to the realization of these shared goals, which in turn results in new knowledge and thus a new (perception of) reality.

4.1.3 VISUALIZATION OF TRANSDISCIPLINARY COLLABORATION BASED ON THEORY AND PRACTICE

Based on the conclusions drawn in sub-section 4.1.2, it can be said that the simplified conceptual visualization initially made for transdisciplinary collaboration (Figure 2.4), still holds. There are two reasons for this. First, all core elements shown in Figure 2.4 still hold after comparing it to empirical data. Second, no core elements based on empirical data were added. For the sake of clarity and completeness, Figure 4.1 again portrays the visualization of Figure 2.4.

Figure 4.2 shows the forces that are at play in transdisciplinary collaboration. It is different from Figure 2.3 since it does not show one kernel in which different communities cannot be discerned anymore. Instead, Figure 4.2 shows how knowledge from (disciplinary) expertise, combined with insights from a combination of communities, results in new models and knowledge that then becomes part of reality in which these communities and combinations of communities exists. It shows how transdisciplinarity is indeed not looking for unity, but coherence. It does so by not completely fading the boundaries of disciplines, but rather making them more fluid and open to others. Building bridges between communities by formulating shared goals allows for both the further development of expert knowledge and the development of new holistic insights based on that expertise. By

building bridges, it is not necessary for disciplines to already overlap to start collaborating.

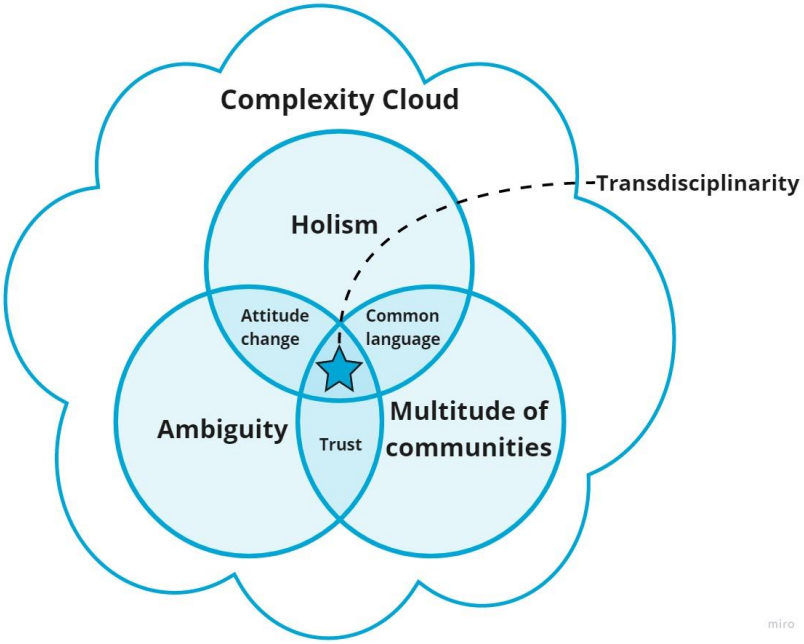


Figure 4.1: Conceptual visualization of the core elements of transdisciplinarity where complexity is the context, holism, ambiguity, and a multitude of communities are the defining characteristics, and trust, attitude change, and a common language are the necessities to make transdisciplinarity work.

Note how in Figure 4.2 the colors of the 'original' communities are red, yellow, and blue, and how the colors of the combination of communities working together are a combination of those colors, namely, orange, green, and purple. Remember how synergy was said to be a result of transdisciplinary collaboration. Synergy can be explained using colors as is shown in the Synergy Fishtail in Figure 4.3. It is important to note that this principle also applies to Figure 4.2, but for the sake of simplicity the more straightforward combination of colors was chosen.

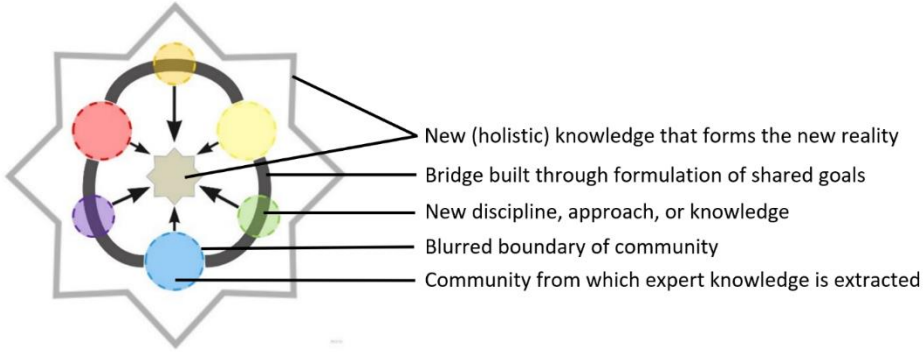


Figure 4.2: The Multicolored Star of Transdisciplinarity. This figure shows how shared goals build bridges between disciplines with fluid boundaries from which expert knowledge is extracted to form new knowledge and create a new reality.

The Synergy Fishtail of Figure 4.3 shows how a combination of knowledge can result in unforeseen outcomes. The orange and purple communities have decided to work together. One might initially think that 'mixing' their knowledge would result in something straightforward, such as brown. However, when taking a closer look at what their knowledge consists of, new combinations become possible. This can result in the agreement of certain knowledge, however now from multiple perspectives, which makes it stronger (red). Another option is that it results in a completely new approach and new knowledge (green). In any case, no one would have initially thought that red and green can come from orange and purple. This is only possible after a re-evaluation of existing knowledge and viewing it as dynamic instead of static.

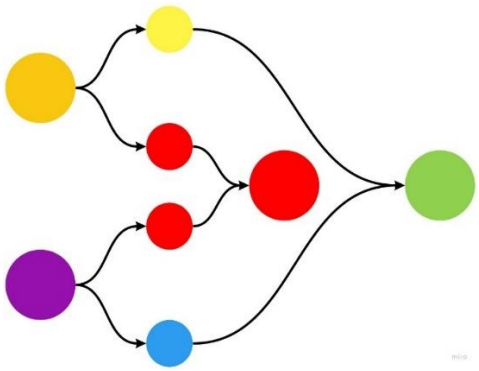


Figure 4.3: The Synergy Fishtail. This figure shows how a combination of knowledge can result in unforeseen outcomes.

4.2 COMBINING THEORY AND PRACTICE – LEARNING

4.2.1 CONTRASTING AND COMPARING INSIGHTS FROM THE LITERATURE STUDY AND QUALITATIVE STUDY ON LEARNING IN A TRANSDISCIPLINARY COLLABORATION CONTEXT

In sub-section 2.3.7 it was concluded that, from a theoretical point of view, the core elements of learning in a transdisciplinary context are *reflexivity, (informal) social interaction, diversity, experimentation (multiple at a time) and exploitation, inclusion, trust, creativity, learning mindset,* and *a supportive environment*. Trust, diversity, experimentation, (informal) social interactions, and creativity were all explicitly mentioned in the interviews to be beneficial to learning. Furthermore, respect, humility, and openness (to others and the unexpected) were also mentioned to be beneficial to learning, which are all elements of inclusion. Going beyond the comfort zone can in part be related to experimentation as it takes place outside of an individual's known and trusted environment. Even though experimentation might provide more learning opportunities, it must still be balanced with exploitation to ensure a secure base and level of trust, as was explained in chapter 2. Having clear boundaries to make it easier to seek out learning opportunities reminds of the reflexivity that is needed to make the boundaries of the community clear so that fruitful experiments can be performed. A supportive environment was not mentioned explicitly during the interviews to be beneficial to learning. However, one interviewee remarked that, to stimulate learning, a leader should be supportive. Therefore, a supportive environment can still be seen as a necessary element for learning. Making learning explicit, which relates to building a learning mindset, was said to be beneficial to learning. Interestingly, despite the notion that the Digital Twin project is perceived as a learning project, learning has not been made explicit. A reason for this could be the fact that learning is thought to be taking place implicitly and was even said to be an inherent part of research. Even so, explicit attention on learning would be beneficial for the overall learning outcomes, as was expressed by the interviewees as well.

Besides the core elements of learning in a transdisciplinary context from a theoretical point of view, additional elements beneficial to learning were named in the interviews. First, failure was prominently named as being beneficial to learning. Additionally, tolerating failure was named to be important for leaders to do to stimulate learning, as was also supported by theory. Logically, failure is also an implicit part of experimentation. Therefore, failure is an important influence on learning and will therefore be taken up as a core element of learning in a transdisciplinary context. Second, getting feedback was said in the interviews to be important for learning. Getting feedback or input was also mentioned in the literature study in relation to introducing silence. Silence was then linked back to inclusion. I.e., getting feedback is a result of practicing inclusion. Therefore, getting feedback is already implicitly part of the core elements of learning. Third, the relevance of what needs to be learned was named in the interviews to be important for learning. In Appendix F it can be seen that, from a theoretical perspective, the perceived value and relevance of what is to be learned influences learning and learning outcomes. This insight was not

taken into consideration in the literature study, however, since the influence of perceptions and experiences on learning did not relate directly to any of the core elements of transdisciplinary collaboration. Even though it may be an important influence on learning, it will not be taken into account due to the reason mentioned previously. Lastly, multiple learning techniques were reported to be currently used in the Digital Twin project. Namely, theoretical self-study on the one hand and practical application of knowledge, often in combination with others and thus social interaction, on the other hand. In the literature study, it was mentioned that "principles of omnivory (the use of multiple approaches) and redundancy are important under conditions of complexity and deep uncertainty" (Swanson et al., 2010, p. 934). In line with that, introducing blended forms of learning logically better accommodates keeping up with changes in the community and its members. Therefore, a blended learning approach can be said to be beneficial for learning in a transdisciplinary context. This blended learning approach should at least include theoretical self-study and practical application with possibly social interaction to better align with the current way in which team members of Digital Twin learn.

4.2.2 CONCLUSIONS

Based on the findings from sub-section 4.2.1, research sub-question 5b, and thus research question 5, can be answered. Recall research question 5, with its subpart 5b:

1. What are the core elements of learning in the Digital Twin project context?
    a. What elements do people involved in the Digital Twin project perceive as important to learning?
    b. How do these elements relate to the learning core elements found in literature?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 5B

Trust, diversity, experimentation, (informal) social interactions, and creativity relate directly to core elements of transdisciplinarity from literature. Respect, humility, openness, and getting feedback relate to inclusion. Getting out of one's comfort zone partly relates to experimentation. Multiple experiments must take place at a time, but must be balanced by exploitation. Clear (community and personal) boundaries relate to reflexivity. Providing a supportive environment came back in relation to leadership and learning. Making learning explicit is part of a learning mindset. Failure was added as a core element due to the link with experimentation and tolerating failure being named as a behavior leaders should portray to stimulate learning. Getting feedback is a result of practicing inclusion. The relevance of what is to be learned is outside the scope of this Master Thesis project. Due to the principle of omnivory in dealing with complexity and uncertainty, as well as to better accommodate adapting to changes in the community and its members, a blended learning approach is added as a core element of learning in a transdisciplinary collaboration context. Blended learning should include at least theoretical self-study and practical application with possibly social interaction.

ANSWER TO RESEARCH QUESTION 5

The core elements of learning in the Digital Twin project context are:
reflexivity, (informal) social interaction, diversity, experimentation (multiple at a time) and exploitation, inclusion, trust, creativity, learning mindset, and a supportive environment, failure, and *blended learning.*

4.2.3 VISUALIZATION OF LEARNING IN A TRANSDISCIPLINARY CONTEXT BASED ON THEORY AND PRACTICE

Based on the conclusions drawn in section 4.2.2, it can be said that the simplified conceptual visualizations initially made for learning in the context of transdisciplinary collaboration still hold. One of them was adjusted to

include the additional elements of failure and blended learning. The final visualizations are portrayed below, where Figure 4.4 is the newly adapted version of Figure 2.12, and Figure 4.5 is the same as Figure 2.13.

As can be seen in Figure 4.4, both blended learning and failure are placed on the boundary of the learning community, implying they take place both inside and outside of the learning community. This is the case for blended learning since both known and unknown learning techniques can be used to stimulate learning. Additionally, one learning technique that was previously mentioned was practical application of knowledge in collaboration with others, thereby implying social interaction. Social interaction was already placed on the boundary of the learning community, and therefore implies that blended learning should be placed on the boundary as well. Note that the blended learning approach should at least include theoretical self-study and practical application with the possibility of social interaction, since these are methods that are already being used in the Digital Twin project. Logically, failure will mostly take place outside of the learning community, since people are most likely to fail on unknown territory. However, human beings are imperfect and will therefore also encounter failure when taking part in known activities. Therefore, failure is placed on the boundary of the learning community, but mostly outside of it.

Figure 4.5 again portrays how reflexivity is needed to ensure that the actual learning community and the perceived learning community are one and the same. This means that the boundaries of the community are clear and true, which is needed to increase learning opportunities since these are most plentiful at and beyond the boundaries of a community. Knowing where the boundaries of a community are enables more effective deployment of both exploitation and experimentation efforts. For if the boundaries are not known, what would be perceived to be experimentation could very well be exploitation, thereby decreasing the learning opportunities. Therefore, reflexivity is constantly needed to get the most (out of) learning opportunities.

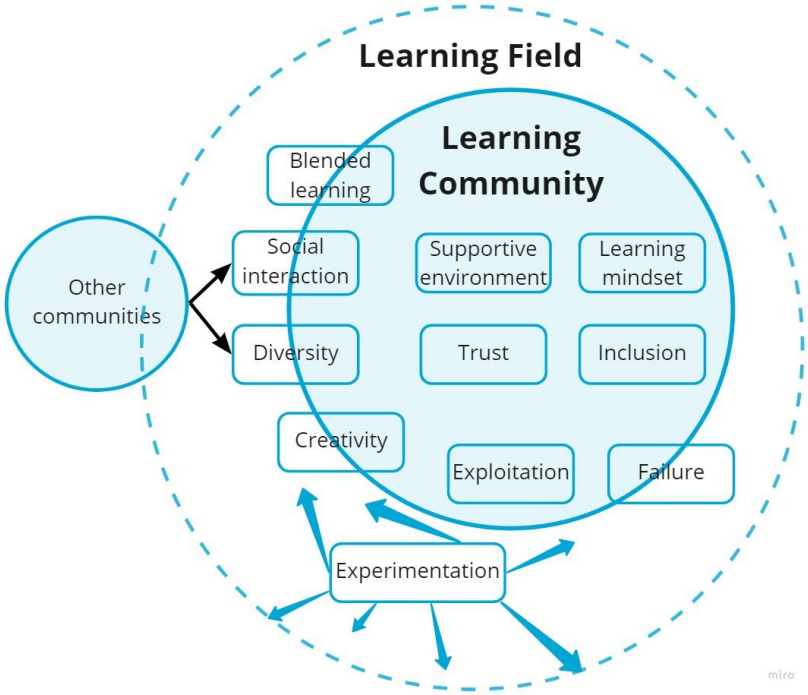


Figure 4.4: A simplified visualization of the core elements of learning in the context of transdisciplinary collaboration based on theory and practice, where the potential for learning is highest in the Learning Field and the border of the Learning Community

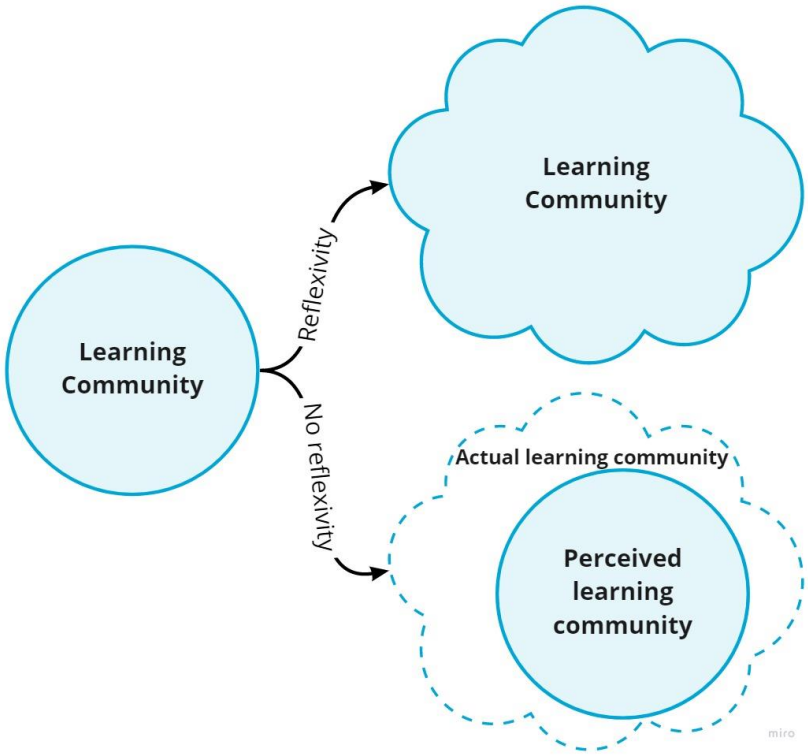


Figure 4.5: A simplified visualization of how reflexivity is needed to enhance the learning opportunities by making the boundaries of the community clear

4.3 COMBINING THEORY AND PRACTICE – LEADERSHIP

4.3.1 CONTRASTING AND COMPARING INSIGHTS FROM THE LITERATURE STUDY AND QUALITATIVE STUDY ON LEADERSHIP TO STIMULATE LEARNING AND HELP DEVELOP A LEARNING MINDSET IN A TRANSDISCIPLINARY COLLABORATION CONTEXT

LEADERSHIP IN RELATION TO TRANSDISCIPLINARY COLLABORATION

In sub-section 2.4.4 it was concluded that, from a theoretical point of view, the core elements of leadership in a transdisciplinary context (from now on referred to as CELTs) are (1) tolerate failure, (2) patience, (3) connect communities, (4) social- & interpersonal skills, (5) encourage diversity, (6) encourage dissent, (7) set boundaries, (8) create & celebrate small wins, (9) link small wins to overall goal, (10) stimulate and facilitate open & honest dialogue, (11) facilitate formal & informal interactions with a diversity of people, (12) duality of practical short-term goals & long-term vision, (13) duality of autonomy & direction, (14) duality of (facilitating) exploitation & experimentation, and (15) iteration of What, How, Why.

Several of the CELTs were also mentioned in the interviews. These were tolerating failure, connecting communities, having social- & interpersonal skills, encouraging diversity, facilitating open & honest dialogue, a duality of practical short-term goals & long-term vision, and a duality of autonomy & direction. Therefore, numbers (1), (3), (4), (5), (10), (12), and (13) can be said to be supported by both theory and practice. Therefore, facilitation, as was mentioned in the interviews to be important for leaders to do, is also supported. Additionally, being future-oriented can be said to be part of having a long-term vision.

Connecting communities is not only about connecting people, but, as can be seen form Figure A in Appendix A, also increases the ability of community members to take on leader roles and with that may increase their willingness to lead. Figure A also portrays how connecting communities, together with stimulating & facilitating open & honest dialogue, results in a safe, inclusive, and supportive environment.

Interviewees mentioned that leaders should be practical and provide clarity and concreteness. Practicality, clarity, and concreteness can logically be provided by setting boundaries and providing practical short-term goals. However, practicality, clarity, and concreteness may encompass more than

just setting boundaries and practical short-term goals. Therefore, 'practicality, clarity, & concreteness' will replace setting boundaries as a core element of leadership in a transdisciplinary context. It will not replace providing practical short-term goals, since this is part of a duality that is still in place.

The duality of long-term vision & practical short-term goals can be linked to an iteration of the Why question, and the What and How questions respectively. Furthermore, it was mentioned in the interviews that an iteration on assumptions is necessary for the collaboration, which relates to an iteration on What, How, Why as well. Inspiring others was mentioned in both the interviews and the literature study to be important for a leader to do. However, the source of inspiration is the answer to the Why question and thus the vision. Therefore, the duality of long-term vision & practical short-term goals and the iteration of the What, How, Why questions still remain CELTs. Furthermore, from the interviews it was concluded that people need to be connected to the vision. This is logical since a vision is not of much use without a connection to the team members who are the ones that need to help fulfill the vision. Connecting people to the vision can be done by linking their individual interests to it and making these into small short-term goals. When these small goals are met, and thus small wins are created, they must be celebrated and linked to the overall goal. This is in line with another duality that was mentioned in the interviews, namely an overall goal (overview) & individual goal (detail). However, connecting individual's interests to the vision or short-term goals necessitates the ability to take individual's interests into account. This cannot be done without being open to and aware of different backgrounds and interests. Based on all this, CELTs can be said to be an iteration on What, How, Why, openness to & awareness of different backgrounds & interests, creating & celebrating smalls wins, linking small wins to the vision, a duality of long-term vision & practical short-term goals, and a duality of overview & (individual) detail. Being connected to communities was mentioned by interviewees to be beneficial for leadership. It was previously mentioned that leaders should connect communities and take values and interests of individuals into account. Logically, being connected to communities positively influences both. Thus, having a close connection to communities is also a CELT.

Facilitation of formal & informal interactions with a diversity of people is not fully supported by the interview results. Diversity was indeed said to be an important part of the collaboration and leaders were said having to value diversity. Furthermore, facilitation and specifically facilitating for people to meet, was mentioned by interviewees to be important. However, formal & informal interactions were not explicitly mentioned in relation to the collaboration. Therefore, the CELT is changed to facilitation of interactions with a diversity of people. On another note, having patience, encouraging dissent, and deploying multiple possible solutions could not be linked to the interview results and are consequently not considered CELTs anymore.

The ability to adapt to changing circumstances was mentioned in the interviews to be important for leaders to have. From a theoretical point of view, it was not a CELT. However, in Figure A it can be seen that leaders should indeed be able to change as the community they are part of changes. Since the ability to adapt to changing circumstances was explicitly mentioned in the interviews and it can also be found in Figure A, it is taken up as a CELT.

Some leadership behaviors were explicitly mentioned by interviewees to be important in relation to the context of the Digital Twin project. However, as was mentioned in sub-section 4.1.1, it cannot be said with certainty that the collaboration taking place within the Digital Twin project is indeed transdisciplinary. Therefore, only the leadership elements mentioned in the interviews that can be directly or indirectly linked to the CELTs were taken into account in adjusting the CELTs. The elements from the interviews concerning the collaboration that were not taken into account are:

- Have status, prestige, or expertise

- Have experience
    a. In leadership
    b. In working in or with multidisciplinary teams
- Clarify that the research process is not linear
- Introducing incentives for such collaboration types
- Ensuring a focus on collaboration and not just on personal interests
- Not imposing things in a top-down way

LEADERSHIP IN RELATION TO LEARNING

In sub-section 2.4.4 it was concluded that, from a theoretical point of view, the core elements of leadership to stimulate learning and build towards a learning mindset in a transdisciplinary context (from now on referred to as CELLs) are (1) tolerate failure, (2) trust followers, (3) portray wanted behavior, (4) apply open governing style, (5) close connections to communities, (6) move between communities, (7) connect communities, (8) making the overall vision implementable daily, (9) stimulate & facilitate exploitation and experimentation, (10) facilitate formal & informal interactions with a diversity of people, (11) stimulate and facilitate open & honest dialogue, (12) duality of practical short-term goals & long-term vision, (13) duality of internal focus & external focus, (14) duality of convergent & divergent thinking, (15) duality of autonomy & direction, (16) duality of (facilitating) exploitation & experimentation, (17) rotating leadership, and (18) iteration of What, How, Why.

Several of the CELLs were also mentioned in the interviews. These were tolerating failure, having a close connection to the community (in this case the Digital Twin project community), facilitating open & honest dialogue, a duality of practical short-term goals & long-term vision, a duality of internal focus & external focus, and a duality of autonomy & direction. Therefore, numbers (1), (5), (10), (11), (12), and (14) can be said to be supported by both theory and practice and are thus still CELLs.

Having a close connection to the community logically makes one aware of what is going on in that community and enables a leader to take the values and interests of individuals into account. Connecting communities is not only about connecting people, but, as can be seen form Figure A in Appendix A, also increases the ability of community members to take on leader roles and with that may increase their willingness to lead. Figure A also portrays how connecting communities, together with stimulating & facilitating open & honest dialogue, results in a safe, inclusive, and supportive environment. Furthermore, from a theoretical perspective, the combination of portraying wanted behavior with stimulating & facilitating open & honest dialogue logically results in leaders having to be open & honest in their communication. From the interviews could also be concluded that leaders should be open in their communication. So, from both a theoretical and empirical point of view, leaders should be open in their communication. From all elements mentioned in this paragraph, the elements that lie at the basis of them all, as can be seen in Figure A, are stimulating & facilitating open & honest dialogue, portraying wanted behavior, and connecting communities. Therefore, these are CELLs from both a theoretical and empirical point of view.

Leaders were prominently mentioned by the interviewees to have a facilitating role. According to the interviewees, this facilitating role includes providing opportunities for people to meet, collaborate, and learn, and facilitating open discussion. From the literature study, it was concluded that leaders should facilitate exploitation & experimentation, open & honest dialogue, and formal & informal interactions with a diversity of people. Opportunities for people to meet can be done by connecting communities. Opportunities to learn should be provided through propagating the CELLs. The same CELLs, additionally with connecting communities so people can meet, will most likely also provide opportunities to collaborate. Open discussion is a product of the facilitation of open & honest dialogue. Facilitating exploitation & experimentation can be directly linked to necessities of learning and are therefore a necessary behavior for leaders to

portray to stimulate learning. Specifically, facilitating experimentation can be said to provide more opportunities for learning and gets people out of their comfort zone. Finally, the facilitation of formal & informal interactions with a diversity of people is still also applicable due to several reasons. First, valuing diversity was explicitly mentioned by interviewees to be important for leaders to do and it was also positively linked to learning. Second, (informal) social interactions have previously been concluded to be of importance to learning. Third, one interviewee specifically said it would have been beneficial for their own learning process if leaders would have organized an opportunity for interactions with people with particular expertise. Organized interaction is another term for formal interaction. Based on the conclusions in this paragraph, CELLs are still connecting communities, facilitating formal & informal interactions with a diversity of people, facilitating exploitation & experimentation, and facilitating open & honest dialogue.

Due to the diversity of the background of the people involved in the project (as reported in the interviews and taken from theory) as well as the facilitating role of leaders concerning formal & informal interactions with a diversity of people, leaders need to be able to deal and communicate with a diversity of people. The latter was concluded from interviews and would logically positively influence the facilitation of interactions with a diversity of people. However, this is not a complete causal relationship in that facilitation and communication are different things. Therefore, both facilitating informal & formal interactions with a diversity of people and the ability to deal and communicate with a diversity of people are CELLs. Furthermore, leaders were said by interviewees to have to be open to different backgrounds and interests. This partly links to the ability to deal and communicate with a diversity of people but they are not fully causally linked. Furthermore, being open to different backgrounds positively influences the ability to connect communities and facilitate formal & informal interactions with a diversity of people. Therefore, being open to and aware of different backgrounds and interests is also a CELL.

Humility was mentioned by an interviewee to be a beneficial characteristic for leaders to have. Humility was previously said to be beneficial to learning (as part of inclusion) from both a theoretical and empirical perspective. In combination with leaders having to portray the wanted behavior, humility therefore can also be considered as an important element of leadership.

Trust was mentioned in interviews as being beneficial to leadership. From a theoretical point of view, trust was also seen as important for leadership but is implicitly implied by the CELLs stimulating & facilitating open & honest dialogue and connecting communities (as can be seen in Figure A). Trust in followers, however, was not mentioned explicitly in the interviews. Still, autonomy was mentioned to be important from both a theoretical and empirical perspective, and Figure A shows how trusting in followers is needed to provide autonomy. Therefore, trust in general is implicitly implied in the CELLs and trust in followers remains a CELL.

Providing feedback was mentioned in the interviews to be important for a leader to do. Feedback was also mentioned in the interviews as being important for learning. However, it was previously explained that feedback was implicitly part or a consequence of practicing inclusion. Practicing inclusion is a behavior that leaders should portray to give a good example. Furthermore, the second part of the duality of autonomy & direction can also be said to include providing feedback. Therefore, providing feedback is already incorporated in the CELLs. The same goes for following up on people or staying on top of things, which was mentioned by interviewees to be important for a leader to do. This can directly be related to the direction portion of the duality of autonomy & direction, where providing direction logically includes staying on top of things. Since, if one does not know what is going on, giving direction seems rather pointless.

The duality of long-term vision & practical short-term goals can be linked to an iteration of the Why question, and the What and How questions respectively. Inspiring others was mentioned in both the interviews and the literature study to be important for a leader to do. However, the source of

inspiration is the answer to the Why question and thus the vision. Therefore, the duality of long-term vision & practical short-term goals and the iteration of the What, How, Why questions still remain CELLs. Furthermore, in the interviews it was said that a leader should be able to connect people to the overall vision. This can be done by making the common vision implementable on a daily basis, which was already a CELL. Therefore, connecting people to the overall vision is an implicit part of one of the CELLs.

In the literature study it was concluded that reflexivity is an important part of the iteration on What, How, Why. Moreover, leaders have been said in the interviews to have to be able to adapt to changing circumstances. In the literature study, reflexivity was linked to being able to spot the changing circumstances. Furthermore, reflexivity in itself has been said to be important to learning and since leaders have been said to need to portray the wanted behavior, they should be reflexive.

Moving between communities and applying an open governing style cannot be linked to the interview results and will therefore not be considered CELLs anymore. Additionally, the duality of convergent thinking & divergent thinking was not backed up by interview results, but could be said to be an implicit part of practical short-term goals & a long-term vision as well as the combination of exploitation & experimentation. Even so, convergent thinking & divergent thinking will not be regarded as a CELL anymore.

Leadership was explicitly mentioned by interviewees to play a role in making learning explicit as well as developing a learning mindset. Specifically, one interviewee remarked that leaders should adopt a learning mindset towards their own leadership, which relates to developing a learning mindset and portraying wanted behavior. Furthermore, it is in line with the previously mentioned notion that leadership should be able to adapt to the changing circumstances, thereby implying that as the circumstances change, so should leadership. Not only seeing leadership as a tool to stimulate learning and developing a learning mindset, but also as being subject to development and learning in itself is therefore important. Consequently, making learning explicit as well as adopting a learning mindset are now seen as CELLs as well.

Some leadership behaviors were explicitly mentioned by interviewees to be important in relation to learning. These were: (1) tolerating failure, (2) getting people out of their comfort zone, (3) being supportive, (4) being vigorous, (5) having vision, (6) setting clear goals, (7) linking what needs to be learned to the project or individual needs, (8) being future-oriented, (9) providing opportunities for people to learn (for example by facilitating social interaction with people with specific expertise), and (10) making learning explicit by mentioning it explicitly and, for example, initiating a 'lessons learned' report for future projects. Numbers (1), (3), (5), (6), (8) (in the sense of having a future-orientation or long-term vision), (9), and (10) have already previously been linked to CELLs from both a theoretical and empirical perspective. Number (7) has previously been said to not be linked to the core elements. Getting people out of their comfort zone was previously mentioned to be partly linked to experimentation, but does not have much weight from a theoretical perspective. Therefore, getting people out of their comfort zone will not be taken into explicit account. The same goes for being vigorous.

Based on what previously has been said, there are several behaviors a leader should portray to set a good example for others. This includes being open in communication, being honest, being humble (and in extension being inclusive), being accepting of failure, being reflexive, and adopting a learning mindset. Therefore, 'portraying the wanted behavior' is from now on seen as the CELL that encompasses these behaviors.

ADDITIONAL LEADERSHIP BEHAVIORS

Some elements that were mentioned in the interviews to be important to leadership were not explicitly mentioned in relation to either the collaboration or learning. They could also not be explicitly or implicitly be linked to CELT or CELL. Even though they might be important behaviors for

leaders to portray, their lacking link to CELT or CELL means they were taken into account in this Master Thesis project. They are:

- Being proactive
- Investing time and effort
- Having guts and being brave

LEADERSHIP STYLES OR STRUCTURES

Based on previously mentioned insights of this sub-section, the list of leadership styles and structures with a lower or higher chance of success in a transdisciplinary collaboration context with a focus on learning still applies. However, based on the contextual nature of leadership, it cannot be said with certainty which style will work in any given situation in the Digital Twin project context. Still, several insights concerning leadership styles that introduce a range of possibilities, change, and learning can be said to be beneficial for the Digital Twin collaboration context. These concern dualities, distributed leadership, and rotating leadership and are elaborated on below.

Duality in leadership was clearly recognized in the interviews. From what has been previously said, the following dualities can be said to be important for leaders to have and portray: (1) a duality of autonomy & direction, (2) a duality of experimentation & exploitation, (3) a duality of long-term vision & practical short-term goals, (4) internal focus & external focus, and (5) a duality of overall goal (overview) & individual goals (detail).

An additional duality that was extracted implicitly from the interviews is a duality of formal leadership & informal leadership. Interestingly, informal leadership was mentioned in the literature study as one of the styles of leadership that was thought to have a higher chance of success in a transdisciplinary collaboration context with a focus on learning. Informal leadership was even mentioned specifically to increase the ability to adapt to changing circumstances by incorporating rotation of leadership in reaction to changing circumstances. A rotation of leadership can logically best be applied to informal leaders, since that is easier than changing formal leadership due to, for example, institutional regulations and responsibilities. Furthermore, formal leaders would logically have to be present for a certain security, clarity, and continuity. Therefore, a duality of formal & informal leadership is added to the list of dualities.

Even though rotating leadership was not explicitly mentioned by any of the interviewees, it can still logically be said to be an important part of leadership in a transdisciplinary collaboration context. First, rotation of leadership was specifically mentioned in relation to informal leadership to increase the ability to adapt to changing circumstances. Second, rotating leadership plays into the learning mindset towards leadership, since it allows further experimentation of leadership styles and allows for different team members to explore themselves as a leader. Third, rotating leadership increases the chances of finding a leadership style that fits a given situation. Fourth, since the transdisciplinary collaboration is a new type of collaboration and thus brings a lot of uncertainty and ambiguity, rotating leadership increases the ability of not only the leader but the team to adapt to changing circumstances. The ability to adapt to changing circumstances was said by interviewees to be important for leaders to have.

Furthermore, distributed leadership was prominently mentioned by the interviewees and was also one of the styles of leadership that was argued to have a higher chance of success in a transdisciplinary collaboration context. Additionally, different styles of leadership were mentioned in the interviews to be important, which is what distributed leadership is most likely to introduce. Distributed leadership was mentioned to allow for experimentation, which introduces a learning element in leadership. This reminds of the interviewee who said that leaders should adopt a learning mindset to their own leadership. Furthermore, an interplay between leaders was said to be important by both interviewees and theory. Additionally, in the literature study it was mentioned that distributed leadership would only be effective if there are some boundaries, a clear common goal, trust, and

open communication. These were already mentioned before as necessary behaviors for leaders to portray or facilitate. Moreover, distributed leadership can entail both formal and informal leaders. Due to all this, distributed leadership can be said to be an appropriate leadership style for a transdisciplinary collaboration context.

4.3.2 CONCLUSIONS

Based on the findings from sub-section 4.3.1, research sub-questions 6b and 6d, and thus research question 6, can be answered. Recall the research question 6, with its subparts 6b and 6d:

2. What leadership styles, structures, or behaviors are necessary or appropriate for leadership in the Digital Twin project context?
    a. What elements do people involved in the Digital Twin project perceive as important to or in leadership?
    b. How do these elements relate to the leadership core elements found in literature?
    c. What leadership styles or structures do people involved in the Digital Twin project perceive as important to or in leadership?
    d. How do these styles or structures relate to the leadership styles or structures found in literature?

The answers to the abovementioned questions are provided next.

ANSWER TO RESEARCH SUB-QUESTION 6B

There were three elements mentioned in the interviews that were not explicitly mentioned in relation to the collaboration or learning and that did not relate to either the CELTs or the CELLs. These were: being proactive, investing time and effort, and having guts and being brave.

Tolerating failure, connecting communities, having social- & interpersonal skills, encouraging diversity, facilitating open & honest dialogue, a duality of short-term goals & long-term vision, and a duality of autonomy & direction related directly to CELTs. Facilitation is included in this summation. Being future-oriented relates to having a long-term vision.

A willingness to lead was linked to connecting communities. A safe environment can be reached through a combination of connecting communities and stimulating & facilitating open & honest dialogue. Practicality was partly linked to practical short-term goals, but was given its own CELT together with clarity & concreteness.

The duality of long-term vision & practical short-term goals links to the iteration of What, How, Why, of which the latter relates to an iteration on assumptions. Inspiring others was linked to answering the Why question and having a long-term vision. People being connected to the vision was said to be done through the sequence of (1) making individual interests into small short-term goals, (2) creating & celebrating small wins, and (3) linking the small wins to the vision. The duality of overview & (individual) detail was extracted from this as well. Furthermore, connecting people's interests to the vision or short-term goals necessitates being open to & aware of different backgrounds & interests. Therefore, the latter became another CELT.

Being connected to communities was linked to connecting communities and taking individual interests into account. The interview results did not link to patience, encouraging dissent, deploying multiple possible solutions, or formal & informal interactions. Diversity, however, was linked to theory. Therefore, patience, encouraging dissent, and deploying multiple possible solutions were not CELTs anymore and the CELT of facilitating formal & informal interactions with a diversity of people was changed to facilitating interactions with a diversity of people. The ability to change to

circumstances was mentioned in the interviews and could be linked to a necessary behavior for leaders to have in a community.

The following elements mentioned in the interviews to be related to be important for leaders to do in the collaboration, were found to not relate to the CELTs:

- Have status, prestige, or expertise
- Have experience
    a. In leadership
    b. In working in or with multidisciplinary teams
- Clarify that the research process is not linear
- Introducing incentives for such collaboration types
- Ensuring a focus on collaboration and not just on personal interests
- Not imposing things in a top-down way

Several elements mentioned in interviews important for leaders to have that could be directly linked to CELLs. These were: tolerating failure, having a close connection to the community, facilitating open & honest dialogue, a duality of practical short-term goals & long-term vision, a duality of internal focus & external focus, and a duality of autonomy & direction.

Being aware of what is going on in a community and taking values & interests of individuals into account were linked to having close connections to the community. A supportive environment was linked to a combination of connecting communities and stimulating & facilitating open & honest dialogue. Being open in communication was linked to a combination of portraying wanted behavior and stimulating & facilitating open & honest dialogue.

Facilitating opportunities for people to meet was captured by connecting communities. Facilitating opportunities to learn was linked to the propagation of the CELLs. The combination of connecting communities and propagating the CELLs was said to facilitate opportunities for collaboration.

Facilitation of open discussion was said to be a result of stimulating & facilitating open & honest dialogue. The interviews did not mention a facilitation of exploitation & experimentation, but it was still concluded a CELL due to the direct link with core elements of learning in a transdisciplinary collaboration context. Getting people out of their comfort zone was (partly) linked to experimentation. Valuing diversity, (informal) social interactions as an important element of learning, and one interviewee mentioning organized interaction in relation to learning, were said to result in facilitating formal & informal interactions with a diversity of people still being a CELL.

The ability to deal and communicate with a diversity of people was linked to a combination of diversity and facilitating formal & informal interactions with a diversity of people and was concluded to be a CELL. Being open to and aware of different backgrounds and interests was linked to facilitating formal & informal interactions with a diversity of people as well as to connecting communities and the ability to deal and communicate with a diversity of people. Being open to & aware of different backgrounds was concluded to be a CELL.

Being humble was captured in a combination of leaders portraying wanted behavior and humility (as part of inclusion) as a beneficial behavior for learning. Trust was implicitly linked to the CELLs and autonomy was linked to a trust in followers. Autonomy still remained part of a duality of one of the CELLs and trust in followers also remained a CELL.

Providing feedback was linked to a combination of portraying wanted behavior and practicing inclusion, as well as the direction part of the duality of direction & autonomy. Following up on people and staying on top of things was also linked to the direction part of the duality of direction & autonomy.

The duality of long-term vision & practical short-term goals was linked to an iteration on What, How, Why. Inspiring others was linked to a combination

of iteration on What, How, Why and having a long-term vision. The latter two were concluded to still be CELLs. Connecting people to the overall goal was said to be implicitly part of the CELL making the common vision implementable daily. Adapting to changing circumstances was linked to reflexivity, which was said to be an important part of the iteration on What, How, Why and spotting the changes in the circumstances.

The results of the interview did not relate moving between communities, applying an open governing style, or convergent & divergent thinking. All three were not regarded as CELLs anymore. Additionally, making learning explicit was linked to the fact that leaders were said to play a role in making learning explicit and them having to adopt a learning mindset. Making learning explicit was concluded to be a CELL. Portraying wanted behavior was concluded to be the CELL that encompasses being open in communication, being honest, being humble (and in extension being inclusive), being accepting of failure, being reflexive, and adopting a learning mindset. Linking what needs to be learned to the project or individuals' goals and being vigorous did not relate to any of the CELLs.

ANSWER TO RESEARCH SUB-QUESTION 6D

Based on previously mentioned insights of this sub-section, the list of leadership styles and structures with a lower or higher chance of success in a transdisciplinary collaboration context with a focus on learning still applies. However, based on the contextual nature of leadership, it cannot be said with certainty which style will work in any given situation in the Digital Twin project context. Still, several insights concerning leadership styles that introduce a range of possibilities, change, and learning can be said to be beneficial for the Digital Twin collaboration context. These are:

- Dualities in leadership
    1. a duality of autonomy & direction;
    2. a duality of experimentation & exploitation;
    3. a duality of long-term vision & practical short-term goals;
    4. a duality of internal focus & external focus;
    5. a duality of overall goal (overview) & individual goals (detail), and;
    6. a duality of informal & formal leadership
- Distributed leadership with an interplay between leaders
- Rotating leadership, mostly applied to informal leaders

ANSWER TO RESEARCH SUB-QUESTION 6

Appropriate or beneficial behaviors for leaders to portray in relation to transdisciplinary collaboration are:

- tolerate failure
- close connection to communities
- connect communities
- social- & interpersonal skills
- encourage diversity
- practicality, clarity, & concreteness
- create & celebrate small wins
- link small wins to overall goal
- stimulate & facilitate open & honest dialogue
- being open to and aware of different backgrounds & interests
- facilitate interactions with a diversity of people
- iteration of What, How, Why
- duality of practical short-term goals & long-term vision
- duality of autonomy & direction
- duality of (facilitating) exploitation & experimentation
- duality of overview & (individual) detail

Appropriate or beneficial behaviors for leaders to portray in relation to learning in a transdisciplinary collaboration context are:

- tolerate failure

- trust followers
- portray wanted behavior
    - reflexive
    - inclusive (and in extension humble)
    - honest
    - open in communication
    - learning mindset
- make learning explicit
- being open to and aware of different backgrounds & interests
- ability to deal and communicate with a diversity of people
- close connections to communities
- connect communities
- stimulate & facilitate exploitation and experimentation
- facilitate formal & informal interactions with a diversity of people
- stimulate and facilitate open & honest dialogue
- iteration of What, How, Why
- duality of practical short-term goals & long-term vision
- duality of internal focus & external focus
- duality of autonomy & direction
- duality of (facilitating) exploitation & experimentation

Appropriate or beneficial styles or structures for leaders to portray in relation to transdisciplinary collaboration or learning in a transdisciplinary collaboration context are:

- Dualities in leadership
    - a duality of autonomy & direction
    - a duality of experimentation & exploitation
    - a duality of long-term vision & practical short-term goals
    - a duality of internal focus & external focus
    - a duality of overall goal (overview) & individual goals (detail)
    - a duality of informal leadership & formal leadership
- Distributed leadership with an interplay between leaders
- Rotating leadership, mostly applied to informal leaders

4.3.3 VISUALIZATION OF LEADERSHIP TO STIMULATE LEARNING AND HELP DEVELOP A LEARNING MINDSET IN A TRANSDISCIPLINARY COLLABORATION CONTEXT BASED ON THEORY AND PRACTICE

Based on the previously mentioned core elements of leadership, the changes made therein, the dualities, and the appropriate styles and structures of leadership, the visualization of leadership in relation to learning and transdisciplinarity (Figure 3.13) was updated. This updated visualization is shown in Figure 4.6 and in essence consists of two sets of discs: one concerning transdisciplinarity and one concerning (continuous) learning. Each set of discs consists of four layers. The inner layer, also referred to as layer 0 or the core, displays the goal of a set of discs. The first layer, layer 1, consists of the core elements of that goal as defined in sub-sections 4.1.2 and 4.2.2. The second layer, layer 2, contains the core elements of leadership that were identified to have a specific relation to layer 1. As can be seen, there is some overlap and some difference between these core elements. The third layer, layer 3, contains the dualities corresponding to that specific set of discs. Again, here is some overlap between discs. The dualities are in layer 3 since they have an influence on every core element and introduce restraints and tensions to the system, making it less unambiguous. For example, having an internal focus & external focus puts a strain on facilitating open & honest dialogue (necessitating more of an internal focus) on the one hand, and facilitating interactions with a diversity of people (necessitating more of an external focus) on the other hand. The first is needed to build trust and a supportive environment and practice inclusion. The latter is needed to introduce diversity and more learning opportunities. Even though they both have positive effects on learning, they may put a strain on each other: increasing diversity too much can decrease a community feel and feelings of trust,

whereas putting too much focus on the community may result in decreased diversity and may eventually result in confirmation bias.

There are several things to note about Figure 4.6. First, additional to the two sets of discs, there is one overall layer that includes styles and structures of leadership. These include distributed leadership, rotating leadership, and a duality of formal leadership & informal leadership. These were added as a separate, overall layer, since provide the setting in which the leadership behaviors take place. Furthermore, they influence the whole system as a shift in leadership leads to a shift in leadership behaviors as well. Second, even though the core elements defined for learning in this Master Thesis project were found in specific relation to transdisciplinarity, there is no explicit relation between the first layer of both sets of discs (except for trust and diversity which are elements of both layers 1). The reason for this is that Figure 4.6 was made from the perspective of leadership to transdisciplinarity and learning (in a transdisciplinary collaboration context), not from the perspective of learning in relation to transdisciplinarity. Third, it can be seen that reflexivity, iteration on What, How, Why, and rotating leadership are blue. This is because they all introduce some sort of renewal or updating mechanism to all levels of the system, as is portrayed by the arrows near reflexivity. This relates not only to the changing of the communities, but also to a necessity to see leadership as being in development itself. Fourth, note how some (parts) of the elements in Figure 4.6 are bold. This relates to the core element *portray wanted behavior* and shows what behaviors leaders must portray to stimulate this behavior in others. Note how this has only been done for elements in the discs of learning, since *portray wanted behavior* is only part of those discs and not of the transdisciplinarity discs. Fifth, there are several forms of influence taking place between the layers of the discs: the first layers contain the elements that all have a direct link to their corresponding core; the second layers contain elements of which some have direct links to elements in the corresponding layer 1, but some have no direct link; the third layer has an effect on the core, layer 1, and layer 2. There was the option to, for example, color the text of elements to indicate a direct influence. However, this resulted in a rather clownish image that was not aesthetically pleasing whatsoever. Therefore, the choice was made to leave them out and go for simplicity instead. Figure A can be consulted if the reader finds themselves curious about the direct links between elements from a theoretical point of view.

For the appropriate structure and style of leadership as portrayed in layer 4 in Figure 4.6, an analogy can be drawn to better describe the relation between distributed, formal & informal, and the rotation of leadership. This analogy concerns a steady rock in the surf and the changing of the tides and waves of the sea surrounding it. The steady rock represents the formal leaders that introduce security, clarity, and continuity. Over time, the rock changes as it is shaped by the water surrounding it. The tides and highly changeable sea represent informal leadership that changes much quicker than the rock. The sea twists and twirls and consists of numerous flows simultaneously, which represents an experimentational element and thus learning in leadership. The combination of the rock and the sea represent distributed leadership.

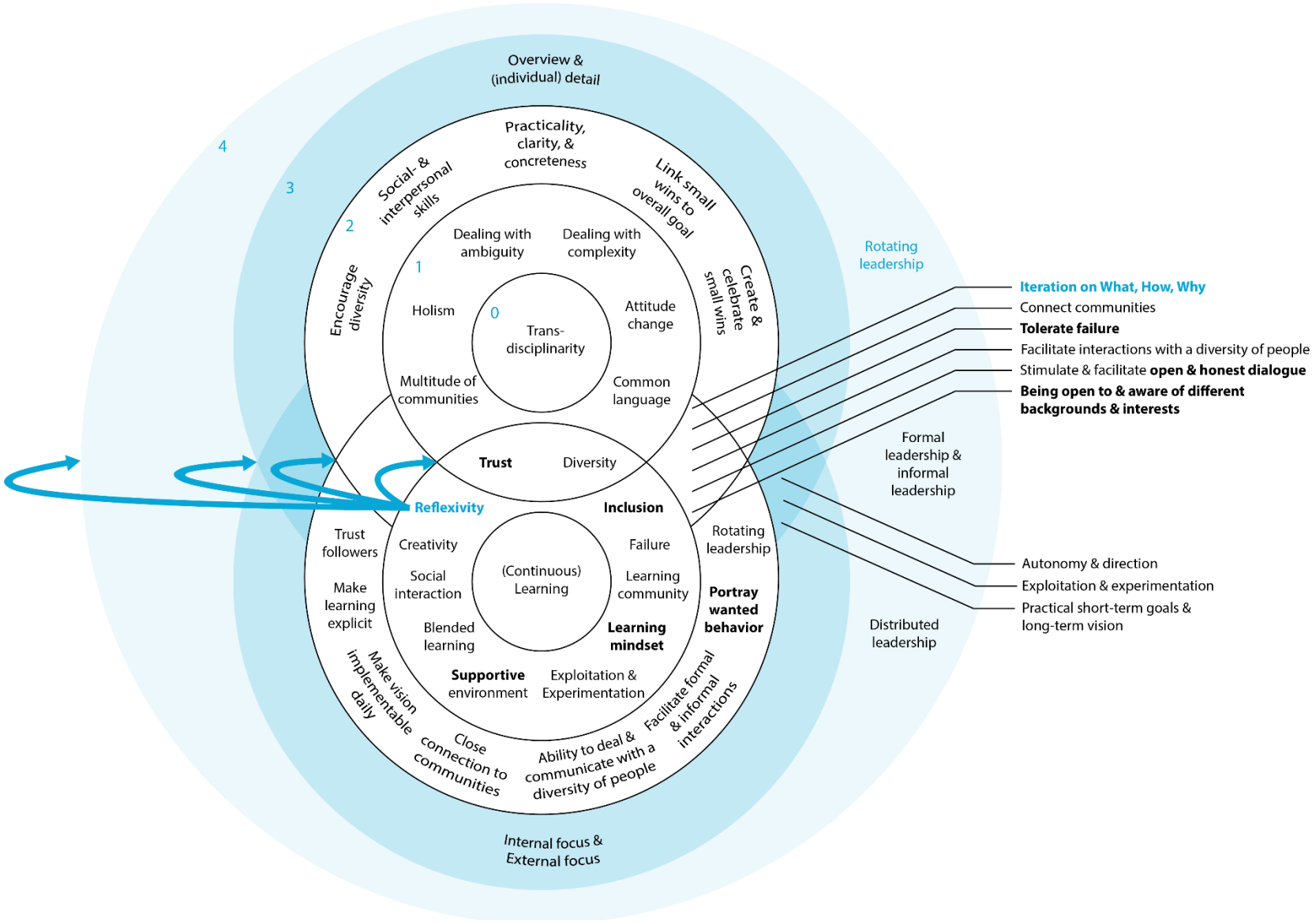


Figure 4.6: The Omni-Discs of Leadership for Transdisciplinarity and Learning. The figure portrays what is needed from leadership to work towards transdisciplinarity and (continuous) learning (within a transdisciplinary collaboration context). Layer 0: the goal of a set of discs – transdisciplinarity or (continuous) learning. Layer 1: core elements of transdisciplinarity or learning. Layer 2: core elements of leadership that support (parts of) layer 1. Layer 3: dualities of leadership, they have an influence on all other layers. Layer 4: structures and styles of leadership that influence all layers. Reflexivity, rotating leadership, and iteration on What, How, Why: influence all layers and help keep up with changes in the community. Bold elements: the behaviors that leaders need to portray as part of the 'portray wanted behavior' element.

5 CONCLUSION

This Master Thesis project set out to discover what leadership styles, structures, or behaviors stimulate learning and help develop a learning mindset in the context of transdisciplinary collaboration as is aimed for the Convergence Agenda of the EMC, EUR, and TUD. Such a discovery would be interesting from a research point of view due to the novelty of transdisciplinarity and the combination of transdisciplinarity, learning, and leadership. Moreover, it would enable the formulation and implementation of more concrete actions to move away from a still rather vague idea of transdisciplinarity and towards actionable steps. The main research question was as follows:

What leadership styles, structures, or behaviors, suited for the transdisciplinary collaboration context of the Digital Twin project of the Health & Technology branch of the Convergence Agenda of the Erasmus Medical Centre, the Erasmus University Rotterdam, and the Delft University of Technology, stimulate and facilitate learning and help develop a learning mindset?

To be able to find an answer to this main research question, a theoretical and empirical understanding of transdisciplinary collaboration and learning in a transdisciplinary collaboration context were established. It was concluded that the initially defined core elements of transdisciplinarity are in line with empirical data and are still *complexity, ambiguity, holism, multitude of communities, attitude change, common language,* and *trust*. However, the meaning of transdisciplinarity was slightly changed to a gathering of communities with blurred boundaries from which expert knowledge is drawn instead of an overlap of everything with indiscernible boundaries. The communities are connected through bridges formed by shared goals. The expert knowledge is applied to the realization of these shared goals, which in turn results in new knowledge and thus a new (perception of) reality. The theoretical core elements of learning in a transdisciplinary collaboration context were concluded to still hold true after taking empirical data into account. Moreover, two core elements were added, resulting in the following list of core elements: *reflexivity, (informal) social interaction, diversity, experimentation (multiple at a time) and exploitation, inclusion, trust, creativity, learning mindset, and a supportive environment, failure,* and *blended learning*.

To know what a leader should do to stimulate learning in a transdisciplinary collaboration context, it is not just important to consider how they can directly influence learning. It is also of great value to take the context in which this learning is taking place into account and portray the behaviors that are appropriate in that context as well to be more effective as a leader. Therefore, the behaviors necessary for a leader to portray to enable and stimulate learning within a transdisciplinary collaboration context consider both CELTs and CELLs. Figure 4.6 shows the accumulation of necessary behaviors as well as styles and structures of leadership for stimulating learning and developing a learning mindset in a transdisciplinary collaboration context.

It should be noted that there is not one style or structure of leadership that will always work in any given situation. I.e., leadership (as well as learning) is highly contextual. Figure 4.6 is not nearly exhaustive and only contains essentials of leadership in a specific context. Still, it was indicated that a form of distributed leadership including formal and informal leaders, involving rotation of leadership, and interplay and interaction between leaders would be appropriate for the Digital Twin project context. This can be linked to the analogy of a steady rock in the surf and the changing of the tides and waves of the sea surrounding it. The steady rock represents the formal leaders that introduce security, clarity, and continuity. Over time, the rock changes as it is shaped by the water surrounding it. The tides and highly changeable sea represent informal leadership that changes much quicker than the rock. The sea twists and twirls and consists of numerous flows simultaneously, which

represents an experimentational element and thus learning in leadership. The combination of the rock and the sea represent distributed leadership.

Figure 4.6 shows how much is being asked of leadership. Take for example the dualities that by themselves are already challenging to fulfill, but also influence everything else. It would be naïve to think that any one person would be able to take everything on. Leadership is a team sport and involves the whole community. Leaders cannot exist without followers, but leadership does not necessarily entail followers looking up at the leaders. It concerns the realization of leadership potential of every community member and feeling the support do so, for the better of the community and the collaboration. Therefore, to increase chances of success, the leadership potential of the whole community needs to be mapped so it can be properly utilized through rotational distributed formal & informal leadership. I.e., leadership needs to be viewed as modular to enable the full use of its potential. This necessitates a continuous process of renewal, iteration, and reflexivity to keep leadership and the community up to date. This is beneficial for the collaboration, despite whether or not the collaboration of the Digital Twin project is transdisciplinary or working towards transdisciplinarity. A learning mindset is crucial herein, makes people more aware of their actions and intentions, and opens up discussions. Furthermore, such a mindset positively influences the documentation of lessons learned and will be beneficial for both this collaboration and any future endeavors of EMC, EUR, and TUD related to convergence.

6 DISCUSSION

This chapter consists of five parts. In the first part, noteworthy insights or thoughts based on some of the interview results will be given. Next, ideas and visualizations for communication or decision support tools in relation to leadership fitted for stimulating learning and developing a learning mindset in a transdisciplinary collaboration context will be provided. These tools are part of the discussion since this research was not a design-based research, meaning the tools were not tested. Third, the quality of the research will be discussed. Thereafter, the contributions of this Master Thesis project to SEC will be discussed. The discussion concludes with recommendations for future research.

6.1 NOTEWORTHY INSIGHTS OR THOUGHTS BASED ON THE INTERVIEW RESULTS

It stood out that several elements mentioned by interviewees in relation to collaboration directly related to core elements of learning in a transdisciplinary context previously defined based on theory. Examples are (informal) social interactions, creativity, trust, calmness, and a willingness to listen to others. This suggests that elements that are beneficial for collaboration are also beneficial for learning and vice versa. Since the focus in the Master Thesis project was on transdisciplinary collaboration and not on collaboration in general, this possible relationship could not be grounded in theory.

Multiple collaborative challenges were named during the interviews. These include: (1) differences in expectations, (2) the online environment, (3) institutional boundaries, and (4) cultural differences resulting in, for example, differences in how research is done and incentives. Numbers (3) and (4) are challenges that will most likely be faced by any collaboration that spans across institutions or even different teams. However, challenges (1) and (2) will likely (mostly) be resolved once the Covid-19 pandemic regulations have been lifted. For (2), this is obvious. Number (1) can mostly be resolved by being able to talk to people face-to-face and more informally. It lowers the threshold of talking to each other, as it enables people literally peaking their head around the corner to ask a five-minute question.

Interestingly, getting out of one's comfort zone (or helping people get out of their comfort zone when mentioned in relation to leadership) was mentioned by interviewees to be important to collaboration, learning, and leadership. It is currently implicitly part of the final visualizations of each main theme – transdisciplinary collaboration, learning, and leadership – but it seems that there is more to it.

Several interview results were reported to be mainly said by people from one institution or with a specific role. They are listed and discussed below:

- The challenge of the online environment was mentioned by only people from the EMC. A reason for this could be that people from the EMC are les tech savvy or are possibly more used to working in groups. The latter often necessitates direct contact to make the collaboration more efficient, which would explain the strain an online environment put on the people from the EMC.
- The necessity for the connection between people, projects, and institutions as well as creativity were only mentioned by people from the TUD and people in leadership positions or a philosopher. A reason for this could be that people from the TUD have experienced greater resistance in collaboration on the institutional level, since it has been quite challenging to get their hands on usable data. It could also be the case that people in a leadership position are more aware of (the necessity of) interrelatedness and creativity. Furthermore, it should be noted that more of the people interviewed that were in leadership positions were from the TUD, which is why it can sometimes be the case that more people in

leadership positions said something and thus also more people from the TUD said that.

- It was clear from the interviews that transdisciplinarity is still a rather vague concept, especially for people not in a leader role. This is not what I expected when going into the interviews. Only people in a leader role were able to provide some description of what transdisciplinarity entails. Furthermore, there was confusion about what type of collaboration could best be used to describe the Digital Twin collaboration, whether such a description was even necessary, and whether transdisciplinarity was even necessary. Additionally, the Digital Twin project was described as a learning project. Clearly, there is confusion about what the collaboration type is and what the goal of the project is. There is a mismatch between how informed the leaders and how informed the followers are. It would be beneficial for the collaboration to reassess the necessity of transdisciplinarity, clearly define it for their followers, and clearly state the goal of the Digital Twin project. Second, the collaboration challenge of differences in expectations was only mentioned by postdocs and philosophers. This implies that leaders are not aware of this challenge or do not believe it to be as big of a challenge as it actually is. Therefore, leaders should be more aware of these differences and actively facilitate and stimulate open & honest conversations to tackle these.
- Descriptions of transdisciplinarity were not only people in a leader role, but also mainly by people from the TUD. Besides the fact that most people in a leader role came from the TUD, it could also be the case that the TUD is more focused on transdisciplinarity and thus people of the TUD know more about it. It would be beneficial for (leaders of) the EMC and TUD to align on what transdisciplinarity entails exactly and how this can be translated to short-term concrete goals.
- Failure, as an important element for learning, was mentioned only by people from the TUD and people either in a leadership position or philosophers. For the first, it could be the case that people from the TUD more often have had to deal with failure and have come to see it as an asset. For the latter, it seems that failure may not be seen as an option or valuable by followers. It may also be the case that the people in leadership positions have had more experience in their field, have thus also failed more often, and have accepted it as part of the process. In any case, it implies that leadership needs to communicate the value of failure in learning, adopt a mindset accepting of failure, and create an environment in which failure is an option.
- Leaders having to be open to different backgrounds and interests was mainly mentioned by people from the EMC. A reason for this could be that people from the EMC already work with a lot of people from different backgrounds and find this an important aspect. Another reason could be that they have experienced a resistance to different backgrounds or interests and are therefore putting emphasis on the importance of it.
- Providing vision, inspiring and engaging others, and investing time and effort were mainly if not only mentioned by people in leadership roles. It may be the case that only people in a leader role see these as necessary as they have experienced what it is to be a leader. It could be the case that, for example, the postdocs are more concerned with practicality and short-term goals as these affect them more readily.
- Both formal and informal leadership were mainly mentioned by people from the EMC. It could be the case that people from the EMC are more used to working with (explicit) formal and informal leaders. This could provide to be useful in employing these forms in distributed leadership.

6.2 IDEAS FOR TOOLS TO STIMULATE LEARNING AND HELP DEVELOP A LEARNING MINDSET

It is clear there is an interaction between transdisciplinary collaboration, learning, and leadership. Additionally, the community, or in this case the community of the Digital Twin project, has also been shown to shape how learning takes place and what leadership is needed. Therefore, community is a fourth player. Figure 6.1 shows a simplistic visual of the interplay between the four forces. It can be seen that, initially, these four forces may not be in sync and there is no obvious feedback since none of these forces react to the crossing of another force. However, if awareness, commitment, and a common belief are introduced, the interaction between the four forces suddenly changes to something that is much more in sync and introduces a learning mindset. It is important to note that being in sync does not mean constantly being on the same page. This is illustrated the fact that the lines do not completely overlap or follow the exact same trajectory (slight changes or exploits made by some of the forces).

The movements shown in the right part of Figure 6.1 can be described as jazz music where there is a certain base line but little experiments are also possible. If others see the value of this experimentation, they can pick up on it and continue on that new path. Furthermore it, differs what force introduces a possible change to the system, as there is not one force that is (always) dominant. This also reminds of the way a flock of birds moves through the air, constantly scanning their surroundings and reacting to changes therein.

Note that the just provided description and the visualization in Figure 6.1 pose a very simplistic idea of reality. However, it does portray the notion that a certain awareness, commitment, and common belief are necessary to truly reap the synergetic fruits from interactions. A more realistic idea of how the lines might flow and they might sometimes cross or not is portrayed in Figure 6.2.

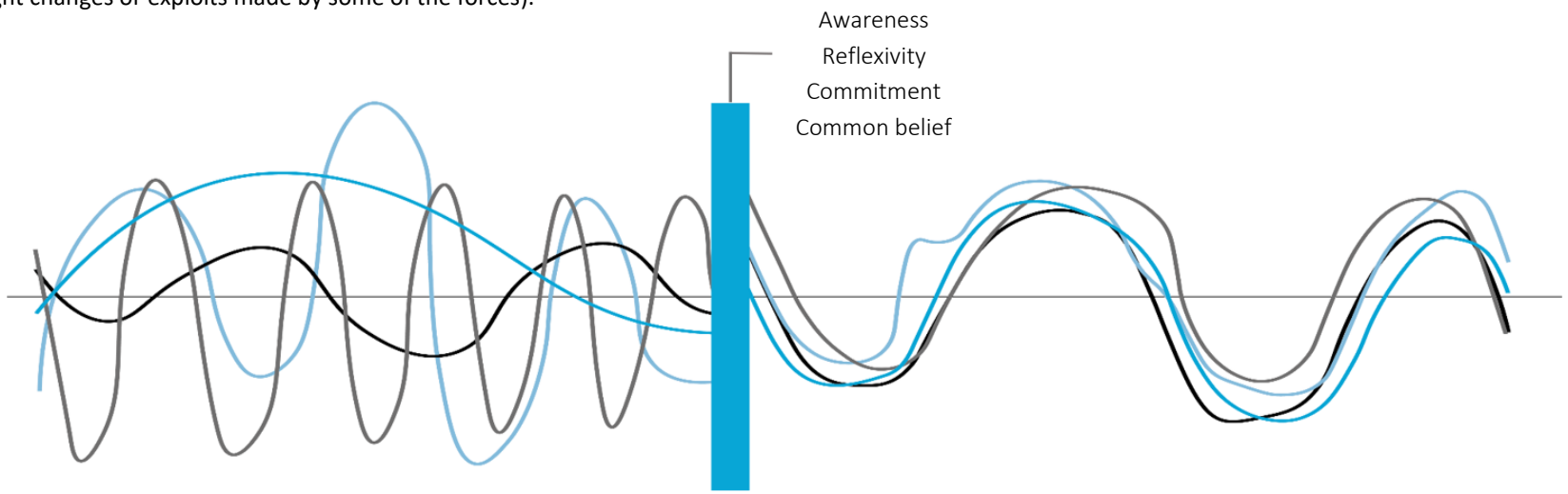


Figure 6.1: Interaction between Community, Collaboration, Learning, and Leadership. These forces can be made to 'sing to the same song' by introducing awareness, commitment, and a common belief. Within this song, some variations are still possible. Through continued alignment and a refocus on awareness, commitment, and the common belief will the forces stay in sync.

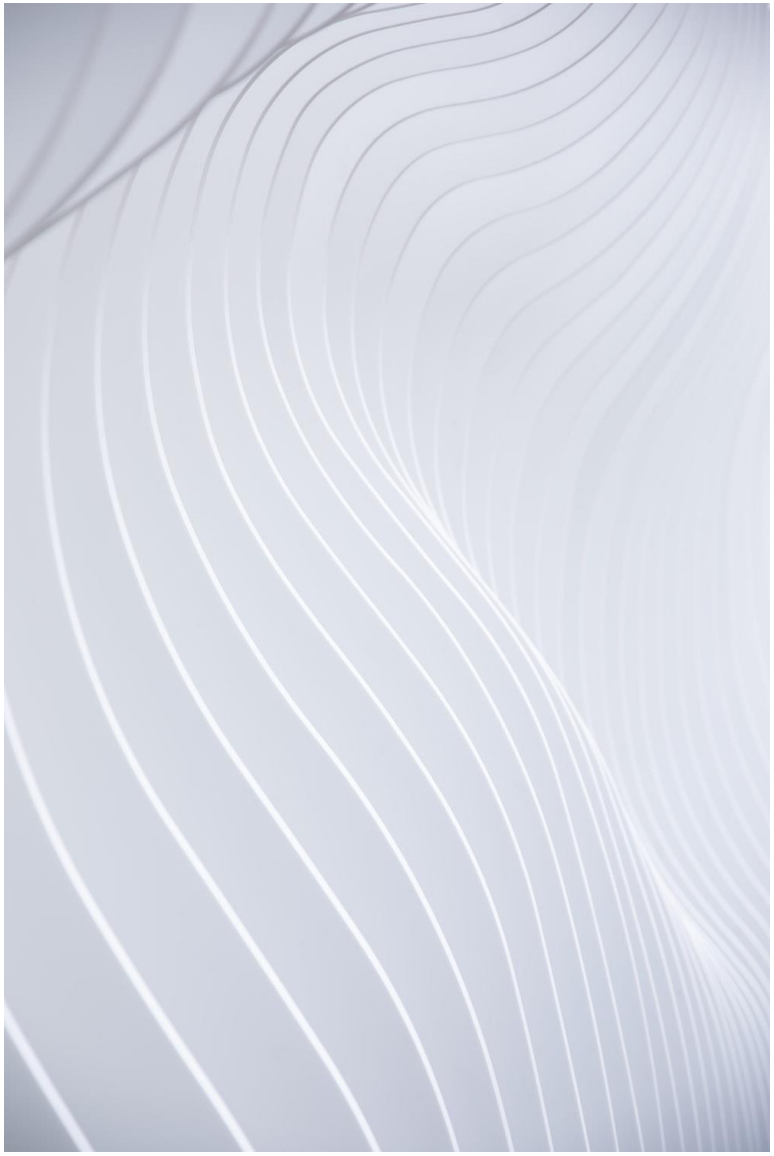


Figure 6.2: An image by Jean-Philippe Delberghe. Retrieved from https://unsplash.com/photos/75xPHEQBmvA

The overall idea portrayed in Figure 6.1 can also be made more concrete, as shown in Figure 6.3, and applied to the Digital Twin project team. Before the figure is applied to the Digital Twin team, it is first important to explain what can be seen in Figure 6.3.

Figure 6.3 consists of four main components: lines, a gate, spheres inside the gate, and a sphere on top of the gate. The lines each represent the trajectory an individual or a team takes. For the sake of simplicity, the lines will in this explanation be said to represent an individual. As can be seen, the lines are either straight (exploitation) or bent (experimentation). The gate represents a planned moment in time where every individual comes together to discuss their insights or lessons learned. The gate can only be unlocked if (1) everyone contributes and (2) a common belief, commitment, awareness, and a learning mindset have been created or adopted. The first refers to the spheres inside the gate. Each sphere and its color represent the findings, insights, or knowledge possessed by that individual. Reflexivity is needed to articulate the 'color' of the sphere. Only if all spheres have been colored can discussion and iteration on the common belief take place. Awareness of the colors of the other individuals is needed to take them into account. A learning mindset is needed to allow for an openness to the other colors. The second condition for opening the gate is that all individuals agree on the (adapted) common belief and fully commit to it. Commitment can be influenced internally from a common belief and externally from the fact that they can only continue working if the gate has been opened. Once a common belief is formulated and all individuals explicitly commit to it, the sphere on top of the gate is given the color of the common belief and the gate is opened. This process repeats itself in predetermined increments agreed upon by the individuals.

As can be seen in Figure 6.3, lessons learned can either be or not be taken up into the common belief. This includes the aspect of failure into the system. Failure is a form of success in itself since it provides insight into what *does not* work, which is just as valuable as knowing what *does* work. The changing or not changing of the color of the common belief (the spheres on

top of the gates) relates to the changing or not changing of the overall rhythm of the song as portrayed in the right part of Figure 6.1.

For the sake of simplicity, the lines in Figure 6.3 were said to be individuals. However, they can also portray the trajectory of a whole team. Take for example Digital Twin. The Digital Twin team consists of several sub-teams, which consist of individuals. The process portrayed in Figure 6.3 can be used by the individuals of one of the sub-teams to come to a common belief and commitment of that sub-team. The sub-teams may then go through the same process to come to a common belief of the whole Digital Twin project team. This may even then be used by other of Health & Technology to come to a common belief of Health & technology. And so on.

Let us dive deeper in one of the parts of Figure 6.3, namely experimentation and exploitation. This can be done in many forms, for example based on the research methodology or meeting formats used. However, a specific example more related to the findings of this research was visualized and will be elaborated on next.

It stood out that getting out of one's comfort zone was mentioned in the interviews in relation to collaboration, learning, and leadership. Therefore, the comfort zone was used as inspiration for one of the tools to stimulate learning and help people adopt a learning mindset. Figure 6.4 shows a visual consisting of skills of one individual. Whether the skills are placed in the top row (inside the comfort zone) or the bottom row (outside the comfort zone) is mainly done based on the perceptions of the individual. There naturally is peers or a supervisor.

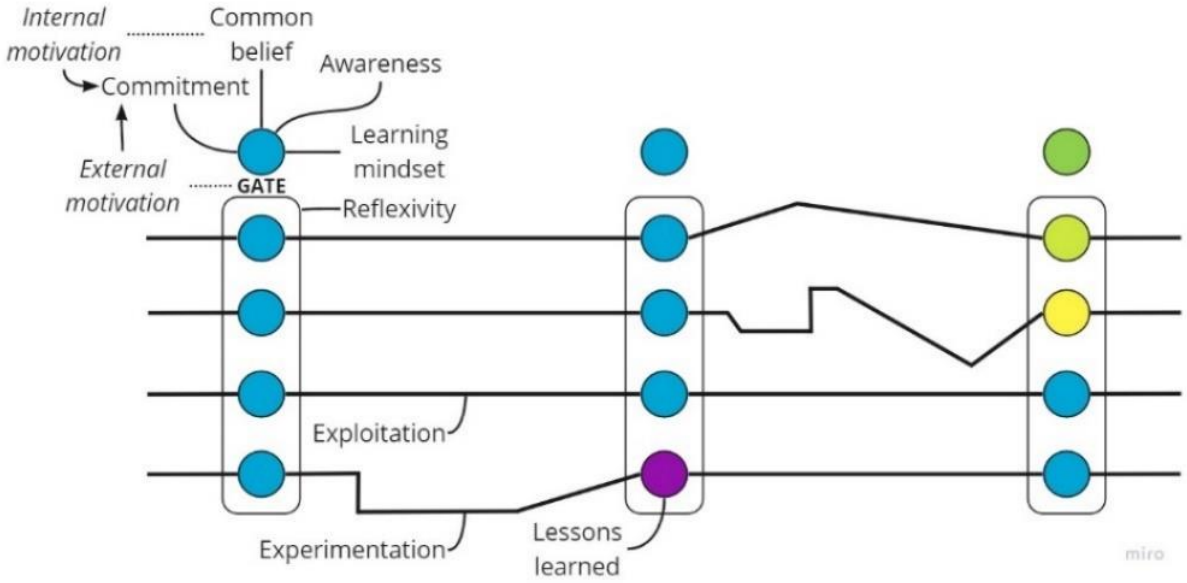


Figure 6.3: Process of reiteration of common belief based on lessons learned from exploitation or experimentation by individuals or teams. The gate represents a predetermined moment in time where commitment to the (adapted) common belief is determined and committed to. Awareness, a learning mindset, and reflexivity are needed to enable this process. Commitment is strengthened externally through the existence of the gate and internally through the common belief.

Placing skills inside or outside the comfort zone, making them explicit, already shows the potential of the individual for learning. The individual can set goals for themselves to have at least pushed themselves to learn or practice a certain skill that is outside of their comfort zone by a specific moment in time. This can, again, also be done in consultation with peers or a supervisor.

The idea of the tool portrayed in Figure 6.4 is that it is continuously updated and takes place 'on the down low' but is open for everyone to see. In other words, the idea of this tool is that it is accessible to everyone on the team to inspire them to take part in experimental endeavors, help each other out, or finds others who are skilled in something that others want to learn about. It lowers the threshold of experimenting and thereby stimulates learning.

The idea that was just sketched can be related to a known concept called Blockchain. In Blockchain, everyone has access to every step that has ever been made within a company, department, or team. It is a transparent system. The same applies to Figure 6.4.

It is important to note that the idea is not to give people a certain score. The point is simply to track people's process and progress, so that they themselves and others can learn from that. It provides an overview of the learning potential and provides easier opportunities to explore them.

The concept shown by the tool in Figure 6.4 can also be applied to leadership and is shown in Figures 6.5 and 6.6. The same format is used, but now also include a duality. One can be used for each duality separately or perhaps they can be paired in some way. The duality of autonomy & direction was taken as an example. The sides of the duality may also represent sides of the comfort zone of a specific leader – it is logical to think that, to some extent, they will be more comfortable adhering to one side of the duality than the other side. Figure 6.5 contains four behaviors that have previously been concluded to be linked to behaviors leaders should portray in relation to transdisciplinarity or learning in a transdisciplinary collaboration context. It can be seen that these behaviors have been placed mainly at one of the sides of the duality but also partly in the other side. The reason for this is that a skill can be said to work best on one side, but might still also work on the other side.

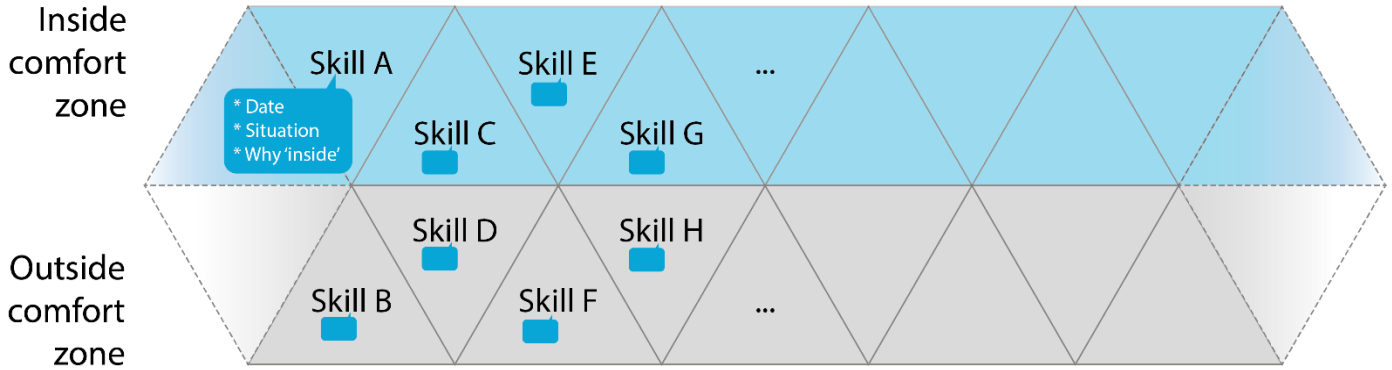
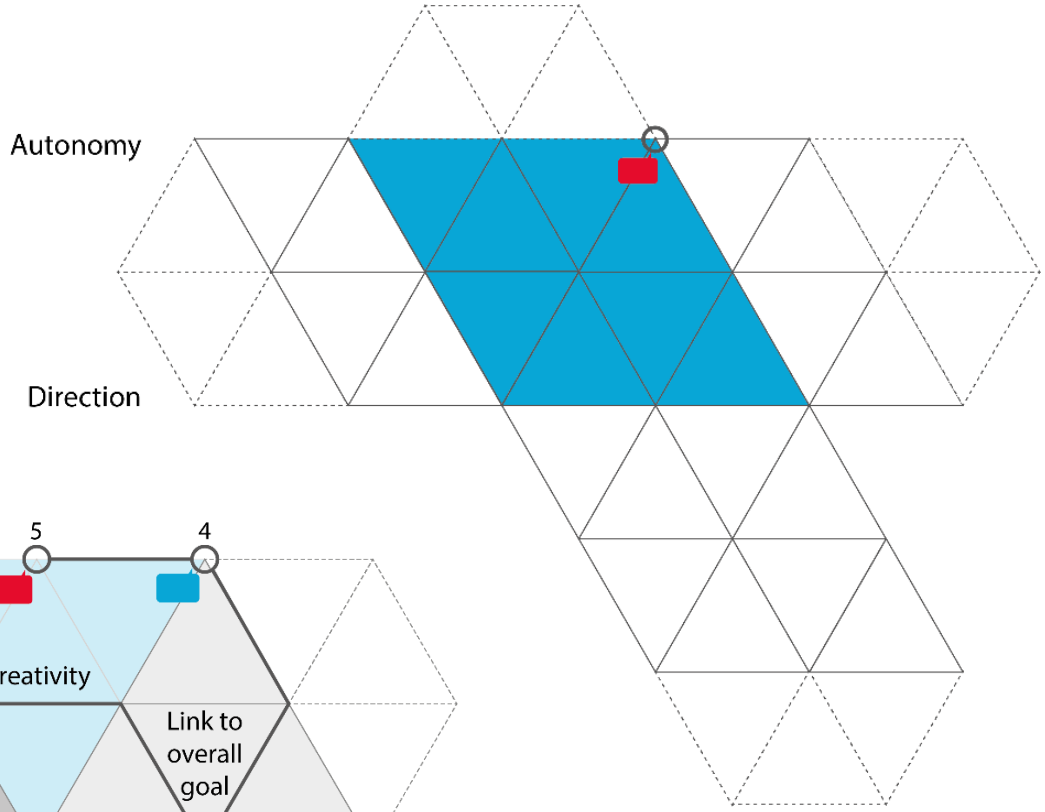


Figure 6.4: The Chainge Tool for Individuals. This omnidirectional transparent tool available to the whole team makes people aware of their learning potential and provides a lower threshold to explore this potential. This tool connects people, stimulates development, and helps bring about a change in mindset concerning learning. I.e., this tool chainges people.

The path shown in Figure 6.5 shows the sequence of points and may reveal additional interesting insights into the behavior of leaders and increase learning therein. The blue boxes provide an opportunity to elaborate on why a certain behavior took place, why a particular side of a duality was chosen, and what the date was. Note that both Figure 6.5 and 6.6 have a red box. This box marks a moment in time where one leader was unsure what to do in a specific situation and consulted a fellow leader who had proven to be better in that particular type of situation. The first leader knew this due to the transparency of the tool and the continuous documentation of situations encountered by leaders.



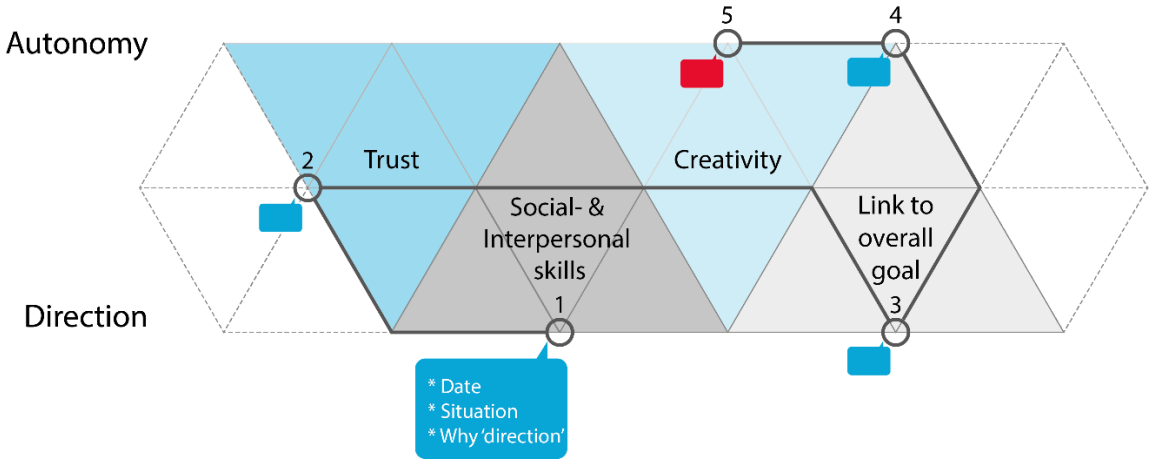


Figure 6.5 (bottom left): The Chainge Tool for Leaders. This omnidirectional transparent tool connects people, stimulates development, and helps bring about a change in mindset concerning learning (it chainges people). It is specifically meant for leaders and instead contain dualities of leadership and leadership behaviors that link to more of one side of a duality. The blue boxes show on what date a specific leadership behavior or focus on one part of a duality took place, what the situation was, and why that focus was chosen.

Figure 6.6 (top right): An example of how leaders can help each other out in instances where one of them is unsure how to proceed. This moment in time, marked by a red box in both figures, documents how the leaders worked together, who were the leaders, how they came to the decision to contact each other, and what the outcome was.

The Chainge Tool for Leaders portrayed in Figure 6.5 not only increases the learning potential in leadership, but also helps leaders develop a learning mindset towards their own leadership by making it explicit. Furthermore, the tool plays into the modularity of leadership, which was previously mentioned to be important to realize and document to enable effective rotational distributed leadership (including both formal and informal leaders). The Chainge Tool for Individuals is not only meant for team members, but also for the leaders. This tool helps map the development of the skills of the team members and makes it easier to adapt (leadership) to change.

6.3 QUALITY OF THE RESEARCH

6.3.1 ASSUMPTIONS

During the conduction of the research, several assumptions were made. The assumptions are:

1. Learning is important
2. Leadership has an influence on learning processes and collaboration
3. Transdisciplinary collaboration is needed in the Digital Twin project
4. People involved in the Digital Twin project know what transdisciplinary collaboration is
5. People are able to reflect on their behavior, their environment, their experiences, and processes
6. People are able to voice their thoughts and opinions about their behavior, environment, experiences, and processes
7. People have an understanding of collaboration, learning, and leadership
8. People are able to think about the abstract concepts of collaboration, learning, and leadership on an abstract level

Assumptions 1-4 may have had an influence on the literature study since they may have colored my perception of the relevance or importance of articles during the literature search and may have influenced the terms used for the literature search as well. This may have resulted in a less critical reflection on the chosen literature. This may therefore have influenced the quality of the literature research.

Assumptions 4-8 may have had an influence on the qualitative research in that it may have influenced the type of questions that were asked or the way the interview was structured. For example, assuming that people involved in the Digital Twin project know what transdisciplinary collaboration is resulted in time management where time needed to explain the different types of collaboration was not taken into account. This may therefore have had a negative influence on the (number of) questions that could and could not be asked. This would in turn influence the extensiveness of the results that could be subtracted from the interviews.

6.3.2 STRENGTHS AND WEAKNESSES OF THE LITERATURE STUDY

The search terms used for the literature study could have been more precise and more precise sooner. Unfortunately, it took me a long time to figure out the outline and connections between the three main pillars of my thesis (transdisciplinary collaboration, learning, and leadership), which led me into many different and too broad directions at the beginning and even half way through. This is not surprising since the subjects of learning and leadership are immensely broad. However, despite the fact that these subjects were eventually regarded through specific lenses – the lens of transdisciplinary collaboration in the first case and through the lens of learning in a transdisciplinary context and the transdisciplinary context itself for the latter case – there is undoubtedly much more theory available on them that has not been taken into account in this Master Thesis project.

Furthermore, collaboration in general was not researched, only transdisciplinary collaboration. Researching what elements are beneficial

for collaboration in general may have provided interesting insights in relation to transdisciplinary collaboration. Furthermore, an overlap between necessary conditions for effective collaboration and necessary conditions for effective learning may have been discovered. This would have provided a grounded explanation of why elements that were considered important for learning from a theoretical perspective were mentioned during the interviews in the context of collaboration.

On the positive side, the literature study is quite extensive and touched upon many different elements of both learning and leadership. Some theories were even left out as they lost their relevance for this specific project, but they have been added as appendices. Furthermore, transdisciplinary collaboration was not regarded on its own but was compared to other more well-known types of collaboration to put it into perspective. Additionally, the literature study was frequently iterated on, also in consultation with my supervisors. Therefore, the selection of the theory is not only based on my judgement, which makes it less biased. Moreover, everything in the literature study has been properly referenced. Therefore, anyone is able to check the statements and conclusions made within the literature study.

6.3.3 STRENGTHS AND WEAKNESSES OF THE QUALITATIVE RESEARCH

THE INTERVIEW CANDIDATES

The selection of what postdocs and PIs would be interviewed was based on their own initiative. During a meeting, one of the leads asked who would be willing to do the interview. Those were the people whom the lead brought me into contact with. So, there may be a bias since these people might be more willing and/or excited to talk about their project and experiences than others, which may give a skewed picture. However, all interviewees seemed open and honest about any concerns, struggles, or challenges they had, which may have decreased the chances of a skewed picture of reality.

The philosophers and people from the governing level that were interviewed were not directly a part of the Digital Twin team, but have worked with them some time or have heard of their processes. Therefore, it is debatable whether or not their insights and experiences are close enough to the reality of the Digital Twin team. However, it could also be said that their (slight) distance from the project may make it easier for them to put things in perspective and offer a less biased image of reality.

In interviewing people, they take with them their contexts and history and experiences. Therefore, the things they say are influenced by their background, discipline, or field. To account for these influences, several measures were taken as listed below:

1. People with different roles were interviewed: governing level, leads, principal investigators, postdocs, and philosophers.
2. At least two people per role were interviewed.
3. People from both institutions (EMC and TUD) were interviewed.

Adding on to the third item on the abovementioned list, the number of people from EMC and TUD were evenly distributed: six people came from EMC and six from TUD. However, this distribution was not even throughout the roles that people portrayed. Both people from the governing role came from TUD. Furthermore, all three postdocs came from the EMC. For the philosophers, two came from TUD and one from EMC. This uneven distribution may have tainted the results when it comes to remarks made concerning the institutional background of interviewees who said a certain statement.

More people, especially postdocs and principal investigators, could have been interviewed for the research. This would have increased the credibility of the study. Furthermore, it would potentially have provided a better distribution of roles and institution. However, this would have taken up a substantial amount of extra time since it would not only mean interviewing

extra people but also transcribing their interviews, analyzing them, and subtracting results from them. This time would have had to be subtracted on another section of the Master Thesis project, which is not the decision that was made. Another factor that influenced the number of people interviewed was the point in time where the introduction to Digital Twin took place. This happened later than was expected and therefore moved up the interviews as well. This was happened outside my sphere of influence.

THE INTERVIEWS

Semi-structured interview format

Semi-structured interviews were chosen as the form in which the perform the qualitative research. Compared to surveys, semi-structured interviews have the advantage of (immediate) interaction with the interviewee. This allows for a deeper understanding of their thinking, allows for follow-up questions, and allows for explanation of their answers if they are unclear. The advantages semi-structured interviews have in relation to structured interviews are as follows:

1. Semi-structured interviews enable the interviewer to have an interactive conversation and mix up the questions according to the answers of the interviewee. This makes for a more organic and relaxed conversation. The latter is the case since semi-structured interviews can be tailored to the expertise or comfort zone of the interviewee. For example, someone from the governance level will most probably have ideas and experiences concerning leadership more readily available than a postdoc. The other way around may be true when it comes to ideas about and experiences with learning.
2. The freedom of a semi-structured interview also enables the interviewer to add any questions that may seem relevant at the time to come to a deeper understanding of what an interviewee is saying or why they are saying it.
3. For a structured interview, the order of the question would have had to be tested as their sequence may evoke a certain reaction or steer the interviewee a certain way.

Despite the advantages of semi-structured interviews, there are also disadvantages. Using semi-structured interviews does not guarantee that every interviewee is asked the same questions and those questions are asked in the same order. Therefore, not every interviewee was given the exact same conditions or opportunities. Consequently, not every topic was covered in the same way for every participant. This could have colored their answers and have resulted in skewed results. However, to diminish this disadvantage, an organic selection of questions was made after some interviews had already taken place. It was ensured that at least the questions that were asked during the first interviews and were seen as relevant would also be asked in the remaining interviews.

Questions of the interviews

The choice was made to not ask the participants high-order difficult questions concerning the topics of collaboration, learning, and leadership. Instead, the questions were formulated and built up in such a way that first the interviewee would be asked about their own experience concerning a certain topic. This experience would help them ease into a subject so that the questions could become increasingly abstract. Examples can be found in the interview protocols in Appendix B.

The questions in the interview protocol were iterated on several times. These iterations took place in consultation with my main supervisor and a PhD candidate. Therefore, the questions were looked at by multiple people, thereby decreasing a chance of bias in the questions and increasing their relevance.

The choice was made to use non-suggestive questions that were (mainly) open-ended. Making questions non-suggestive allowed for people to openly and honestly share their own experiences and how they view a situation,

process, or experience. If people had trouble answering a question or coming up with, for example, characteristics of a good leader, a list of specific characteristics was kept on hand. However, this methodology may have resulted in people not mentioning everything they think or feel, simply because theory and practice often differ, it is not in their priority list, or they are not aware that they think it or not. For example, it may be the case that if someone was asked about characteristics of a good leader they would mention A, B, and C. In my list I could for example also have the characteristics D, E, and F. If I would ask specifically whether that person would agree with a good leader having the characteristics D, E, and F that they might agree with some if not all of them. Just because they did not mention D, E, or F themselves does not mean they do not agree with them. So, this methodology may have inhibited obtaining the complete opinions or perceptions of the interviewees. On the other hand, if people would mention certain characteristics or circumstances on their own, it would make their answer all the weightier.

Additionally, the chance existed that, due to the level of abstractness of some of the questions, that some people would not be able to provide answers. However, this was counteracted by introducing lower-level questions concerning a topic first and relating to their experience to ease them into an abstract theme.

Conducting the interviews

If the interviewee was Dutch, the interview was conducted in Dutch. Since Dutch was in those cases the native language of both the interviewer and the interviewee, it allowed for easier and more elaborate conversation. This in turn increased the chance of obtaining the interviewees' complete perception and opinions.

In some occasions, only 30 minutes were available for conducting the interview instead of 60 minutes due to the interviewee's busy schedule and my deadlines. This influenced the number of questions that could be asked during the interview as well as the time available to ease people into more abstract level questions. However, the people that only had 30 minutes available seemed to handle these abstract level questions well and the questions that had to be asked at the least were indeed asked. Therefore, the effect the time constrain had on the interview outcomes was minimal. Still, having had more time would have enabled me as an interviewer to go more into depth and possibly revealing more relevant information.

Transcripts and analyses of interviews

The interviews were fully transcribed. This allowed for the extraction of relevant quotes to support statements made or results shown in chapter 3 and thus positively influenced the credibility of the research. Furthermore, the full transcriptions can be used by the PhD candidate of the faculty of SEC for their own research.

Structural coding was used to process the qualitative data. Only the three main themes (transdisciplinarity, learning, and leadership) and two additional themes (background and extra) were predetermined. This method of coding gave me a general idea of what I was looking for, but left enough room for additional or unforeseen results.

As was stated previously, some of the interviews were conducted in Dutch to allow for easier and more elaborate conversation. However, the results were reported in English, meaning that statements or conclusions drawn from the Dutch interviews had to be translated. This may have resulted in slightly skewed results, since things can get lost in translation. For example, in English there are separate words for positive stress (excitement) and negative stress (anxiety). In Dutch, however, this is not the case: there is one word for both (spannend). Still, since answers that described the same type of situation or behavior were grouped together, this influence will have been limited. This grouping of statements, however, will have been based on my personal understanding of terms, concepts, and constructs. I.e., the

grouping may very well be biased and thus a (slightly) different interpretation of the data by someone else may be possible.

THE RESULTS

The results were given in the form of ratios. Ratios were chosen over percentages due to the small size of the group. A percentage would have been misleading, whereas a ratio directly shows how many people were linked to a certain statement.

Quotes were used to support statements made in the results, which increased their credibility. For all quotes used, permission was asked to the corresponding interviewees and the context in which the quote was to be used was shared as well. Furthermore, the quotes used in the final version of the report were somewhat 'smoothened out' to make them more easily readable. This did not change their essence or meaning, thereby not influencing their implication.

6.3.3 STRENGTHS AND WEAKNESSES OF THE COMBINATION OF THEORY AND PRACTICE

Combining the literature study with the qualitative study strengthened the final results. This combination of several methods is also referred to as triangulation and increased the validity (Finfgeld-Connett, 2010) and credibility of the research.

Naturally, elements that from theory and empirical data that could directly be linked were used in the final result. However, elements that could be implicitly or indirectly linked were often also used in the final result, which may have decreased the credibility and validity of the results again.

The weight of a certain result was not taken into account in combining theory with practice. For example, it did not matter if something was said by $10/12^{th}$ or $2/12^{th}$ of the interviewees, the result was taken into account all the same. A reason for this is that since only interviews with open question were used, it was noteworthy if even just one person mentioned something that was also considered a core element of transdisciplinarity, learning, or leadership. It was noteworthy since there were no nudging words or questions used, so everything came from the interviewees' own formulations. Additionally, it might have very well been the case that, if surveys and lists of specific elements were used, more people would have mentioned certain elements to be important. Also, recall that this Master Thesis project was referred to as an explorative study. Therefore, the final results shown in Figure 5.1 serves as a good basis or first indication of what might be important for leadership to portray specifically to stimulate learning in a transdisciplinary collaboration context.

It was said that it could not be concluded with certainty that the Digital Twin project is indeed transdisciplinary, is working towards transdisciplinarity, or should even be(come) transdisciplinary. This poses a problem for the transferability and validity of the final model. However, since many elements of transdisciplinarity defined from a theoretical point of view were also mentioned in the interviews (even if it was not in relation to transdisciplinarity specifically), it can be said that the final results are still a good indication and provide an interesting starting point for future research.

6.3.4 ETHICAL CONSIDERATIONS

The research can be said to have been conducted in an ethical manner. There are several reasons to support this:

1. All sources used have been properly referenced, thereby respecting other people's work
2. No harm was brought to participants of the interview. This was ensured through:
    a. Voluntary participation.
    b. Informed consent.
    c. Asking permission for recording. If the participant refused, the interview was indeed not recorded.

d. Asking permission for the use of specific quotes in the final report. These quotes and the context in which they were planned to be used were provided.
e. Confidentiality. The identity of the interviewees cannot be revealed based on the master thesis project.
f. A debriefing in at the end of the interview allowed people to add anything they felt was necessary, relevant, or important.

3. The final product of the Master Thesis project was shared with the participants as it was tailored to their project team and could benefit them and their team.
4. In line with the ethical obligation to the scientific community (Babbie, 2016), the research limitations of both the literature study and the qualitative research are shared.

Number 2a lists voluntary participation as a way to ensure participant safety during interviews. However, the norm of voluntarity "can conflict with the scientific need for generalizability" (Babbie, 2016, p. 84). This will be elaborated on later on.

6.3.5 VALIDITY AND RELIABILITY

Let us first clarify what validity and reliability mean. Validity "refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration" (Babbie, 2016, p. 148). Reliability "is a matter of whether a particular technique, applied repeatedly to the same object, yields the same result each time" (Babbie, 2016, p. 146). Triangulation of sources was used as well by interviewing five different groups of people (G, L, PD, PH, PI) (Finfgeld-Connett, 2010). Semi-structured interviews enabled a deeper understanding of the given answers, which positively influenced validity. Furthermore, triangulation of methods through a combination of a literature study, qualitative study, and consultation with my supervisors further increased validity. Another form of triangulation was used as well, namely

Additionally, the diversity in people's role and differences in institution was beneficial as it provided different perspectives. On the other hand, validity could have been further improved by combining the semi-structured interviews with surveys. Moreover, elements that could be implicitly or indirectly linked were often also used in the final result, which may have decreased the validity of the results. It was also noted that it could not be concluded with certainty that the Digital Twin project is indeed transdisciplinary, is working towards transdisciplinarity, or should even be(come) transdisciplinary. However, since many elements of transdisciplinarity defined from a theoretical point of view were also mentioned in the interviews (even if it was not in relation to transdisciplinarity specifically), it can be said that the final results are still a good indication and provide an interesting starting point for future research.

The reliability of the research was increased by recording the interviews (if permission was given to do so) and fully transcribing them. Furthermore, tables containing statements from the interviews and the conclusions drawn based on them were provided in appendices. Additionally, the used interview protocols were provided in the appendix as well, and the questions that were ask to all interviewees was marked as bold. This all increased the reliability of the research further. Moreover, for each group (G, L, PD, PH, PI), at least two people were interviewed to increase the reliability of what was said by those groups. However, the group in totality was rather heterogeneous and would have benefited from even more people per group. The nature of semi-structured interviews also poses a challenge to reliability. The reason is that every interviewer has a different style of interviewing or will decide on a different order of asking the questions. Furthermore, who is to say that the same people would give the same answers a next time. However, this is only true if a researcher would decide to start from scratch. Since the interview protocols were provided

and the interviews were recorded and fully transcribed, the results presented in this Master Thesis project can be (partly) recreated. Still, there is of course also a certain selection and grouping bias that needs to be accounted for. It might very well be the case that an emphasis was put on certain elements, both in theory and in the interviews, that might have influenced the final result.

Based on all this, it can be said that this Master Thesis project is mostly valid and reliable. There are some ways in which the validity and the reliability could have been increased, as is wise to do for any (future) researcher reading this.

6.3.6 TRANSFERABILITY

Transferability concerns the extent to which the results found in one study can be applied in a different context. "The degree of generalizability or transferability between contexts is a direct function of the similarity between the two situations or their associated fittingness" (Finfgeld-Connett, 2010). Therefore, to be able to make any conclusive remarks concerning transferability, both situations needs to be fully understood by the practitioner that intends to transfer a framework, model, or theory from one context to another. Since I am not in possession of such information, no conclusive remarks concerning transferability can be given. However, some relationships between certain contexts can be drawn based on logic, as will be done below. It is up to the practitioner that intends to act upon these possible transferability opportunities to check whether this transferability is indeed present enough.

It is logical to think that the results found in this Master Thesis project can to some extent be transferred to project teams that can be characterized the same way as the Digital Twin team. These include (1) people from EMC and TUD, (2) the aim to work towards a transdisciplinary way of collaborating, and (3) being part of the Health & Technology theme of the Convergence Agenda. These types of project teams will most likely face the same kind of problems and include the same type of people, and will therefore combine into a similar context as that of the Digital Twin team.

Note that even though the Convergence Agenda also concerns the EUR, the Digital Twin team does not currently have people from the EUR as team members. This may make this Master Thesis project less transferable to convergence projects of the Convergence Agenda, since people from EUR have a different culture and probably a different way of thinking that would have introduced different types of answers to the interview questions, and thus to the overall result.

The transferability of the results of this Master Thesis project can be said to have been increased by including not only people from within the Digital Twin project, but also outside of it. This includes people from a governing level as well as philosophers. These people will have most likely provided a more general idea of transdisciplinarity, the collaboration, learning, and leadership, which may have resulted in a more general end result that may be used in other flagships of the Convergence Agenda and in other themes as well.

Transferability is said by Finfgeld-Connet (2010) to be linked to validity. It was previously concluded that this research is mostly valid and can therefore also be considered mostly transferable to contexts that are very similar to that of the Digital Twin project.

In general, it should be noted that "all theoretical frameworks are tentative when they are applied in a new context" (Finfgeld-Connet, 2010, p. 248). This is (partly) due to the fact that teams include people, who are dynamic, diverse, and complex. Therefore, even though context A might in theory be exactly the same as context B, transferability of a model that concerns humans and human behavior is never 100 percent.

6.4 CONTRIBUTION TO THE FACULTY OF SEC

This Master Thesis project was carried out to obtain a MSc degree at the faculty of SEC and therefore had to be of relevance to SEC. below will be explained in what way this Master Thesis project is indeed relevant to the faculty of SEC. In extension, this project may be of great value to the Convergence Agenda and the involved institutions EMC, EUR, and TUD.

The Convergence Agenda is currently being employed and would benefit from the insights of this Master Thesis project as it may relate to other research teams within the Convergence Agenda too. As SEC is a part of the TUD, convergence endeavors may very well influence their way of working as well. In line with that, having insights in this new type of collaboration and how to deal with it from a leadership perspective may provide SEC with an advantage compared to the other faculties for two reasons: (1) it is the first to be aware of these insights and can therefore be the first to take them into account, and (2) SEC is already a place where innovative ideas about science, communication, education, and collaboration are formed and executed. Point (2) also means that the new SEC students may be the first to be educated to become the new transdisciplinary leaders or are at least the ones that know how to deal with transdisciplinarity and incorporate a learning mindset. I.e., SEC may become one of the biggest forces to develop and secure the new way of working in the Convergence Agenda.

The synthesis of this Master Thesis project included a collaboration with a PhD candidate from the SEC faculty. Communities of practice is a main focus of his research, which has many direct links with elements discussed in this thesis (such as trust, community, and social learning). He is also taking Digital Twin as a case study. Therefore, this Master Thesis research project is of relevance to the research of a PhD candidate from SEC and thus of relevance to SEC.

As this Master Thesis project was an explorative study, it provides numerous opportunities for additional and future research. Propositions for some specific subjects include change, personality, a network perspective, or even an elaboration or further exploration of the specific topics discussed in this project, are mentioned in section 6.5.

6.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Based on everything that has been said, discussed, and visualized in this Master Thesis project, there are several subjects that are recommended for future research. Either to continue onto the explorative path that has been set in this project, or to explore another path that relates to the themes discussed in this project.

6.5.1 FOLLOWING THE TRAJECTORY OF THIS MASTER THESIS PROJECT

ADDING TO THE RESEARCH

As was previously mentioned, the validity and reliability of this Master Thesis project could be improved. One way to do so is by interviewing more people from all groups (G, L, PD, PH, PI) as well as taking surveys. Another option is to interview people from other flagships within the Health & Technology theme of the Convergence Agenda to shed more light on the transferability of the results of this Master Thesis project.

COLLABORATION

In this Master Thesis project, only multi-, inter-, and transdisciplinary collaboration were discussed from a theoretical point of view. An additional focus on collaboration could have introduced many more interesting elements or could have possibly ruled out a relationship between certain elements of collaboration in general and elements of transdisciplinary collaboration.

A noteworthy relationship was found between elements mentioned in the interviews to be important for the collaboration and elements found in theory to be important for learning in relation to a transdisciplinary collaboration context. It could very well be the case that the elements necessary for stimulating learning are similar to if not the same as elements necessary for effective collaboration to take place. If that is the case, the results of this Master Thesis project could have been concluded to not only work for learning, but for collaboration in general.

DESIGN-BASED RESEARCH

The research presented in this Master Thesis project is literature based in nature. A first idea of what decision support tools might help in making learning explicit and adopt a learning mindset (also to leadership), was previously shown in section 6.2. These models, however, are based on my logic and ideas and have not been tested. It may therefore be interesting to research the topics discussed in this Master Thesis project from a design-based research approach. A start has already been made by the group Human Touch of the 2020-2021 C-Lab course of the Science Communication (later called Communication Design for Innovation) Master, with a specific focus on duality in leadership. Their tool introduces a role-playing element and aims to increase awareness about different perspectives as well as train the ability to change perspectives.

CONSIDER THE LEFT-OUT ELEMENTS

There were several elements, either from theory or empirical data, that did not end up in the finalized core elements of the three themes (transdisciplinarity, learning, and leadership). This does not, however, mean that these elements are not of importance. They were simply not supported enough from either a theoretical or empirical point of view. The elements that were left out are listed below.

The elements concerning collaboration that were not taken into account are:

- It is challenging. Four challenges were identified: (1) differences in expectations, (2) the online environment, (3) institutional boundaries, and (4) cultural differences resulting in, for example, differences in how research is done and incentives.
- It is time consuming
- Open discussion (including talking about expectations, a willingness to contribute, and discuss biases and assumptions and iterate on them)
- (informal) social interaction
- Clarity & concreteness
- People being open to sharing
- Knowing what others can contribute
- Creativity
- Reciprocity
- Daring to speak up
- Calmness
- A willingness to listen

The elements concerning leadership that were not taken into account are:

- Have status, prestige, or expertise
- Have experience
    - In leadership
    - In working in or with multidisciplinary teams
- Clarify that the research process is not linear
- Introducing incentives for such collaboration types
- Ensuring a focus on collaboration and not just on personal interests
- Not imposing things in a top-down way
- Patience
- Applying an open governing style
- Moving between communities
- Being vigorous
- Linking what needs to be learned to the project or individual goals

COLLABORATE WITH THE PHD CANDIDATE ON COMMUNITIES OF PRACTICE

The collaboration with the PhD candidate could be continued, either in the same direction as this Master Thesis project or more specifically in relation to communities of practice. The results of this explorative research can be used to determine links with communities of practice so that this project can be used as a basis for the collaboration with the PhD candidate.

6.5.2 ADDITIONAL AND DIFFERENT PERSPECTIVES

PERCEPTIONS & EXPERIENCES

Naturally, past experiences and perceptions influence the way we see the world. Collaboration, learning, and leadership are no exception to this. Specifically, how perceptions and experiences influence learning used to be part of the literature study. However, a direct link with the eventually determined core elements of transdisciplinarity could not be found, thereby rendering this part of the literature study superfluous. However, perceptions and experiences still provide interesting insights in relation to learning and are therefore proposed as an opportunity for future research. The parts of the literature study relating to perceptions & experiences can be found in Appendix F and can be used as a basis for future research.

NETWORK PERSPECTIVE

A network can be constructed in any team, community, organization, institution, etc., and may reveal interesting relationship between members of that network. Specifically, the flow of information or the strength of relationships may influence collaboration, learning, and the effectiveness of leadership. Constructing informal and formal networks of the same community may provide additional insights on why certain behaviors take place or why certain methods are successful or not. A network perspective was initially taken into consideration in the literature study, but could eventually not be linked to the core elements of transdisciplinarity and was therefore cut. This part of the literature study can be found in Appendix F and can be used as a basis for future research.

PERSONALITY

"The selection of an appropriate leadership style depends on the situation as well as the personalities of leaders" (Sethuraman & Suresh, 2014, p. 171). Additionally, the personalities of the team members influence the effectiveness of certain leadership styles as well. Introducing personality as another element that has to be factored in to determine an appropriate leadership style may increase the generalizability and transferability of the results presented in this Master Thesis project.

CHANGE

The introduction of the Convergence Agenda and the corresponding transdisciplinarity as a novel type of collaboration introduce a massive change to not only the way of collaborating, but also to perceptions, structures, incentives, goals, commitments, and so on. It is an immense subject that has interesting relations to learning and leadership as well. I would be curious to see to what extent change is truly necessary to enable the adoption of transdisciplinary collaboration and how it affects the whole system of institutions.

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APPENDIX

APPENDIX A – CAUSAL DIAGRAM OF LEADERSHIP IN RELATION TO LEARNING AND TRANSDISCIPLINARITY

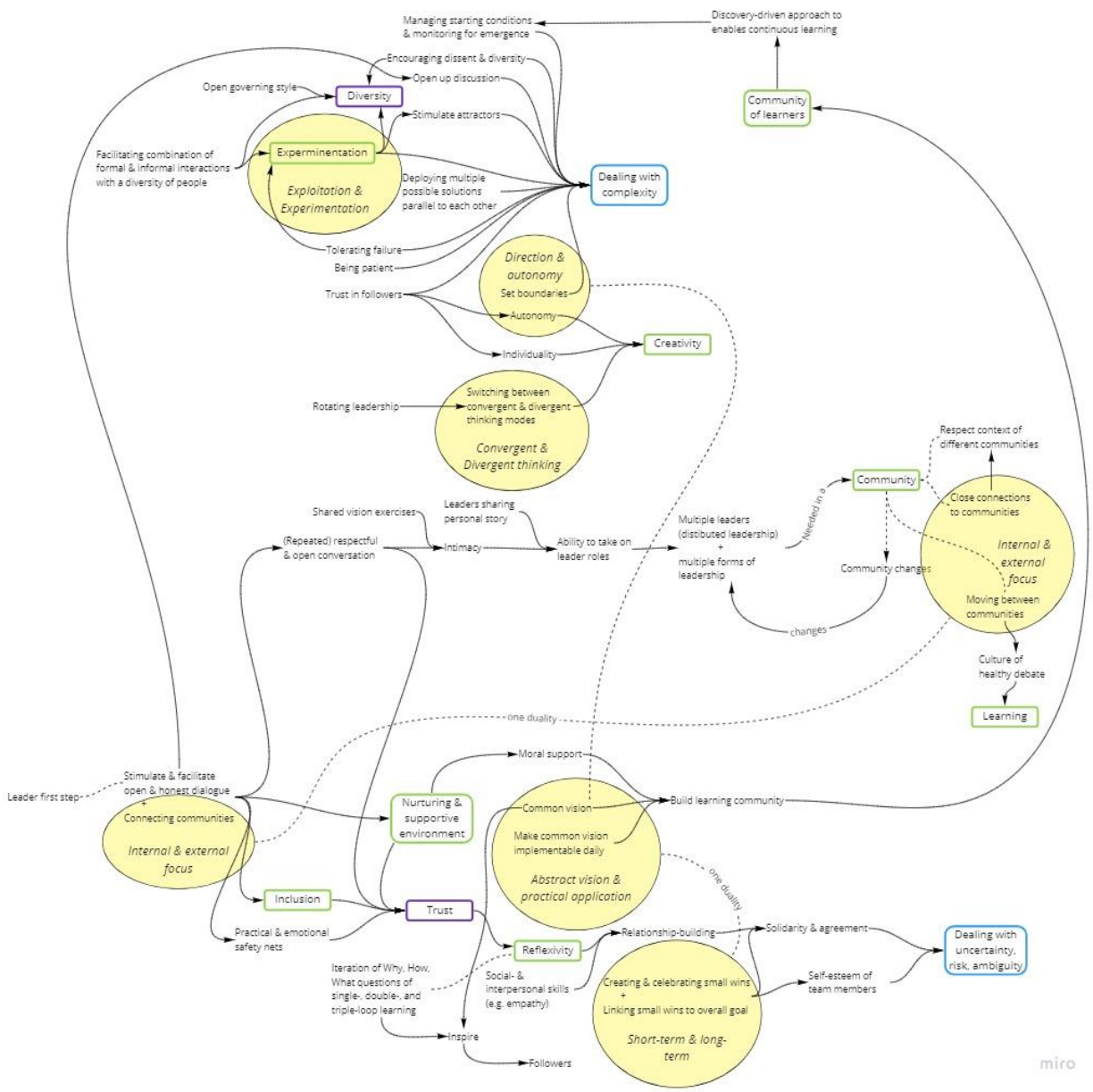

Figure A: Causal diagram of necessary leadership behaviors for stimulating learning or working towards transdisciplinarity based on the literature study. The blue boxes are elements of transdisciplinarity, the green boxes are elements of learning, the purple boxes are elements of both transdisciplinarity and learning. The yellow circles portray dualities of leadership.

APPENDIX B – INTERVIEW PROTOCOLS

Below are two interview protocols. The first was used in interviews with PIs, postdocs, and philosophers. The second was used in interviews with people from the governance level and the leads of Digital Twin. Some questions are bold. This means they were viewed as especially important and the interviews provide an answer to these questions, either through direct or indirect answering of these questions.

INTERVIEW PROTOCOL USED FOR PIS, POSTDOCS, AND PHILOSOPHERS

Part I: Instructions

General instructions *[these will be sent to the interviewees beforehand]*

Good morning/afternoon. My name is Emmy Thans and I am a graduate student of the Science Communication Master of the TU Delft. This interview is part of research I am conducting for my graduation project. My graduation project concerns the Convergence Agenda of the TU Delft, Erasmus University of Rotterdam, and Erasmus MC. My focus is on finding a fitting leadership structure to facilitate continuous learning and to enable transdisciplinary collaboration. Digital Twin serves as a case study to make the findings as practical and concrete as possible. Hopefully, the insights that I get from the Digital Twin case might later on be translated to fit other research teams as well.

The goal of the interview is to hear your ideas about and experiences with your project team, learning, and leadership. In the interview there are no right or wrong, or desired or undesired answers. I would like you to feel comfortable in answering the questions honestly and openly. The interview will last about 45-60 minutes.

Recorder instructions

If you agree, I'll record our conversation. (IF YES, TURN RECORDER ON). The purpose of this is that I can get all the details but at the same time have an attentive conversation with you. I assure you that all your comments will remain confidential. After the finalization of my thesis, the raw interview data and the transcripts will be deleted from my personal devices and saved onto a special and secure drive of the TU Delft where my supervisors still have access to them. My final report may contain some anonymous comments from the interviewees.

Do you have questions about what has just been explained?

Part II: Questions

Overall questions

Q1. How are you feeling?

Q2. Please tell me something about yourself and your role as a postdoc.

Project questions

Q1. What project are you currently working on?

Q2. How would you describe the collaboration within this project?

Q3. How would you describe the collaboration within Digital Twin?

Q3.a. Would you describe it as transdisciplinary? Why?

Q4. Would you call the project you are currently working on an Erasmus-TU Delft project?

Q5. Would you call the project you are currently working on to be part of the Convergence Agenda?

(IF YES): Q5.a. Can you describe what makes it part of the Convergence Agenda?

(IF NO): Q5.b. What would make it part of the Convergence Agenda?

Q6. Has this project been different to the other projects you have worked on? How?

Q7. What project has 'opened your eyes'? Why?

Q7.a. What were the conditions of this project? *(context, size of group, setting, method, length, intensity, content, theory vs practice, etc.)*

<u>Leadership questions</u>

Q1. Who is your boss / supervisor?

Q1.a. What do you think of them? *(professionally and personally)*

Q1.b. Would you also call them a leader?

(IF YES) Q1.b.i. Why?

Q1.b.ii. How do you experience working with a boss that you view as a leader?

Q1.b.iii. What are they doing well?

Q1.b.iv. What could they do better?

(IF NO) Q1.b.i. Why not?

Q1.b.ii. How do you experience working with a boss that you do not view as a leader?

Q1.b.iii. **Who would you call a leader? Why?**

Q1.b.iv. What are they doing well?

Q1.b.v. What could they do better?

Q2. Does it change over time who your boss is? How?

Q3. Does it change over time who you consider to be a leader? How?

Q4. What do you think about the switching of the chairman each meeting?

Q4.a. What do you like about it? What does it contribute?

Q4.b. What do you not like about it?

Q5. If you had the choice, would you propose a different format for the team meetings? Why?

(IF YES): Q5.a. What would the format be? Why?

Q6. Can you give an example of a good leader?

Q6.a. What makes them a good leader? *(E.g. dual mindset, relationship building, having a vision, knowledgeable (content wise), status, empathetic, etc.)*

Q6.b. Have you experienced such a leader? How was that?

Q7. Can you give an example of a bad leader?

7.a. What makes them a bad leader?

Q7.b. Have you experienced such a leader? How was that?

Q8. If you were asked to become the leader of your team or research group, what would your response be? Why?

Q8.a. What would it entail to be a leader of your team / research group?

Q8.b. What would you make sure to do if you would become the leader?

Q8.c. What would you make sure <u>not</u> to do if you would become the leader?

Q9. If you were to become a leader of your team, what challenges do you think you would have to face?

Q10. What do you think the difference is between 'leader' and 'leadership'?

<u>Learning questions</u>

Q1. When was the last time you learned something new?

Q1.a. Can you describe the conditions? *(environment, schedule, time, participants, leadership, theoretical/practical, etc.)*

Q1.b. Did you learn from someone else?

Q1.c. Was this a pleasant way for you to learn something new?

Q1.d. Did it help you to become a better researcher or person? How?

Q2. Can you name an example where you felt you learned a lot? Please elaborate *(context, size of group, setting, method, length, intensity, content, theory vs practice, etc.)*

Q2.a. Was it already during the process that you saw the added value, or was it only after?

Q3. Can you name an example where you felt you learned nothing or little? Please elaborate. *(context, size of group, setting, method, length, intensity, content, theory vs practice, etc.)*

Q4. How do <u>you</u> best learn something new? *(Ask about internal and external processes, with or without others).*

Q5. Do you ever learn from or with others? Can you describe such an experience?

Q6. What value does learning have for you?

Q7. Where would you say learning takes place within Digital Twin?

Q8. What role does learning have in your work, currently?

Q9. What role should learning have in your work, do you think? Why?

Q10. Has learning been discussed this way within Digital Twin before? Has it gotten explicit attention?

(IF YES): Q10.a. How? By whom?

Q11. Should learning get explicit attention? Why?

Combining questions

Q1. Going back to the learning experience you mentioned before:

Q1.a. Where did you notice an influence from leadership?

Q1.b. Where did you feel a need for leadership?

Q1.c. Where (in the learning process) do you think leadership could make a difference? How?

Q1.d. Could you draw this on a timeline?

Q2. What do you think leadership could do to stimulate learning?

Q3. What do you say would be challenging for leadership in the Digital Twin team?

Q3.a. Do you think this is also challenging for other teams? Why?

Q3.b. Do these challenges have anything to do with convergence?

Q3.c. Do these challenges have anything to do with the Health and Technology sector specifically?

Additional questions

Q1. If you had to draw the people of the Digital Twin team in a network, what would that look like?

Q1.a. Who would be connected to whom?

Q1.b. What would be the nature of that connection?

Q1.c. Would the network look different on a personal level vs a professional level? How so?

Q1.d. Are there currently links missing, in your opinion?

(IF YES): Q1.d.i. What links are missing? Why are they missing?

Q2. If I could magically conjure a person that would become a part of the Digital Twin team, what kind of role would you hope that person would fulfil? *(E.g., leading role, connecting role, administrative role, researcher role, data managing role, visionary role, confidant role, etc.)*

Q2.a. Where would you want to place them within the network? Why?

Q2.b. Is this an existing person, someone you know? Who?

Q2.b.i. What do you feel when you think of them?

Q3. What do people come to you for when they need help?

Part III: Debriefing

Thank you for participating in this interview.

The aim of this interview and the research is to get an idea about what leadership structure or model might fit with the convergence of the TU Delft, Erasmus University Rotterdam, and Erasmus Medical Centre. As you are an integral part of that convergence, I was interested in your opinions and experiences. This research is confidential, any references to individuals will be done anonymously, and the raw interview data and transcripts will be safely and securely stored on a TU Delft server.

Q1. Is there information about your experience or your ideas that you think will be helpful for me to know?

(IF YES) Q1a. Can you share that information with me?

Q2. Do you have any other comments?

Q3. Is it possible to send you a message afterwards if I have any additional questions?

(IF YES) Q3a. May I have your LinkedIn and / or email address? *If I don't have it already.*

Thank you again for your participation.

(TURN RECORDER OFF)

INTERVIEW PROTOCOL USED FOR GOVERNANCE LEVEL AND LEADS OF DIGITAL TWIN

Part I: Instructions

General instructions *[these will be sent to the interviewees beforehand]*

Good morning/afternoon. My name is Emmy Thans and I am a graduate student of the Science Communication Master of the TU Delft. This interview is part of research I am conducting for my graduation project. My graduation project concerns the Convergence Agenda of the TU Delft, Erasmus University of Rotterdam, and Erasmus MC. My focus is on finding a fitting leadership structure to facilitate continuous learning and to stimulate collaboration. Digital Twin serves as a case study to make the findings as practical and concrete as possible. Hopefully, the insights that I get from the Digital Twin case might later on be translated to fit other research teams as well.

The goal of this interview is to hear your ideas about and experiences with leadership, learning, and convergence, and to form a first impression of those concepts in relation to each other. In the interview there are no right or wrong, or desired or undesired answers. I would like you to feel comfortable in answering the questions honestly and openly. The interview will last about 45-60 minutes.

Recorder instructions

If you agree, I'll record our conversation. (IF YES, TURN RECORDER ON). The purpose of this is that I can get all the details but at the same time have an attentive conversation with you. I assure you that all your comments will remain confidential. After the finalization of my thesis, the raw interview data and the transcripts will be will be deleted from my personal devices and saved onto a special and secure drive of the TU Delft where my supervisors still have access to them. My final report may contain some anonymous

comments from the interviewees. Do you have questions about what has just been explained?

Part II: Questions

Overall questions

Q1. How are you feeling?

Q2. Please tell me something about yourself and your role in relation to Digital Twin / Health & Technology.

Project questions

Q1. What project are you currently working involved in?

Q2. How would you describe the collaboration within this project?

Q3. How would you describe the collaboration within Digital Twin?

Q3.a. Would you describe it as transdisciplinary? Why?

Q4. Has this project been different to the other projects you have been involved in? How?

Q4. What project has 'opened your eyes'? Why?

Q4.a. What were the conditions of this project? *(context, size of group, setting, method, length, intensity, content, theory vs practice, etc.)*

Leadership questions

Q1. Would you call yourself a boss or supervisor? Why?

Q2. Would you call yourself a leader? Why?

(IF YES): Q2.a. When was the moment you felt you were a leader?

(IF NO): Q2.b. Who would you call a leader? Why?

Q3. Can you name an example of an effective or good leadership moment, either from yourself or someone else?

Q3.a. What made it effective or good? *(E.g. dual mindset, relationship building, having a vision, knowledgeable (content wise), status, empathetic, etc.)*

Q3.b. Are any of those conditions or behaviors currently missing in leadership?

Q4. Can you name an example of an ineffective or bad leadership moment, either from yourself or someone else?

Q4.a. What made it effective or good?

Q4.b. Are any of those conditions or behaviors happening now?

Q5. Does it change over time who the boss? How?

Q6. Does it change over time who you consider to be a leader? How?

Q7. What do you think the difference is between 'leader' and 'leadership'?

Q8. How are research teams of the Convergence Agenda currently being led?

Q8.a. Has this changed over time? How?

Learning questions

Q1. When was the last time you learned something new?

Q1.a. Can you describe the conditions? *(environment, schedule, time, participants, leadership, theoretical/practical, etc.)*

Q1.b. Did you learn from someone else?

Q1.c. Was this a pleasant way for you to learn something new?

Q1.d. Did it help you to become a better researcher or person? How?

Q2. Can you name an example where you felt you learned a lot? Please elaborate *(context, size of group, setting, method, length, intensity, content, theory vs practice, etc.)*

Q2.a. Was it already during the process that you saw the added value, or was it only after?

Q3. Can you name an example where you felt you learned nothing or little? Please elaborate. *(context, size of group, setting, method, length, intensity, content, theory vs practice, etc.)*

Q4. How do you best learn something new? *(Ask about internal and external processes, with or without others).*

Q6. Where would you say learning takes place within the Convergence Agenda?

Q7. What role does learning have in your work, currently?

Q8. What role should learning have in your work, do you think? Why?

Q9. Has learning been discussed this way in context of the Convergence Agenda before? Has it gotten explicit attention?

(IF YES): Q10.a. How? By whom?

Q10. Should learning get explicit attention? Why?

Combining questions

Q1. Going back to the learning experience you mentioned before:

Q1.a. Where did you notice an influence from leadership?

Q1.b. Where did you feel a need for leadership?

Q1.c. Where (in the learning process) do you think leadership could make a difference? How?

Q1.d. Could you draw this on a timeline?

Q2. What do you think leadership could do to stimulate learning?

Q3. What do you say would be challenging for leadership in a team of the Convergence Agenda?

Q3.a. Do you think this is also challenging for other teams? Why?

Q3.b. Do these challenges have anything to do with convergence?

Q3.c. Do these challenges have anything to do with the Health and Technology sector specifically?

Additional questions

Q1. If you had to draw the people of the Digital Twin team in a network, what would that look like?

Q1.a. Who would be connected to whom?

Q1.b. What would be the nature of that connection?

Q1.c. Would the network look different on a personal level vs a professional level? How so?

Q1.d. Are there currently links missing, in your opinion?

(IF YES): Q1.d.i. What links are missing? Why are they missing?

Q2. If I could magically conjure a person that would become a part of the Digital Twin team, what kind of role would you hope that person would fulfil? *(E.g., leading role, connecting role, administrative role, researcher role, data managing role, visionary role, confidant role, etc.)*

Q2.a. Where would you want to place them within the network? Why?

Q2.b. Is this an existing person, someone you know? Who?

Q2.b.i. What do you feel when you think of them?

Part III: Debriefing

Thank you for participating in this interview.

The aim of this interview and the research is to get an idea about what leadership structure or model might fit with the convergence of the TU Delft, Erasmus University Rotterdam, and Erasmus Medical Centre. As you are an integral part of that convergence, I was interested in your opinions and experiences. This research is confidential, any references to individuals will be done anonymously, and the raw interview data and transcripts will be safely and securely stored on a TU Delft server.

Q1. Is there information about your experience or your ideas that you think will be helpful for me to know?

(IF YES) Q1a. Can you share that information with me?

Q2. Do you have any other comments?

Q3. Is it possible to send you a message afterwards if I have any additional questions?

(IF YES) Q3a. May I have your LinkedIn and / or email address? *If I don't have it already.*

Thank you again for your participation.

(TURN RECORDER OFF)

APPENDIX C – FULL TRANSCRIPT EXAMPLE

(Dutch)

This appendix shows an example of a full transcript. The transcript is in Dutch. Due to the fact that it is a full and literal transcript (expect for the 'uhms' and pauses), the sentence structure is not grammatically correct. 'A' refers to the interviewer and 'B' to the interviewee. (???) means I was not able to hear what was being said. The person that was interviewed for this transcript gave their permission to show the full transcript.

A: [00:00:00] Yes ik ben begonnen met opnemen Dus nogmaals welkom Valentijn Goedemorgen hoe is het met je

B: [00:00:11] nou wat ik net al zei ik ben blij dat het weer mooi weer wordt maar verder is het Vooral achter de laptop zitten ontzettend druk

A: [00:00:25] Kan je even iets kort vertellen over jou over je achtergrond en jouw rol als tracker binnen Digital Twin

B: [00:00:37] ik ben Universitair hoofddocent Industrieel Ontwerpen bij de afdeling Human centered design en de sectie Design Statics Ik werk hier nu een jaar of 12 ik doe eigenlijk vooral onderzoek naar motivatie van de gezondheid dus ik zit heel in heel erg veel project Eigenlijk zit het begin al ontwerp projecten om op de een of andere manier mensen voor gezondheids toepassingen meer te motiveren dmv daarvoor heb ik ook heel veel game design gedaan een aantal jaren persuasive game design een groep zo'n beetje opgericht daar en ja allerlei andere motiverende elementen onderzocht een aantal projecten lopen over storytelling over het bereiken van moeilijke of het bereiken van kwetsbare groepen lachen 6 groepen heb ik ook project oplopen Hoe kan je die nou het beste met ontwerp bereiken in het kader van de gezondheidsproject Ja ik ben ook bezig met data design dus op welke manier kun je nou big data op zo'n manier vormgeven dat het motiverende kleinere data wordt en dat is ook mijn interesse in het Digital twin project en het gaat over heel veel data eigenlijk de Digital twin data en hoe kan je nou Digital twin gemaakt van data Ze wou individuele of collectieve data en wij vragen is niet alleen of Mijn adres is niet alleen hoe kan je dat verzamelen en wat kan je daar uit leren voor predicties maar vooral ook weer terug op een manier die aansluit bij de belangen van de individuele stakeholders en dat zijn dus de vraagstukken dus vandaar en dat is mijn interesse in het project Ik ben nou verbonden als en ja hoe heet dat ik denk projectmanager samen met [*other lead*] dat kwam eigenlijk Ik zat eerst een beetje wat meer op op de achtergrond bij en sinds ik denk oktober ben ik het officieel op gaan pikken als projectleider daarvoor deed Richard Goossens dat en nou doet hij ook toen hij een andere rol kreeg binne convergence kon hij niet meer combineren en heb ik zijn plaats meegenomen dus ik ben er iets later bij gestapt Ik was in het begin wel bij betrokken maar wat zijdelings

A: [00:03:16] dus zie jij jezelf als een leider binnen Digital Twin

B: [00:03:25] ja dat hangt er een beetje van af hoe je leiders noemt wel als iemand die probeert om het project tot een geheel te brengen Dat is eigenlijk mijn voornaamste taak en dat is ook een taak die altijd bij leiders paste lijkt mij dus in die zin wel

A: [00:03:52] Heb je het idee dat anderen ook zo naar jou kijken dat ze jou in ieder geval benaderen als een van de leiders van

B: [00:03:59] ja

A: [00:04:02] en op wat voor manier merk je dat

B: [00:04:04] aan de ene kant hoe Er wordt omgegaan met feedback die ik geef Dus dat ik dus dat het niet alleen serieus wordt overwogen maar vaak wordt overgenomen en aan de andere kant Ja Ook als het gaat over eigenlijk beslissingen die niet alleen op individueel niveau zich voordoen maar op

collectieve niveau dat mensen dan ook altijd vragen aan mij om advies daarin

A: [00:04:43] en hoe voelt dat voor jou om in zo'n positie te zitten

B: [00:04:47] Ja ik heb dat wel vaker ik ben projectleider al heel lang in verschillende projecten sinds 2012 denk ik dat ik mijn eerste grote interdisciplinaire project met ook meerdere Team Partners had dus ik ben net wel gewend Meestal ben ik het projectleider in mijn eentje Dus voor het eerst dat we met zijn tweeën doen Ik heb nog twee andere projecten waar ik wel projectleider in mijn eentje ben die lopen ook parallel hieraan toevallig vorige week een overzicht gemaakt van het project en dat zijn er volgens mij nu zes of zeven waar ik in zit waarvan ik er drie leidt zeg maar en eentje dus met z'n tweeën in Digital twin en die andere die ik in mijn eentje en die andere twee zit ik alleen als externe

A: [00:05:36] en daarnaast moet je ook nog lesgeven

B: [00:05:37] ja ja

A: [00:05:39] wauw oké ja ja

B: [00:05:40] ja het is het is druk

A: [00:05:44] Ja dat geloof ik meteen

B: [00:05:46] en qua projectleiding ja dan in het algemeen als ontwerper en ook in het project waar ik in zit ben ik het heel erg gewend om samen te werken met mensen van heel veel verschillende disciplines dus zowel wetenschappelijke disciplines als buiten wetenschappelijke sectoren en de Digital Twin is eigenlijk wel een van de projecten waarbij dat veel minder rol speelt dan Ik zou willen dus in het algemeen Nou ja een typisch project wat ik doe dat heeft een ontwerp bureau dat heeft een ziekenhuis dat heeft een medisch specialist en een andere medische sector zoals psycholoog of een taalwetenschapper en dan een ontwerp wetenschapper en vaak ook nog een patiëntenvereniging die daarin aan is gesloten en een maatschappelijke organisatie zoals er nog meten en dan heb je een filmtrailer Palet aan Partners en dat zijn de typische projecten waarin waarin ik werken Digital twin is veel meer ja de hoofd modes zijn daar data Scientists maar dan op verschillende niveaus vanuit diedjies maar wel nou PhDers zijn er ook zijdelings bij betrokken maar iedereen zijn het postdocs en tenue trekkers en vasten staffleden is op een paar niveaus binnen Data Science maar Data Science is wel de grote chunk en daarbij zitten nog wat andere wetenschappelijke disciplines zoals [*other lead]* die (?) anticonceptie en van mijn faculteit ook een paar mensen maar het is allemaal Universitair maar ook allemaal nog eens tudelft en Erasmus En in die zin iets minder spannend als projectleider dan ik gewend ben

A: [00:07:31] minder of meer spannend

B: [00:07:34] minder

A: [00:07:36] minder spannend. Wat maakt het minder spannend?

B: [00:07:38] ja omdat ik in dezelfde soort ja weet hoe ze een beetje met elkaar om moeten gaan qua en wat ze van elkaar kunnen verwachten als in tijd spade en ook in opleveringen En ja dat ze anders altijd bij een patiënt vereniging of bij een design bureau die hebben een compleet andere idee van inputs wat ze kunnen leveren en ook wel ze uit een project te kunnen halen dan dan bij zo'n Digital Twin. Pageantry zit wel de uitdaging vind ik omdat het allemaal wetenschappers zijn dat ja wij wetenschappers binnen het algemeen Ik ben niet de enige die druk heeft er zijn er meer die het druk hebben dus dat dat al heel snel de focus gaat liggen op het eigen op de eigen interesse soms Of in ieder geval zorgen dat je dat het eigen stukken stukje wat je uit een project wil halen dat goed afsluit en iets minder oog hebt voor

de samenwerking dus ja normaal heb je een andere partner erbij die zorgt wel dat die samenwerking moet want die moet Daarom betrokken worden dus dat is misschien een iets makkelijker. Maar ik denk wel dat het minder spannend is kijk De Uitdaging is wel wat ik eerder al zei ik vind de uitdaging vooral er iets uit te halen Wat voor iedereen relevant is dus dat je een samenwerking maakt die waarbij je iedereen overeenstemming heeft over de Doelen in het begin Maar ook dat de uitkomst breed gedragen worden en niet voor een groep interessant maar voor meerdere groepen interessant en dan zou ik het liefst een uitkomst hebben in plaats van allemaal uitkomsten samen maar dat weet ik niet of dat haalbaar is ik denk eigenlijk dat als het een uitkomst wordt met specifieke takken en dan maatschappelijke relevantie Ja dat is nog wel dat is lastig omdat daar geen partner zin hebben en dat merken we nu ook al met rekenen of de moeilijkheid van datasets die nodig zijn voor het onderzoek waar we niet zo makkelijk aan kunnen komen

A: [00:09:50] probeert men wel daarnaartoe te werken dus ook een beetje maatschappelijke aansluiting of Partners vinden

B: [00:09:55] Jawel maar ja het is maar 2 jaar dus dat is best wel weinig wat je in ieder geval probeert is een uitkomst te maken die je die maatschappelijke potentie hebben en of dat dan gebeurd in dit project of in het vervolg project die gekoppeld zijn Het zal waarschijnlijk het laatste zijn we hebben bijvoorbeeld al een aanvraag gedaan afgelopen januari die veel meer maatschappelijk betrokken was Er zit ook een hele hoop maatschappelijke Partners bij maar die is wel geënt op ideeën uit de Digital twin dus wat we binnen Digital twin willen doen is eigenlijk vooral kijken van hoe hoe kunnen we nou concepten en mechanismes ontdekken die uiteindelijk zullen leiden tot een maatschappelijke impact maar niet binnen dit project maar de volgende project is dat we voorbereiding doen voor werk in een ander project.

A: [00:10:46] Dus eigenlijk de lessen die men in Digital Twin leert worden hopelijk dus overgedragen naar het volgende project

B: [00:10:55] ja (???) in het algemeen dus dat is niet zo moeilijk

A: [00:10:59] Oké interessant

B: [00:11:02] Ja dat is belangrijk om te weten die tot 2 dat is een van de belangrijke functies is de katalysator functie dus we worden ook beoordeeld op basis van onderzoeksvoorstellen en het geld dat we genereren dus niet alleen wat de de uitkomst zijn de oplevering van nieuwe papers en nieuwe prototype of een nieuwe service of een maatschappelijke impact maar het hoofddoel is eigenlijk om elkaar te leren kennen en daarvoor is dat geld vrij gemaakt om al die mensen aan te stellen om te weten wat je aan elkaar hebt en dat om te kunnen zetten in eigenlijk vervolg projecten dus dat is het eerste diertje naar vervolgtraject tattoo dus op die manier

A: [00:11:49] Oké dus het is eigenlijk bijna meer het doel om momentum te creëren als ik het al zo mag noemen

B; [00:11:53] Ja ja Momentum Ja ja misschien wetenschappelijk netwerk zou ik het zo op die manier zeggen

A: [00:12:01] ja het is echt die opbouwende stap en inderdaad nog niet zozeer wat je zegt het aantal papers

B: [00:12:06] de potentie van de convergence dus was ook betaald vanuit de convergence met als doel om de tudelft en het Erasmus MC beter te laten samenwerken dus dit is een eerste stapje daarvoor

A: [00:12:18] Oké en wil je dat zo schetst dat dat dus het doel is van Digital Swing Hoe zie jij jouw rol daarin als leider

B: [00:12:29] nou om juist te zorgen dat mensen niet op een eigen interesses blijven maar samen dingen gaan doen dus een beetje naar elkaar toe trekken en ook dus Samen nieuwe stappen eigenlijk de onderzoeksdoelen formuleren die ze niet in hun eentje kunnen formuleren en ook om na te denken de hele tijd over wat zij aan een ander hebben en wat zij kunnen bijdragen dus echt wel het het samenbrengen

A: [00:12:57] Ja en hoe probeer je dat concreet te doen door middel waarvan probeer je dat te doen

B: [00:13:04] concreet Wij hebben laatst een presentatie gehouden die kan ik je volgens mij hebben jullie die al 2 weken geleden en toen had ik aan iedereen gevraagd ook om inderdaad We hebben vier work packages in Digital twin om aan iedere work package heb ik gevraagd wat Breng jij nou naar de andere woordkaartjes toe en wat haal je uit het hele project voor jezelf en wat is het doel van jou individuele project dus dat waren wel vragen die expliciet naar samenwerking toen eigenlijk jouw rol in het grotere geheel maar ja en dat is dan weer geformuleerd dus dat is prettig en dat is één stap. Verder hebben we een half jaar geleden geprobeerd met het hele clubje gemeenschappelijke Doelen op te stellen en dat was de eerste stap dus jouw rol ten opzichte van de algehele doel en dat een beetje bijstellen en een derde concreter activiteit is het schrijven van een gemeenschappelijk position paper waarin eigenlijk alle mogelijkheden van een Digital Twin dus dan heb je het over de potentie beschrijven vanuit iedere discipline en Samenvoegen in een paper dus dan zie je ook heel erg duidelijk van het kiezen Welke sowieso Welke onderwerpen jij dan ziet als relevant binnen jouw expertise maar ook Uiteindelijk hoe dat in die paper terecht komt in de structuur als geheel dus je schrijft met zijn allen maar het is 1 tekst.

A: [00:14:44] juist ja Ja en wat zou je zeggen dat misschien meer in zijn algemeenheid Wat is er nodig vanuit leiderschap om een dergelijk project zoals Digital twin Onder the convergence agenda paraplu te kunnen leiden op een goede manier

B: [00:15:05] Nou ja eerlijk gezegd denk ik dat binnen Digital twin eigenlijk gaat om een Een groep mensen wetenschappers dat je voor deze om die goed te kunnen leiden zou ik dit geval ook wel een wat meer algemene manager Die zou volgens mij wel heel goed werk kunnen doen dus en wat minder inhoudelijk betrokken maar echt kijken naar het overzicht moet wel goed weten van wat kan nou iedereen bijdrage maar dat kan je ook gewoon aan mensen vragen en dan vertellen ze dat en dat moet je wel snappen maar goed dat kunnen de meeste mensen wel ja ja ik denk hierbij wil ik namelijk altijd inhoudelijk betrokkenleiderschappen en leiders en dat hebben we ook bij de meeste projecten dus bij alle projecten die schrijf ik zelf tenminste de projecten die je lijdt doe ik ook het grootste deel van projectaanvraag geschreven dus daar zit ik heel diep in die sturen we ook gaandeweg gewoon met een inhoudelijke feedback of dat je je eigen ideeën blijft vernieuwen samen met de onderzoekers dus dan wordt eigenlijk ook verschil tussen de leider en mensen die in het project werken die wordt dan wat kleiner je wordt gewoon onderdeel van het onderzoeksteam en dat is de meest Nou dat is altijd een heel prettige manier om een project te leiden. Dat is bij de Digital twin heb ik het idee dat het iets Belangrijker is dat die leiders juist een klein beetje afstand nemen om te zorgen dat al die mensen die ogenschijnlijke allemaal met hetzelfde bezig zijn dat ook concreet doen dat is misschien ook op die manier en dat kan je veel beter doen wanneer je een klein beetje afstand hebt van de inhoud dan wanneer je zelf ook een rol hebt in de inhoud Ik heb zelf wel een rol in de inhoud trouwens ik probeer de hele tijd Het human-centred Perspectief naar voren te brengen en maar ik probeer dat wel een klein beetje te scheiden van het algeheel en die scheiding Ik zie wel dat het hier sterker van belang is dan bij andere projecten

A: [00:17:55] Ja oké dus een beetje de dubbele rol van Enerzijds dus inhoudelijk er wat van af weten maar anderzijds dus ook meer overkoepelend kunnen bekijken dus het grote geheel en in detail

B: [00:18:10] Ja en dat overkoepelende dat is hier wel belangrijker denk ik dan bij andere projecten kijk andere project zijn iets meer inhoudelijk gestuurd zou ik zeggen en dit is iets meer overkoepelend

A: [00:18:21] oké duidelijken in zijn algemeenheid zijn er volgens jouw mening volgens jou bepaalde eigenschappen Bepaalde stel qua leiderschap belangrijk om te hebben misschien los van dit project maar Als basis

B: [00:18:40] ja ja wat ik ja ik moet nog steeds een leiderschapscursus volgen om eerlijk te zijn Ik stond ingeschreven in een grote in Engeland maar die is afgeblazen vanwege covit Ik heb dan wel wat kleine kleine dingen gedaan maar het stelt eigenlijk niet zoveel voor in Engeland of wordt wat intensiever ik hoop dat wel volgend jaar te kunnen doen wat ik zelf heb gemerkt Het is ook een soort leiderschap wat bij jou past natuurlijk en iedereen doet dat op mijn eigen manier wat ik zelf heel belangrijk vind is wel om te proberen eigenlijk mensen in je team uiteindelijk een eigen verantwoordelijkheid eigenlijk betrokkenheid en daarmee ook een eigen verantwoordelijkheid Voor het project onderdeel te laten nemen en dat betekent ook dat je als leider niet alleen maar op de inhoud moet gaan zitten van het moet die kant op gestuurd worden wat ik in het begin deed toen ik als eerste projectleider was bij mijn eigen project maar en dat je ze iets meer vrijlaat Ja en wat zachter probeert bij te sturen zeg maar ja is dat vind ik wel belangrijk dus eigenlijk het opwekken van engagement van betrokkenheid van projectmedewerkers en daarmee ook een verantwoordelijkheid geven in het project en dat is bij phds wat makkelijker dan bij postdocs omdat phders is ook een eigen belang hebben die moeten nog een proefschrift afleveren terwijl postdocs die hebben Ja die hebben gewoon een contract afloopt is dat is altijd lastiger vind ik postdocs managen

A: [00:20:38] En hoe ga je daar dan mee om of hoe probeer je dat die verantwoordelijkheid die betrokkenheid te stimuleren

B: [00:20:47] nou door ze ja en dan moet je eigenlijk eerst iemand goed leren kennen en kijken van wat wil je nou eigenlijk want wat is zijn manier van werken wat deze manier van onderzoek doen Welke vragen wil hij oplossen want er zijn altijd project vragen die mensen op willen lossen Maar die niet altijd passen in een wat groter geheel van de eigen wetenschappelijke interesse die ze hebben in een projecto of in het leven van een onderzoeken en zeker van een postdoc want het is vaak maar een korte tijd dus hoe past het nou in het wat bredere en langdurig gevraagd die man heeft in dienst carrière dus om daar achter te komen en vervolgens te kijken van Hoe kunnen we nou ruimte bieden zodat het gewoon heel goed past in jouw project ook naar de toekomst toe en dan gaat het wel met afwisselen van hoe zeg je dat het aftasten van Waar zit je de ruimte en wat super belangrijk is daarbij is om de onderzoeksvraag van het project wel heel erg helder te hebben en te houden en dat ook wel en wel op de voorgrond te houden maar die moet dan wel wat een belangrijk is is dat hij dat je daar ook de ruimte inziet dus ja het is gewoon een hele heldere definitie van de onderzoeksvraag van het project dat je die voor ogen hebt. En dat je daarin ook weet van er zoveel ruimte en als jij wil focussen op een financiële beloning in plaats van op sociale beloningen dan kan dat zolang het maar past in het bijvoorbeeld de onderzoeksvraag naar lange termijn motivatie

A: [00:22:25] Oké dus dus dan is het het eind doel inzicht houden maar wel

B: [00:22:33] Nou het is niet zozeer het doe maar meer onderzoeksvragen daar is wel verschil want een doel dat kan variëren dat weet je nooit precies maar het is vooral de onderzoeksvraag dat die dat je het onderzoekt doet wat de hele tijd onder die onderzoeksvraag geschaard kan worden want die Doelen naar die veranderen soms is dat eigenlijk altijd wel Doelen in het begin van de projecten die een klein beetje ambitieus zijn en die haal je misschien niet door een te hoge ambitie maar ook door inzichten tijdens het werk dan verandert ook je Doe een klein beetje maar de onderzoeksvraag die blijft meestal wel heel lang constant

A: [00:23:12] Oké juist okéJe noemde eerder dus dat je normaliter dus vaak de enige leidinggevende bent En nu dus het samen met [*other lead*] doet Welke vorm heeft jouw voorkeur

B: [00:23:27] Het hangt een beetje af van de projecten zelf in hoeverre ik mijzelf daar betrokken bij voel bij dit project Ja ik voel me wel betrokken maar inhoudelijk ook niet superveel niet zoveel als bij andere projecten bijna Ja weet ik veel pijn project over storytelling In de gezondheidszorg dat vind

ik eigenlijk veel interessanter omdat ik daar meer van kan leren ook inhoudelijk en hierbij leer ik ook wel wat van maar ik vind het iets minder spannend voor mijn eigen interesses en daarom zit dat management Of zit dat projectleider ook iets meer op managementniveau dan loopt de inhoudelijke bijdrage en dat management Ja dat vind ik wel leuk om te leren en ook belangrijk om te weten ik gebruik het een klein beetje als een test punt van Hoe ga ik er nou mee om voor mezelf zeg maar in de andere projecten en dan vind ik het juist wel heel erg fijn omdat ik het samen met Regina doe want anders zou het mij veel te veel tijd kosten dan zou ik het misschien niet waard vinden om te doen want ik verder ook wel leuk vind is de rolverdeling bij ons zelf [other lead] die zit er veel inhoudelijk erin dan Ik wil het gewoon toepassen in haar eigen apps van slimmer zwanger en het hele peri conceptie verhaal een Digital twin daarvoor toepassen en ik zit er op een fiets abstracte niveau en ik vind het interessant om te kijken van hoe werkt het nou met al die postdoc samen en eigenlijk van Wat is nou de algemene potentie van ICT en informatica en data voor human-centered design dus een iets abstracte vlak en dat vind ik leuk om te weten maar ik vind het ook heel prettig dat ik ja eigenlijk dat management als geheel doe en af en toe pik ik er iets uit kijk ik of ik er iets uit kan pikken wat voor andere projecten of in dit project van belang is van voor dit project heel prettig dat [other lead] eigenlijk inhoudelijk betrokken is en ik kan een beetje dingen uitproberen over projectmanagement en interdisciplinaire samenwerking en een klein beetje over data

A: [00:26:02] Oké oké dus het is juist wel Het voelt elkaar wel fijn aan

B: [00:26:07] Ja ik ken [other lead] ook wel langer dan vandaag en het gaat prima met haar samen werken

A: [00:26:15] werking met [other lead] heb je tot nu toe de samenwerking met het met en binnen het Digital Twin team ervaren hoe zou je het omschrijven

B: [00:26:29] Ja we zijn heel gestructureerd gestart ook of bestwelsnel in ieder geval toen ik erbij kwam de periode Waarvoor iets minder was het volgens mij een klein beetje chaotischer maar vanaf de derde maand ofzo toen is het ja een soort best een soort strakke structuur met meetings op verschillende levels van medewerkers dus de vaste staff de tenue trackers en de work packages en de postdocs volgens mij nu drie of vier groepen hebben ieder hun eigen meetings En ja dat lijkt wel tot veel meetings maar begint ook wel Zijn vruchten af te werpen dat iedereen elkaar een beetje kent en weet wat ze van elkaar kunnen verwachten dus die samenwerking met het team dat gaat eigenlijk Ja volgens mij gaat dat wel goed maar het duurt lang Ik vind wel met Digital twin je werd ook een klein beetje in het diepe gegooid eigenlijk was het vind ik het project een beetje groot moet ik zeggen Ik was als katalysator liever begonnen met de helft van alle medewerkers omdat ik denk dat je dan iets minder tijd kwijt bent aan het projectmanagement en aan elkaar leren kennen en iets meer tijd kan steken in het ontdekken van nieuwe richtingen dus ja dat zou Mijn suggestie naar convergence zijn dus bijvoorbeeld Er zijn nu in dit project even denken hoor volgens mij ja 8 postdocs aangenomen die nu ook nog eens samenwerken met postdocs uit het ethische work package Dus 9 in totaal zijn er betrokken en dat zijn er best veel Ik zou zelf eerder gaan voor de helft zeg maar en dan misschien nog een phder erbij want de phder zorgt altijd voor een lekker strak stramien en dan heb je gewoon die 4 jaar wat heel prettig is wat heel prettig werkt en publicaties maar als nadeel heb je dat je minder snelheid maakt en wat ze hier wilde was snelheid Vandaar dat ze je hebben ingezet op postdocs van 2 jaar dus ik snap ik wel de bedoelingen de snelheid van de convergence maar het zorgt ook wel eigenlijk die grote die zorgt ook wel voor een iets vertragend effect voordat je erachter bent van wat je nou met elkaar kunt doen ja dus dat is is dat heeft ook echt wel tijd gekost dan zijn we nu pas zo'n beetje achter en nu is het alweer bijna een jaar verder dus ja met een kleinere groep heb je gewoon minder Management en dan kan je ook wel snellere stappen maken dus ik snap heel goed de keuze van de convergence maar ik weet niet of het de beste keuze is

A: [00:29:35] ja dus dat is een van de lessen die jullie dan weer meenemen naar voor de volgende

B: [00:29:39] Ja ik heb ook zelf nog nooit een project gehad met zoveel postdocs want ik vind ook sowieso een gezeik om ze te managen omdat ze korte termijn traject hebben en het valt altijd in een moment van hun leven dat ze veel bezig zijn met andere dingen met een gezin of met hun huis als je je ergens wil vestigingen bepaald gebied en inhoudelijk of ik bedoel qua (???) dus ja postdoc zijn altijd best wel lastig op een ruimte sowieso aan een project te koppelen omdat je altijd allerlei andere belangen hebben en dat heeft iedereen ik ben zelf ook postdoc geweest en dat had ik ook dus het is een hele onrustige periode en al heb je erachter die mensen dan is het veel moeilijker omdat om ze apart is allastig om op een project te zetten en dan ook nog met elkaar op één project dat is echt wel een stevige uitdaging dus ja dat blijkt ook wel een beetje Vind ik uit dit project dus het Kost gewoon veel management tijd het is ook alweer leuk omdat je er veel van kan leren maar ik weet niet hoe praktisch het allemaal is

A: [00:30:56] en hoe open staan mensen voor het met elkaar delen van kennis of openstaan voor elkaar

B: [00:31:04] dat is een goede vraag heel erg open volgens mij Ik heb nog niet gemerkt dat mensen dingen achterhouden wel dat je merkt dat instituten dingen achterhouden dus dat je bijvoorbeeld een datum zet wil delen vanuit Erasmus MC de patiënt dataset met informatica met design maar dat blijkt dat het instituut van het ziekenhuis dat helemaal niet daar allerlei regels en barrières voor worden geholpen dat je daar dan achter komt En het geldt ook voor geld of voor de toegang tot programma's die je nodig hebt die zijn vanuit ieder Instituut anders geregeld dan bij het andere institutie En dan zie je dat instituten de samenwerking wat in de weg kunnen staan maar dat zijn hele goeie leermomenten want daar kom je achter in zo'n project en convergence zojuist dat die samenwerking vloeiend gaat is dan moet je ook goed weten waar zitten naar de barrières en daar kom je op zo'n manier achter

A: [00:31:59] Ja precies zou je de samenwerking transdisciplinair noemen

B: [00:32:08] maak je een onderscheid tussen Trans en interdisciplinair of

A: [00:32:14] ja. of ik die nu wil maken

B: [00:32:20] ja

A: [00:32:21] hoe ik het heb begrepen in ieder geval vanuit de theorie is dat bij interdisciplinair heb je dus een overlap stukje overlap van disciplines en in dat stukje wat overlapt daar gaat men naar kijken dus daar bestaat eigenlijk al een soort Common language maar al het andere van disciplines die wordt verder niet meegenomen dus wordt door gekeken naar het stuk waar wat overloopt en vanuit daar wordt dus onderzoek gedaan en vanuit daar wordt er ook een overkoepelend model gemaakt wat voor ieder van disciplines geld bij Transdisciplinariteit probeert men in ieder geval ook nog de rest van hun discipline in acht te nemen of zich daar in ieder geval bewust van te zijn en daarnaast het nog breder te pakken en dus ook stakeholders groepen vanuit de maatschappij te pakken dus bedrijven of overheden of the public zeg maar En er wordt ook gesproken over een het überhaupt vervagen van disciplinary boundaries dus dat het niet eens weer wordt gezien als Oh dat komt uit discipline en Oh dat komt uit discipline maar dat er meer een soort algehele kennis Wat is waaruit wordt geput

B: [00:33:51] Nou ik zou het anders zien bij Digital Twin juist niet dat dat we een overlap is maar de ruimte tussen disciplines vullen en dat is behoorlijk uniek aan dit project ook dus die Digital twin Dat is een tweeling en data evenbeeld van een individu bestaande uit je eigen data en alle data die daar voor ook van belang is dus het zijn ook de dataset collectiviteiten en die zit heel duidelijk tussen al die verschillende disciplines in alle ICT Partners of data onderzoek Partners eigenlijk die houden zich vooral bezig met Hoe kan je nou de infrastructuur voor die data bouwen en hoe kun je die data analyseren Hoe kan je die data opslaan en een capturen dan heb je eigenlijk de partners en die zijn vooral geïnteresseerd in het in de medische toepassingen van de data er zijn Erasmus MC partners En er zit ook de medische ethiek erbij van de data maar ook in hoeverre kun je nou praten inzetten voor individuele predicties of diagnose van ziektes of personalized Medicine dus dat is echt het gebruik van de data in een medische context

en dan heb je nog de ontwerpgroep zoals waar ik dan in zit en die zijn veel meer geïnteresseerd in Hoe kun je nou data communiceren naar de verschillende Partners toe op een of andere manier en welke data gaat het dan over en hoe moet je dat voor me geven en eigenlijk hebben we Heb je die drie disciplines Dus je hebt data de mensen die op de datum zitten demente Mensen die op de toepassingen zitten de medische toepassingen zitten en de mensen die op het ontwerp zitten van de datum of het gebruikers ontwerp misschien meer zelfs en die ruimtes of disciplines nu nog wat uit elkaar liggen en die zijn allemaal zo bezig op zichzelf met heel veel onderzoek maar de verbindende Bruggen tussen die bestaan nog niet en die Digital twin zit wel heel duidelijk daar binnen dus die verbindt echt disciplines en dat is dus in die zin is het trouwens disciplinaire niet met een overlap maar juist de ruimte die wordt opgevuld en dat is wel heel leuk aan dit onderzoek

A: [00:36:34] Ja heel mooi verwoord Ja zo had ik er nog niet naar gekeken en hoe probeert men dat dan dus hoe probeert men die brug tussen of die ruimte op te vullen

B: [00:36:46] Nou dat doen we dus heel sterk door die gemeenschappelijke Doelen als het ziekenhuis data geeft aan ICT dan willen ze er wel wat voor terug in het systeem waar ze productie kunnen maken op zwangerschapscomplicaties en dan heb je al een brug zeg maar tussen die twee en als zij dat dan weten die productie dan zijn wij er vanuit IO weer in geïnteresseerd van Op welke manier kan je nou die informatie over die complicaties aan een patiënt geven dat die patiënt niet meteen in de stress schiet en weet ik veel de zwangerschap nog erger wordt en dat is weer onze terug naar aan de ene kant de patiënten toe en aan de andere kant naar de data toe van Hoe kunnen we nou die data Waar bestaat die data precies uit en klopt hij wel met de data zoals die in het dagelijks leven van de patiënt geleefd wordt daar zit natuurlijk wel een verschil tussen Ja typisch Je hebt meer wat medische data typisch maar je hebt ook dun Nou ja omgeving data typisch of de sociale datatypen die soms ook belangrijk is voor een patiënt om te communicerenof weet je iets Nou ja je hebt verschillende patiënten natuurlijk de ene patiënt die kan heel goed omgaan met twijfel en de andere patiënt helemaal niet En ja dat moet Weet welk type data je kan voordat je eigenlijk aan de ICT kan vertellen van Ik heb deze datum nodig

A: [00:38:25] Ja alright wil ik over naar Het Derde en laatste onderwerp leren. Wanneer is de laatste keer dat je iets hebt geleerd

B: [00:38:38] binnen het project of binnen überhaupt

A: [00:38:41] beide ben ik wel geïnteresseerd naar

B: [00:38:50] Nee ik leer heel erg veel Ik heb daar om met het project te beginnen maar ik heb heel veel studies gedaan heel veel verschillende om eigenlijk heel veel dingen te leren dus ik ben afgestudeerd in literatuurwetenschappen bijvoorbeeld in muziek Kunstacademie heb ik gedaan nou ja van alles cognitieve psychologie en nu zit ik hier ik heb ook ontzettend veel hobby's Ik speel heel veel piano ik sport heel veel en daarin leer ik allemaal ja pianospelen bijvoorbeeld bestaat eigenlijk alleen maar uit leren als je begint aan een stuk en na een tijdje in het begin snap je echt niet hoe je dat ooit voor elkaar zou krijgen dat is ook heel leuk want dan zie je eigenlijk alleen maar Experience van potentie heb je dan En na een tijdje Dan leer je echt wel hoe je dat moet doen en na een tijdje internaliseren dat een beetje en dan kan je het ook gevoel meegeven dus dat is eigenlijk leren en dat is met sport even zo mountainbiken doe ik veel En op een gegeven moment weet je precies hoe je iets moet kantelen om toch nog overeind te blijven en keihard de bocht door te kunnen het is dat is ook de hele tijd een grens opzoeken en verleggen en dat is ook een duidelijke manier van wat meer fysiek leren in plaats van muzikaal binnen projecten leren Nou ja en die hebben het best wel vaak te maken Vind ik ook met leren in werk het kan niet zonder elkaar Ik probeer altijd zo min mogelijk te werken maar dat lukt niet helemaal maar wel ook heel veel tijd hebben voor die andere dingen die ik belangrijk vind in het leven omdat je juist vind ik veel eigenlijk alleen maar kan leren als je een beetje uitgerust bent en als je een beetje losgescheurd bent dan is er pas weer ruimte in je hoofd om dingen te leren en vandaar dat hij afwisseling met bijvoorbeeld sport of andere activiteiten

Dan weet ze het zijn er voor mij in ieder geval meer essentiële dingen om een goede wetenschapper te kunnen zijn binnen Ja en dat heeft nou ja bijvoorbeeld vorige week was ik op vakantie en toen was ik ook aan het mountainbiken en dan heb je als je in een bocht als je een bocht maakt heb je altijd het Ja je hebt altijd een soort Angst En dan ga je remmen en als je remt dan kom je altijd voor je ideale lijn af en als je van de ideale lijn of bent dan word je bocht wat minder vloeiend en dan ga ik wat minder hard en het wordt wat minder mooi maar het is wel het vergt ook lef om niet je remmen aan te raken en elke vorm van remming eigenlijk omdat je iets niet vertrouwt of iets niet durft dat daarmee zo'n eigenlijk zo'n ideale uitkomst daarmee verstoord wordt dat is ook wel pest toe te passen altijd op project Wat was er zo op wetenschappelijk denken denk ik omdat je door remmingen maar ja je verliest daarmee de Flow eigenlijk van een idee waar je mee bezig bent van onderzoeksvraag maar uiteindelijk en ja dat is niet alleen de Flow op dit moment maar ook achteraf dat je resultaat uiteindelijk minder overtuigend maakt dat het resultaat een beetje zwabberend bereikt wordt dat dus veel minder overtuigend dan een resultaat en een mooie boog en voor zo'n mooie boog heb je wel Ja moet je wel soms een beetje wat vertrouwen hebben en wat lef niet alleen in de andere maar ook weg die je gewoon in geslaagd bent persoonlijk of naar bijvoorbeeld een paper zelf aan het schrijven bent dat bepaalde ideeën ook gewoon goed zal zijn dus niet al te veel daarin zwabberen dus dat is wel een soort van leermoment

A: [00:43:13] ja Wow Volgens mij heb je zojuist een prachtige analogie omschreven voor leren en wat daarbij komt kijken

B: [00:43:21] ja en binnen dit Digital twin jaar dan ben je aan het leren ook de hele tijd wat ik hiervan leer je eigenlijk vooral nog niet zoveel over die datum want het meeste wist ik eigenlijk al of verwacht ik eigenlijk wel wat er uitkomt Ik ben geïnteresseerd wetenschappelijk in Hoe kan ik nou daar op een motiverende manier vormgeven en daar heb ik veel ideeën over maar ja daar heb ik nog niet een vernieuwend antwoord op gekregen binnen het project moet ik zeggen maar daarvoor staat het project ook nog inhoudelijk iets te ver van me of is het de organisatie met al die postdocs schiet het nog niet zo op dus in die zin heb ik nog niet zo heel erg veel geleerd waar ik wel veel van geleerd heb is het management zelf dus eigenlijk in nou Ja vooral die explosie te vragen van wat kom je nou brengen en wat kom je halen en ik vind het altijd leuke vragen om te stellen maar om die op elke niveau te stellen binnen zo'n project hoe dat kan helpen eigenlijk met zo'n grote hoeveelheid van mensen om daarmee te zorgen dat het project dus als rahil eigenlijk verdeeld wordt dat is wel een van de projectleiding dingen die ik hierbij aan het leren Ben

A: [00:44:35] mooi en je had het net over dat om die bocht goed door te komen dat je wil proberen niet te remmen om de Cindy Flow te blijven maar daar is dus vertrouwen voor nodig dat wat je zei Hoe kan dat vertrouwen verhoogd worden Hoe kan dat ondersteund worden

B: [00:44:56] ja nou jabelangrijk is daarbij wel niet alleen maar in Dat hoor je natuurlijk wel vaker maar dat heeft er wel mee te maken en ook echt wel een soort van durf om ook uit te glijden letterlijk zeg maar op je mountainbike of Nou ja op je mountainbike voel je je willen als het een beetje slippen en soms zijn er twee wielen soms je voorwiel en gaat vaak op hoge snelheid dat is echt wel eng ja maar ja dat mag best dat slippen na een tijdje pakt hij hem wel weer ja als het helemaal mis gaat dan niet meer maar op gegeven moment kun je dat een beetje logeren en weet je dat je nog wel dat er eigenlijk een soort van nieuwe manier of dat het vertrouwen risico's beheersbaar zijn zoiets kan je zeggen en dat daar dat je eigenlijk meer risico's kan nemen dan je denkt vaak en En juist dat is dat scherp hoe zeg je dat zo'n niet het scherp van de snede maar het punt van Vertrouwen Ja de grens van wanneer het wanneer er vertrouwensbreuk optreedt die is best wel vloeibaar en die is vlak vloeibaarder dan je denkt daar heb je eigenlijk wel ruimte in een watje kan verschuiven en wat ik heel sterk merk als projectleider is dat ook de projectmedewerkers Dat is niet altijd weten we gaan vaak een beetje soms heel erg ijverig om die grenzen op te zoeken en ja wat ik altijd probeer te doen is juist mensen over de grens heen te laten gaan maar daar moet je ook weer mee uitkijken want soms dan gaat het alle kanten op en dan ja dan verwaterd ook zo'n project zomaar dus dat is een beetje lastig maar wel wat wel belangrijk is de hele tijd te zorgen dat die grens wel een beetje wordt opgerekt en in die zin dat je vertrouwen geeft eigenlijk als projectleider eigenlijk binnen wetenschappelijk onderwerp of

project stom die grens stapje bij stapje te verleggen Er is altijd gewoon meer mogelijk ook binnen zo'n onderzoek vraagt zijn diverse in het begin en weet je dat nog niet zo goed waar die liggen je worden steeds concreter En vervolgens als concreet zijn kan je ze steeds een beetje gaan verschuiven en dat is wel heel prettig om dat samen met mensen te doen en dan moet je ook zomaar met iemand doen want als jij dat doet als enige als projectleider en die andere durft dat niet of die daar het nut niet van in dan kom je dan maak je niet juist die essentiële of die vernieuwde stap dus in die zin is dat dus een soort van wederzijds vertrouwen eigenlijk het verleggen van de grens

A: [00:48:01] mooi krijgt leren momenteel expliciete aandacht binnen Digital Twin

B: [00:48:08] niet expliciet expliciet doen waar we expliciet op Focus f is vooral de samenwerking en het leren van elkaar dat Nee dat niet Er is eigenlijk hebben we Ik denk dat dat een stap te ver is nog wat we nu willen doen is eerst het samenwerken Wat heb je aan elkaar dus eerst samenwerken van ja ja misschien whatsappje aan elkaar dus elkaar leren kennen Misschien is dat de eerste stap vervolgens Wat heb je aan elkaar en hoe kan je een derde stap hoe kan je nou samen iets een product opleveren en dat is dan niet ditching En wat heb je er dan van geleerd dat is ja Nee dat hebben we nog niet in het of de tenminste ik nog niet bedacht als een van de Doelen in het project maar ik weet ook niet of ik dat ga doen misschien wel goed maar ja dan moet ik over nadenken

A: [00:49:14] Ja precies Ja want dat is ook een vervolgvraag van Denk je dat dat nuttig zou zijn om er expliciet aandacht aan te geven

B: [00:49:20] Ja dat weet ik niet Het lijkt me wel goed sowieso aan het eind van het project is dat belangrijk dan om een soort reflectiemoment in te brengen dan wat heb je nou geleerd van elkaar maar dat is meer achteraf leren misschien dan tijdens het project leren van elkaar en tijdens het project gebeurt natuurlijk altijd impliciet heel veel maar omdat expliciet te maken ja dat werkt niet zo goed is een goede suggestie dan moet ik even over nadenken

A: [00:49:56] Alright ik heb eigenlijk nog maar een vraag

B: [00:50:02] heel goed want ik moet ook door

A: [00:50:02] Ja Stel ik zou een toverstaf hebben en ik kon daar gewoon een extra persoon mee toveren wat zou je dan het liefst willen wat die persoon zou gaan doen binnen Digital twin dus Welke rol die persoon zou gaan vervullen

B: [00:50:19] Even denken hoor wat mij goed lijkt is iemand die en misschien is dat wel een functie van projectleider maar Ikzelf heb daar geen tijd voor iemand die bij iedereen langs komt als een soort van (???) met de koffiejuffrouw en is iemand die de koffie komt brengen en dan met iedereen meteen een praatje aan de knapste meid hoe gaat het en ook misschien meteen dat de gemeenschappelijke belangen ook gemaakt en dat proberen wij een klein beetje te doen met die meetings maar die zijn altijd in grote groepen dus nooit individueel en individueel heb ik daar niet de ruimte voor en [other lead] ook niet dus iemand die dat zou doen Dat lijkt mij heel erg dat lijkt me erg leuk

A: [00:51:26] dus iets maar dat persoonlijke en weer even een beetje een iteratie van Waar zijn we ook weer mee bezig daar doen we het ook alweer voor en zitten nog op de juiste lijn

B: [00:51:35] Ja dus iemand die individueel eigenlijk langs alle deelnemers gaat om het project Ja dat lijkt me super goed voor erbij en hoe dat heet dat weet ik niet maar dat lijkt me wel heel leuk en heel nuttig

A: [00:51:50] nou heel mooi Nou dan sluiten we hem hier mee Af Hartelijk dank Valentijn Ik heb er echt ontzettend veel aan gehad dus heel fijn dat je tijd kon vrijmaken Mocht je nog vragen hebben Je weet me te vinden of als er nog dingen in je opkomen dat je denkt oh dus misschien wel relevant om te weten

B: [00:52:05] wat ga je hiermee doen precies

A: [00:52:08] Dit gebruik ik om want ik heb een hele theoretische basis en dan wil ik dat is een beetje gaan testen met dus de Experience van mensen uit Digital twin dus ik wil eigenlijk vooral kijken Wat werkt wel en niet als het gaat om leiderschap en leren binnen zo'n samenwerkingsverband Daar hoop ik dan uiteindelijk een soort idee voor een model uit te kunnen halen Waar dan concretere stappen in staan vandaar blijkbaar is dit nodig Als basis en daar kan men concreet dit voor gaan doen om echt een beetje een baas te houden vanuit leiderschap om leren te stimuleren om de samenwerking te verbeteren dat is de insteek

B: [00:52:50] oké ja dan hoor ik het wel Ik zie het wel tegemoet want dat komt ook in je scriptie natuurlijk denk ik soort interviews of delen eruit

A: [00:53:03] Ja precies dus anoniem uiteraard maar wordt er specifiek voor jou een stukje in voorkamer dan ga ik dat natuurlijk eerst even voorleggen en met jou akkoord dan moet het goed zijn

B: [00:53:15] ja dat hoeft Van mij hoeft niet perse anoniem hoor ik bedoel ik zit hier dit is ook een rol vanuit als wetenschapper weet je wel Het gaat over mijn werk dus ik ben geen patiënt ofzo dus wat mij betreft

A: [00:53:30] oké

B: [00:53:32] Nee dat vertel ik ook Aan mijn eigen studenten Ik bedoel mensen die in mijn werk geen moet worden die ik vind het soms helemaal geen probleem om met naam genoemd te worden hoor dat maakt het ook wel helderder daarna om achter te zetten niet alleen biertje is maar ook Welke rol die heeft binnen het project maar dan moet je maar even over nadenken of dat een toevoeging is

A: [00:53:51] Ja dat zal ik doen Nogmaals hartelijk dank Valentijn en een hele fijne dag gewenst

B: [00:53:56] Oké jij ook succes ermee

A: [00:53:59] Bye

APPENDIX D – OVERALL RESULTS OF SEMI-STRUCTURED INTERVIEWS

This appendix presents the results of the interviews. There are three tables, one for each main theme of this Master Thesis Project: (transdisciplinary) collaboration, learning, and leadership.

Table D.1: Quotes of the semi-structured interviews related to the collaboration. 'A:' refers to the interviewer, 'B:' refers to the interviewee. Any reference to a person has been deleted. All Dutch parts have been put together in a randomized order. The same goes for the English parts.

COLLABORATION	
Statements	**Conclusions**
Je wil alle drie instellingen mee laten doen, dat is convergentie. Dus sociale kant, economische kant, en ethische kant, en techniek integreren met elkaar. Je wil dus dat onderzoekers van die instellingen bij elkaar gaat brengen. Alleen in die gezamenlijkheid kom je tot initiatien waarin de drie instituten mee kunnen doen. De projecten binnen digital twin stemmen tussen en binnen projecten veel af en er lijkt een lange termijn focus te zijn, dus men kijkt verder dat het huidige project. Men werkt toe naar begrip voor elkaar en met probeert te snappen wat de ander bedoelt. Het begrijpen van elkaars taal is essentieel. Ook is het belangrijk om eerst duidelijk te krijgen at het probleem precies is en wat iedere discipline kan bijdragen. De samenwerking is nu erg multidisciplinair maar het doel is transdisciplinair omdat bekend is dat dat de enige manier is om maatschappelijke problemen op te lossen. Maar transdisciplinair worden kost tijd. Transdisciplinair betekent de schotten tussen techniek, kliniek, alfa, bèta, gamma los te laten. Dus dat problemen meer integraal worden benaderd in plaats van vanuit hokjes. Hier is een andere manier van denken voor nodig zodat het meer holistisch wordt. Holistisch is een belangrijke eigenschap van transdisciplinariteit. Een eerste stap is de onderzoekers bij elkaar brengen. Laat ze vertellen wie ze zijn, wat hun expertise is, en relateer dat aan problemen en vragen die momenteel liggen in de zorg, en ga kijken waar zij vanuit hun expertise een bijdrage kunnen leveren. Je ziet dan vaak tot synergie. De onderzoekers zelf moeten de meerdere zien van de samenwerking. Dan krijg je ze makkelijker mee. Bijvoorbeeld tot oplossingen komen die ze alleen nooit zouden kunnen halen, maar zij moeten er natuurlijk ook wat uit halen	• Creativity is meant to be a part of the convergence collaboration • The collaboration is going well, people are excited. • Being in the same work group makes it easier for people to approach each other, specifically based on content. So, informal interaction makes collaboration easier. • A challenge was the differences between institutions in culture and that people sometimes felt they had to defend their institution, but that was counteracted by openly talking about it. • People need to possess a calmness and willingness to listen to others. Whether or not people do also depends on cultural differences. • Even though people may have a willingness to do something it can get blocked by institutional boundaries. This sometimes leads to impatience and incomprehension. • Cultural differences can also mean differences in incentives. • Having something concrete and clear to work on increases the effort people put into a collaboration.

creatieve geesten werpen een heel ander licht op zaken. In het team, organisatie, inhoudelijk, etc. Kijken naar competenties die je al helpt en kijken naar wat er nog mist. Sowieso verschillende achtergrond, expertise, en skills om een team te versterken. “het begint natuurlijk met het eerste idee van de convergentie waar je input op kunt leveren in een multidisciplinair team samenwerking eigenlijk mensen van de tudelft die je allemaal niet kent en mensen van het Erasmus MC die je grotendeels wel kent maar toch vanuit andere specialisme en domeinen samenwerken” “dus dat was de eerste fase en dat vond ik eigenlijk dat was heel helder Ja dat vond ik het was Helder gecommuniceerd wat de Doelen waren en wat er van je verwacht werd. Toen kwam flagships aan de orde nou ik moet zeggen dat ik ook een heel goed traject daar heb ik eigenlijk weinig weinig Hinder van ervaren er waren weinig barrières” “en dan begint er een periode van Ja echte uitdaging omdat eigenlijk niemand precies wist hoe moet zo'n flagship hoe moet het eruit zien en hoe moet het functioneren” “Digital twin bestaat uit vier projecten die met elkaar samen hangen dat is de enige manier om samen te werken en om ook	• Discussions helps people understand each other better. These discussions take place more often and easily if there is a shared goal to work towards. • Transdisciplinary collaboration is described to go beyond just involving scientific disciplines but also companies and governments. • The collaboration is definitely interdisciplinary. The goal is transdisciplinary collaboration but it is not quite there yet. • The involved parties need to get out of their comfort zone. A long-term collaboration can help to enable this. • To build trust, there needs to be a clear interest for all parties involved. So, there needs to be reciprocity to build trust.
grote stappen te kunnen maken en dat betekent dus ook dat hij 8 postdocs 2 op elk project ook moeten samenwerken binnen het project maar ook tussen de projecten en de PIs die 8 die als die dan weer op die projecten zitten die kunnen dat dan ook beter aansturen” “waar je tegenaan loopt is dat je toch soms de personen die je aanstelt niet helemaal aansluit bij wat je van ze verwacht en wat zij verwachten dat wij kunnen wel als leidinggevende kunnen communiceren tussen de vakgebieden maar dat geld absoluut niet voor de postdocs die moeten dat echt leren één voor één complicerende Factor was ook dat nou uiteraard de corona want we hebben ze allemaal nog nooit in een keer fysiek ontmoet sommige heb ik wel ontmoet maar omdat we dat gewoon tussendoor toch apart deden maar nooit bij elkaar en dat is natuurlijk echt niet dat is niet wat je wenst (…) en ook culturele drempels (…) En dan blijkt dus ook nog dat ik had het net over die communicatie tussen de postdocs moet ook de aansturing door de PIs van depot straks ook nog verschillend is om dat in sommige afdelingen is er veel meer en hiërarchische structuur en aansturing en bij andere weer veel meer wordt veel meer vrijheid gegeven” “als je dan hebt over die communicatie ja dat dat was ook verrassend wij vanuit onze discipline als je als je onderzoek doet dan heb je eerst een vraagstelling en	• Convergence entails involving social, economic, ethical, and technical sciences and integrating them. Scientists from all three institutions need to be connected so that the institutions can partake in the convergence initiatives. • The projects within Digital Twin seem to regularly and intensively communicate and align within and between them. They have adopted a long-term vision and look beyond the current project. People are working towards common understanding. • Understanding others and their language is essential. It is also important to have a clear problem description and know what everyone can

dan ga je kijken welke data kan ik verzamelen en dan ga je Ze verzamelen en dat analyseren en opschrijven nu is het zo er zijn data maar de mensen de mensen van verschillende disciplines bij sommige maakt het helemaal niet uit wat voor data Het zijn ook niet wat voor vraagstelling Het is die willen gewoon spelen met data en daar kom je dus pas veel later achter en dat heeft ook te maken weer met cultuur” “wat de conclusie is is dat het gigantisch veel tijd kost moet ik je zeggen al die overleggen” “mensen zijn heel erg voorzichtig met elkaar dat is heel goed en dat is ook omdat we elkaar niet goed genoeg kennen omdat we elkaar nog nooit en nog nooit een borrel of koffie met elkaar drinken dat is nog nooit gebeurd dus mensen zijn nog heel erg aan en in een aftasten de fasen zitten ook zelf in de nieuwe positie als postdocs over het algemeen dus zij weten ook niet zo goed wat ze wel en niet mogen zeggen ja en wij zeggen gewoon jongen hartstikke leuk en aardig maar dan moet je wel eens wat af gaan spreken en wat is je tijdslijn ja nou dat vinden ze heel eng om die tijd zijn te zetten” “maar je project Heb je meestal drie vier maximaal verschillende disciplines die toch al wat dichter bij elkaar liggen omdat je ze toch elke keer bij elkaar zoekt	contribute from their discipline • The collaboration now seems multidisciplinary mainly but the goal is transdisciplinary collaboration. However, this takes time. • Transdisciplinary means letting go of boundaries, introducing holistic thinking, and approaching problems in an integrative way instead of from separate disciplines. • A first step is to get the scientists together, let them share their expertise, relate that to a problem at hand, and see how everyone can contribute. This often leads to synergy. • Creativity is beneficial for collaboration. It is useful to be aware of who you have in
en het gaat echt allemaal over hetzelfde soort onderzoeksvraag of het domein en dit is heel anders” “en ik noem het toch weer het Zoom en Teams dat echt niet bevorderlijk Want je ziet niet maar ja dat hoef je niet te vertellen het blijven platte schermen je voelt elkaar toch net onvoldoende aan en dat is juist in zo'n fase dat je kennismaakt met elkaar en een samenwerking start zeker zo'n complexe is dat en daarom was het ook zoveel energie” A: “zou je de samenwerking transdisciplinair noemen” B: “ja zeker” A: “wat maakt het transdisciplinair” B: omdat je je werkt samen met verschillende disciplines en samen kom je weer tot nieuwe kennis en dat vind ik transdisciplinaire dus één en één is niet twee maar is drie of vier” “en ze [postdocs] moeten ook leren wat dat inhoudt en auteurschap en dat dat niet niet zomaar iets is dus dat is wel weer heel goed en dat geeft ook een band tussen de postdocs dat helpt heel goed en ook met de PIs.” “het begint natuurlijk met het eerste idee van de convergentie waar je input op kunt leveren in een multidisciplinair team samenwerking eigenlijk mensen van de tudelft die je allemaal niet kent en mensen van het Erasmus MC die je	your team and work towards diversity. • The collaboration is described as multidisciplinary • According to P3, the collaboration goals and what people could expect were clear and communicated clearly. • The collaboration in the Digital Twin flagship is going well and there are few boundaries to collaboration. • The second part of the collaboration was vague and unclear. No one knew what to do exactly or how to structure the flagship. • The only way to collaborate and take big steps therein is to not only collaborate within projects but also between projects. • Challenges considering collaboration are

grotendeels wel kent maar toch vanuit andere specialisme en domeinen samenwerken” “dus dat was de eerste fase en dat vond ik eigenlijk dat was heel helder Ja dat vond ik het was Helder gecommuniceerd wat de Doelen waren en wat er van je verwacht werd. Toen kwam flagships aan de orde nou ik moet zeggen dat ik ook een heel goed traject daar heb ik eigenlijk weinig weinig Hinder van ervaren er waren weinig barrières” “en dan begint er een periode van Ja echte uitdaging omdat eigenlijk niemand precies wist hoe moet zo'n flagship hoe moet het eruit zien en hoe moet het functioneren” “Digital twin bestaat uit vier projecten die met elkaar samen hangen dat is de enige manier om samen te werken en om ook grote stappen te kunnen maken en dat betekent dus ook dat hij 8 postdocs 2 op elk project ook moeten samenwerken binnen het project maar ook tussen de projecten en de PIs die 8 die als die dan weer op die projecten zitten die kunnen dat dan ook beter aansturen” “waar je tegenaan loopt is dat je toch soms de personen die je aanstelt niet helemaal aansluit bij wat je van ze verwacht en wat zij verwachten dat wij kunnen wel als leidinggevende kunnen communiceren tussen de vakgebieden maar dat geld absoluut niet voor de	(1) different expectations, (2) a lack of communication skills between disciplines, (3) not being able to meat in real life, (4) cultural differences, and (5) differences in leadership styles per team • It takes up a tremendous amount of time • Since people have not met each other in real life and have not been able to communicate informally, they are unsure what to say and what not to say and are very careful with each other. On the one hand it is respectful, on the other hand it inhibits the formulation of a clear time line and deliverables. • Seeing each other in person is necessary to get a sense of one another, get to know each other, and positively

postdocs die moeten dat echt leren één voor één complicerende Factor was ook dat nou uiteraard de corona want we hebben ze allemaal nog nooit in een keer fysiek ontmoet sommige heb ik wel ontmoet maar omdat we dat gewoon tussendoor toch apart deden maar nooit bij elkaar en dat is natuurlijk echt niet dat is niet wat je wenst (…) en ook culturele drempels (…) En dan blijkt dus ook nog dat ik had het net over die communicatie tussen de postdocs moet ook de aansturing door de PIs van depot straks ook nog verschillend is om dat in sommige afdelingen is er veel meer en hiërarchische structuur en aansturing en bij andere weer veel meer wordt veel meer vrijheid gegeven” “in het project waar ik in zit ben ik het heel erg gewend om samen te werken met mensen van heel veel verschillende disciplines dus zowel wetenschappelijke disciplines als buiten wetenschappelijke sectoren en de Digital Twin is eigenlijk wel een van de projecten waarbij dat veel minder rol speelt dan Ik zou willen” A: “Wat maakt het [de samenwerking] minder spannend?” B: “ja omdat ik in dezelfde soort ja weet hoe ze een beetje met elkaar om moeten gaan qua en wat ze van elkaar kunnen verwachten als in tijdspan en ook in opleveringen En ja dat ze anders altijd bij een patiënt vereniging of bij een design bureau die hebben een compleet andere idee van inputs wat ze	influence collaboration. • This collaboration is seen as complex • This collaboration takes a lot of time and energy, especially since it has to currently take place online • This collaboration is seen as transdisciplinary because it entails working with people from • different disciplines, developing new knowledge, and synergy. • Writing together and partaking in a certain action helps learn about that action (in this case writing a paper together). Undertaking an action with others helps create a bond and strengthens collaboration. • Digital Twin is a collaboration of different disciplines, but

kunnen leveren en ook wel ze uit een project te kunnen halen” “ja wij wetenschappers binnen het algemeen Ik ben niet de enige die druk heeft er zijn er meer die het druk hebben dus dat dat al heel snel de focus gaat liggen op het eigen op de eigen interesse soms Of in ieder geval zorgen dat je dat het eigen stukken stukje wat je uit een project wil halen dat goed afsluit en iets minder oog hebt voor de samenwerking” A: “probeert men wel daarnaartoe te werken dus ook een beetje maatschappelijke aansluiting of Partners vinden” B: “Jawel maar ja het is maar 2 jaar dus dat is best wel weinig wat je in ieder geval probeert is een uitkomst te maken die je die maatschappelijke potentie hebben en of dat dan gebeurd in dit project of in het vervolg project die gekoppeld zijn Het zal waarschijnlijk het laatste zijn” B: “een van de belangrijke functies is de katalysator functie dus we worden ook beoordeeld op basis van onderzoeksvoorstellen en het geld dat we genereren dus niet alleen wat de de uitkomst zijn de oplevering van nieuwe papers en nieuwe prototype of een nieuwe service of een maatschappelijke impact maar het hoofddoel is eigenlijk om elkaar te leren kennen en daarvoor is dat geld vrij gemaakt om al die mensen aan te stellen om te weten wat je aan	currently does not have a strong collaboration with disciplines outside of the scientific sector • For Digital Twin, the parties working together know better what to expect from each other concerning time span and deliverables, more so than non-scientific parties. This makes the collaboration easier. • A challenge in this collaboration is making sure that people not only focus on their own piece but also keep the overall goal in mind. This is challenging since people are generally immensely busy, which makes people focus more on their own work than on collaborative work.

elkaar hebt en dat om te kunnen zetten in eigenlijk vervolg projecten” A: “Oké dus het is eigenlijk bijna meer het doel om momentum te creëren als ik het al zo mag noemen” B: “Ja ja Momentum Ja ja misschien wetenschappelijk netwerk zou ik het zo op die manier zeggen” “met als doel om de tudelft en het Erasmus MC beter te laten samenwerken dus dit is een eerste stapje daarvoor” “drie of vier groepen hebben ieder hun eigen meetings En ja dat lijkt wel tot veel meetings maar begint ook wel Zijn vruchten af te werpen dat iedereen elkaar een beetje kent en weet wat ze van elkaar kunnen verwachten dus die samenwerking met het team dat gaat eigenlijk Ja volgens mij gaat dat wel goed maar het duurt lang Ik vind wel met Digital twin je werd ook een klein beetje in het diepe gegooid eigenlijk” “ik snap ik wel de bedoelingen de snelheid van de convergence maar het zorgt ook wel eigenlijk die grote die zorgt ook wel voor een iets vertragend effect voordat je erachter bent van wat je nou met elkaar kunt doen ja dus dat is is dat heeft ook echt wel tijd gekost dan zijn we nu pas zo'n beetje achter en nu is het alweer bijna een jaar verder” A: “hoe open staan mensen voor het met elkaar delen van kennis of openstaan voor elkaar” B: “dat is een goede vraag	• Collaboration takes more time if you do not speak each other’s language or do not have a common understanding of things. • The scale on which collaboration is taking place as well as the feeling of every discipline that they truly must do this together makes this convergence project different from other projects. • Much of the issues people will come across in this collaboration cannot be defined from the onset. • Collaboration with(in) Digital Twin has gone very smoothly because people are open to and interested in others. • Collaborating more interactively and on a small project makes it easier to collaborate later on.

heel erg open volgens mij Ik heb nog niet gemerkt dat mensen dingen achterhouden wel dat je merkt dat instituten dingen achterhouden dus dat je bijvoorbeeld een datum zet wil delen vanuit Erasmus MC de patiënt dataset met informatica met design maar dat blijkt dat het instituut van het ziekenhuis dat helemaal niet daar allerlei regels en barrières voor worden geholpen dat je daar dan achter komt En het geldt ook voor geld of voor de toegang tot programma's die je nodig hebt die zijn vanuit ieder Instituut anders geregeld dan bij het andere institutie En dan zie je dat instituten de samenwerking wat in de weg kunnen staan maar dat zijn hele goeie leermomenten want daar kom je achter in zo'n project en convergence zojuist dat die samenwerking vloeiend gaat is dan moet je ook goed weten waar zitten naar de barrières en daar kom je op zo'n manier achter" "Nou ik zou het anders zien bij Digital Twin juist niet dat dat we een overlap is maar de ruimte tussen disciplines vullen en dat is behoorlijk uniek aan dit project (…)die ruimtes of disciplines nu nog wat uit elkaar liggen en die zijn allemaal zo bezig op zichzelf met heel veel onderzoek maar de verbindende Bruggen tussen die bestaan nog niet en die Digital twin zit wel heel duidelijk daar binnen dus die verbindt echt disciplines en dat is dus in die zin is het transdisciplinaire niet met een Overloop maar juist de ruimte die	• People from different backgrounds and disciplines are working together where integrating them was one of the goals more so than in other collaborations. This integration happened through formulation of shared goals.Some collaborative issues revolve around data usage and access. • A lot of different disciplines are involved in the collaboration. • The meetings and collaboration are seen as (mainly) multidisciplinary • Developing a common understanding or common language can be helped by (1) ensuring regular social interaction, (2) an awareness that there are differences in perspectives and assumptions, (3) the guts to speak up if something is unclear, (4) giving it time, (5) providing opportunities to start a dialogue such as seminars or meetings, (6) concretely talking about it. • Short informal links are pleasant to work with as it inspires some loyalty and stimulates reciprocity. • Unsure whether transdisciplinary collaboration can even be achieved or should even be sought after. P10 thinks that disciplinary knowledge is needed as a basis to build collaboration on. Getting rid of that would mean renouncing what universities do and how they work. What could work, however, may be more in line with interdisciplinary collaboration.
wordt opgevuld en dat is wel heel leuk aan dit onderzoek" "waar we expliciet op focussen is vooral de samenwerking en het leren van elkaar dat Nee dat niet Er is eigenlijk hebben we Ik denk dat dat [focus op leren] een stap te ver is nog wat we nu willen doen is eerst het samenwerken" "elkaar leren kennen Misschien is dat de eerste stap vervolgens Wat heb je aan elkaar en hoe kan je een derde stap hoe kan je nou samen iets een product opleveren" "We hebben een aantal sessies gehad met onderzoekers in Delft waarbij we gezamenlijke aandachtspunten hebben geformuleerd dus in die zin werkt het wel degelijk" "onbekend maakt onbemind het kost echt inspanning om te kijken wat anderen doen en openstaan voor wat anderen doen zodat je daar gezamenlijk je je meerwaarde kan formuleren Dat is niet altijd iets wat voor het land ligt omdat we allemaal onze eigen groep mensen hebben met wie we met wie er wel samenwerkt" "Ik heb het al dus ik heb het alleen maar tot nu toe alleen maar in een positieve zin meegemaakt mensen zeggen van Hey Ja maar daar zijn wij ook achter Ik heb het nog niet meegemaakt in de tenminste in	

de samenwerking met Delft nog niet meegemaakt in de negatieve zin" "vager algemeen idee van ja Digital twin is wel een heel breed concept en En hier moet je dan in dat (…) toch wat brede vraagstelling als ware bottom-up je samenwerkingen zoeken met anderen dus het is in die zin echt een omgekeerd traject en dat is wel anders ja" "Het hele doel van onder andere Digital Twin Maar ook andere activiteiten is juist het faciliteren van samenwerking" "Wat is transdisciplinair (…) ik vind dat zo'n vaag concept daar kan ik allemaal niet zoveel mee" "het hele idee achter de convergence als concept is het goed en is het denk ik ben er een voorstander van samenwerking Het heeft ook echt een meerwaarde in de samenwerking met Delft echt een evidente meerwaarde of je dat nou in hokjes van multi en Trans en ik zou niet weten hoe ik dat zou moeten beoordelen" "maar ik heb wel een klein beetje de hoop dat in de samenwerking met Delft wij toch een aantal bruggen kunnen slaan met andere afdelingen die die wel stappen in die richting misschien kunnen gaan zetten als aan het einde van de dag de samenwerking beperkt zou blijven dus jij doet jouw ding en wij doen ons ding en	• There is a lot of vagueness and ambiguity in this collaboration • To take collaboration a step further, to for example transdisciplinary collaboration, and to make it fruitful, people need to learn about others and what they do. • Informal social interaction is crucial for getting to know each other and improve collaboration. Corona and the online environment have been an impediment on that front. • The time constraint of this project (2 years) provides a challenge for collaboration. However, it does change the overall goal of this collaboration more towards learning to work together than focussing on

een enkele keer werk verzamelen omdat het ons beide uitkomt Ja dat is die Ja dat zou wel een beetje een missed opportunity zijn" "Ik denk dat dat dat geeft dan kunnen mensen elkaar ontmoeten lijkt me ook uitstekend" "Hey weet jij iemand in Delft die dit doet ze krijgt een soort informeel circuit" "waarin we mensen met elkaar met onderzoekers van heel verschillende afdelingen van verschillende universiteiten hebben nagedacht over ja hoe kan je nou zo'n onderzoeksprogramma vorm gaan geven die veel meer die integratie van de verschillende vakgebieden onderzoeksgebieden bewerkstelligen en nastreven tot wanneer meer dan gebruikelijk was gaat samenwerken probeer dat ook echt te integreren in gezamenlijke door onder andere te beginnen met gezamenlijke doelstellingen gezamenlijke vraagstellingen" "Ik heb een zekere sympathie voor je want je moet hele vage concepten proberen uit te leggen en tastbaar te maken in gesprekken met mensen die de neiging hebben om concreet te willen worden"	concrete outcomes. This collaboration can be seen as a catalyst for future projects, so its success is based on the scientific network it establishes and how much people have gotten to know each other to make collaboration between the involved parties better. • The collaboration is thought to be going well. The many meetings within and between groups are beginning to pay off in the sense that people are getting to know each other and are learning what to expect from each other. However, this process cost a lot of time, which this project does not have. • People in this project are very open to sharing

“bij dat soort bijeenkomsten daarover van gedachten te wisselen maar ook de vragen die daarop tafel werden gelegd van ja hoe doe je dat dan praktisch Hoe Praat je met elkaar als je elkaar's taal eigenlijk helemaal niet spreekt Welk weer uitgewisseld wordt over hoe ingewikkeld soms is in hoeveel tijd het dan kost als je elkaars vakgebieden helemaal niet kent Wil je soms met dezelfde woorden heel verschillende dingen kan bedoelen” “maar de schaal waarop ze nu en nu samen gewerkt wordt en ook het feit dat het ook echt voor alle disciplines geldt dat dat we het gevoel hebben dat we samen iets moeten doen Dat maakt het Dat maakt het wel anders” “bij alle flagships zitten waarschijnlijk ethische kwesties kun je van tevoren ook niet helemaal overzien” “Digital twin is tot nu toe degene waarbij we eigenlijk het beste contact te hebben en hadden waarbij de mensen ook vanuit die flagship geïnteresseerd zijn in ethiek” A: “Ja en als je dan hebt over hier zitten dan de issues waar waar het net over had Waar gaat het dan specifiek over” B: “nou ligt op een aantal vlakken Het gaat over het verzamelen van data en het gebruiken van dataprivacy issues and data governance issues sowieso toestemming voor wat voor soort	their knowledge and ideas. The institutions are the ones causing collaborative hurdles. • Taking part in collaboration and trying to figure it out helps one learn about collaboration. • The collaboration in this project is not necessarily about looking at overlapping parts, but trying to build bridges between disciplines. This is what is said to make it transdisciplinary. • Convergence is referred to as complex • People are enthusiastic, committed, and energetic towards the collaboration. • This collaboration is seen as more challenging than others because it combines different disciplines.

gebruik of Hoe vraag je die toestemming dat soort vragen” “Digital twin Ja ik zit er zelf echt zijdelings bij maar wat ik begrijp van de postdoc die zit nu regelmatig bij de Ja die hebben meer multidisciplinair Team bijeenkomsten dus allerlei mensen die bij de Digital twin betrokken zijn (…) allemaal uit verschillende disciplines” A: “en uit eigen ervaring Hoe kan je dat aangaan dus dat is een goede manier om toch met elkaar te kunnen werken zonder dat misschien die basis van een Common language er nog niet is” B: “ja nou ja ik denk inderdaad dat het op zich op veel contact en met elkaar samen toch proberen te praten over iets dat meestal helpt Ik denk wel dat mensen zich ook bewust moeten zijn van oh ja wij gebruiken niet dezelfde taal wat ik nog wel eens mis in wat grotere bijeenkomsten of groepen die elkaar nog niet zo goed kennen is dat mensen vaak ook niet goed durft te zeggen dat ze iets niet snappen of dat ze niet begrijpen en dat dat dan wel jammer want eigenlijk praat je dan heel lang langs elkaar heen of zit het heel lang mensen braaf enthousiast ja knikken maar wel aan het eind denkt Ja ik snap er echt helemaal niks van maar het zal wel en dan ga je lekker je eigen ding zoveel mogelijk doen dus dat is niet zo positief dat is niet handig Ik heb een ander project daarin werken samen met psychologen en daar hebben we echt heel expliciet daarover	• Every discipline has their own expectations and goals, which is challenging to deal with. People need to be open about their norms, values, and motivations behind them. Otherwise miscommunications are bound to happen, which in turn lead to misinterpretations and wrong expectations. This is a continuous communication process that needs iteration. • This collaboration is dynamic and so new it could be considered pioneering. • People need to be pragmatic and proactive in making and maintaining social connections so that others know them and know where to find them. • Transdisciplinary collaboration is described as

maar dan werk je ook hoe ongelooflijk lang het duurt. (…) Als je kan beginnen met een soort dialoog van Kennen jullie deze problemen of hebben jullie heel andere problemen is het die zin hebben nou een serie van een aantal bijeenkomsten gepland daar geweest en nou ja doe maar gewoon concreet over dingen te gaan praten en uitleg te geven hoop dat je daar gaandeweg wat meer van die komen language gaat ontwikkelen"" "makkelijk schakelen met korte lijntjes informele dus even bellen of een soort loyaliteit van weet je als jij nou dit doet of deze als je nu tijd hebt om even hier aan bij te dragen dan doen wij het de volgende keer weer of goede afstemming heel prettig" "sinds het project draait heb ik toch wel een beetje het gevoel dat iedereen meer gewoon lekker op zijn eigen eilandje dingen aan het doen is ook wel vind ik niet dat het een heel helder samenwerkings verhaal is" A: *Explains transdisciplinary collaboration* B: "Ja nou ja kijk als je het zo omschrijft en daar kan ik me ook goed in vinden dan weet ik eigenlijk niet of transdisciplinariteit überhaupt mogelijk en wenselijk is dan vind ik het ook wel een beetje een utopie maar ook een beetje en ik weet niet of een utopie is Wil je dan afstand doen van alles wat	boundaries that become fluid, transcending boundaries, having a broad perspective and a hybrid character, consisting of synergetic and new insights, and the inability to having solved the issues from any one domain. This type of collaboration is said to be necessary to come to the innovations that people are currently after. • To support transdisciplinary collaboration, people need to adopt a pioneering perspective, be open to others and other perspectives, and be able to look beyond their own domain. • Being able to work towards transdisciplinary collaboration necessitates both a depth of knowledge
wetenschap is namelijk problemen reduceren en in behapbare blokjes op delen En als je de suggestie wekt dat je weer terug kan naar een theorie van alles waar alles in meegenomen wordt dan denk ik Ja volgens mij kan dat helemaal niet dus ik weet niet precies wat het ideaalbeeld nou eigenlijk is en of dat een realistisch een wenselijk ideaalbeeld is wat ik zie waar het naar mijn gevoel best succesvol is en kan zijn is wat jij dan beschreef dat interdisciplinaire dat je gewoon op de onderdelen jouw expertise inbrengt dat het ook wel echt samen tot een en artikel een richtlijn misschien iets als een product of behandeltraject of iets zou kunnen leiden maar dat er altijd nog wel de disciplines die erbij betrokken zijn ook een heleboel kennis en inzichten en mogelijkheden zijn die niet zomaar in dat ene product kunnen zitten en waar ik me soms wel zorgen over maak ik bedoel zover zijn we nog lang niet het idee van dat het ideaal transdisciplinair zou zijn dat veronderstelt toch nog steeds je moet wel vertrekken vanuit iets van kennis vanuit een discipline (…)Ja en ik denk dus eigenlijk dat je juist wel al best heel veel van een discipline moet weten om vruchtbaar met anderen samen te kunnen werken" "Maar ook bijvoorbeeld Wat zijn criterium voor groep onderzoek hele praktische dingen rondom auteurschap Nou ja draakje ook aan dingen rondom scientific integrity natuurlijk is wat	(expertise) and an openness to other points of view and thus a wider perspective. So, a duality of breadth and depth of perspectives is needed. • People need to strive for synergy • The main focus of this project is learning to work together • A first step is said to be getting to know each other, the second step is discovering what the added value is of everyone, and the third is figuring out how they can collectively come to a product or innovation. • The collaboration is going well and shared goals have been formulated • Collaboration is harder if you do not know the people you are collaborating with. It takes effort to

misschien het ene vakgebied als een no-go wordt gezien zijn het andere vakgebied de normaalste zaak van de wereld en daar moet je ook duidelijk nou elkaar over zijn wat de normen in de sub discipline zijn Waar je vandaan komt wat daar de motivatie achter is" "En dan zie je dat de verwachtingen wederzijds tot misverstanden kunnen leiden en tot verkeerde interpretaties verkeerde inschatting" "Ja zijn er heel veel verzwegen premissen die je met elkaar moet uitspreken elkaar continu over bij moet praten" B: "Je hebt natuurlijk ook mensen nodig die bijvoorbeeld in een medisch technische projecten die daar ook heel gespecialiseerd en de diepte induiken maar ik denk dat het wel heel erg belangrijk is dat ze altijd ook die open mindset hebben ja openstaan voor de inzichten uit de andere vakgebied want anders kan je die transdisciplinaire slag ook niet maken (…)" A: "Dus je hebt het over dus Enerzijds openheid maar anderzijds dus ook wel met een been de diepte in kunnen dus een beetje die dualiteit tussen die twee begrijp ik dat goed" B: "ja inderdaad" "alleen als je die openheid hebt in de samenwerking en tot synergie leiden in plaats van allemaal losse projectjes die die wellicht her en der raakvlakken	know what others are doing and to open to them, which is needed to formulate the joint added value. It takes effort because everyone has their own community of people they are used to working with. • This project has introduced a new type of collaboration and organization, which is more bottom-up than top-down like it normally is. • The overall goal of the Convergence Agenda and Digital Twin is to facilitate collaboration • It is unclear what transdisciplinary collaboration is. It is perceived as vague and difficult to grasp. • The idea of Convergence is seen as valuable, but P6 is unsure whether trying to give specific name to this new

hebben en dat is te weinig denk ik je moet echt streven naar die Synergie" "Dat er gewoon veel onbekendheid bestaat en dat als je op een vruchtbare manier ook wilt samenwerken aan ethische problemen je eerst mensen moeten uitleggen of dat zij ook iets moeten leren over wat zei dat dan en hoe zit dat dan dus dat is gewoon nodig is om zoiets te doen Wil je überhaupt zo'n project multidisciplinair een stapje verder krijgen of interdisciplinair" B: "je zit natuurlijk liever gewoon bij elkaar met een Seminar en daarna een borrel bedoel daar gebeurd het dan en dat is nu gewoon niet zo" A: "Je zegt bij die borrels gebeurt het" B: "Nou ja als je het hebt over elkaar leren kennen en met elkaar samenwerken ja" A: "dat maakt het inderdaad allemaal wel wat makkelijker het informele" B: "Ja dat heb je eigenlijk wel gewoon heel hard nodig" "wat we in eerste instantie misschien liever gewild hadden en meer geprobeerd zouden hebben als het niet allemaal online had gemoeten is iets meer jij toch een tikje workshop achtiger iets meer mensen zelf aan het werk zetten met vragen en dan kan je een breakout room maar dat is toch allemaal mensen die elkaar nog helemaal niet kennen en dan zit je nou dat werkt gewoon niet zo goed Terwijl als je een halve dag met elkaar iets kan doen dan kan je wel in kleine groepjes ook aan en	collaboration of the convergence is beneficial. • Building bridges is mentioned as a potential benefit of this new collaboration, which goes beyond multidisciplinary aspects. It makes it easier for people to meet. • Informal circuits are important in collaboration. • Transdisciplinary collaboration is a very vague term and what it entails is also vague. The people in this collaboration, however, are people that are more used to being very clear and concrete, which may make it harder to collaborate.

vragen of een probleem of iets werken dus ik denk dat het dan iets meer workshop achter wat interactiever wat meer zelf met elkaar over een vraagstuk praten en nadenken was geweest dan dat het nu is en inderdaad met ruimte voor informele contacten” “Het grote convergence geheel heeft natuurlijk haar eigen uitdagingen want het is organisatorisch enorm complex” “Nou ik denk dat iedereen ontzettend als enthousiast en gecommitteerd is en er enorme energie en drive” “Ik denk dat de uitdaging is dat je natuurlijk inderdaad hebben we vaker projecten waar je meerdere universiteiten samenwerken dus altijd een beetje ingewikkeld maar hier werk je ook met hele verschillende disciplines samen” “De Doelen en de verwachtingen en deze kunnen verschillen per instelling per type discipline” “ja het is echt pionierswerk waarbij zoveel beweging is” “dan moet je denk ik ook voor een deel pragmatisch in zijn dat je gewoon daar waar je ingangen hebt dat je daar ook voortborduurt en toe geprobeerd hoogte houden dat je mensen die hier nog niet zo op het netvlies hebt en dat je ervoor	

zorgt dat zij je ook weten te vinden dus ik denk dat dat een beetje wat praktische uitdagingen zijn ja” “de boundaries tussen de vakgebieden dat zij wat fluïde worden als ik dat goed begrijp dat dat kenmerkend is voor transdisciplinair dan denk ik zeker dat dat hier aan de orde is dat in ieder geval beoogd wordt en ook denk ik nodig is voor het typen innovaties waar je binnen dit convergence Health and Technology initiatief toe wil streven Je moet er echt grensoverschrijdend zijn denk ik echt brede karakter hebben vermoed ik Ik denk ook dat het dat je op gegeven moment bij een aantal van die innovaties in een aantal projecten die is maar heel duidelijk kan zeggen oh dit is eigenlijk medisch van met een beetje techniek of dit technisch met een beetje mee eens Maar dat je echt ik denk waar je echt naartoe gaat Waarschijnlijk is dat het echt een hybride karakter heeft (…) dat je in een soort van Synergie met het nieuwe inzichten komt die nu nog een beetje moeilijk te voorzien zijn maar we merken in ieder geval dat heel veel van onze uitgangspunten dat zij heel goed bij elkaar passen maar ik ga ervan uit dat we na een tijdje ook zullen zeggen Oh maar dit is iets wat Zo uniek is dat hadden we niet alleen maar in het één of het andere domein kunnen oplossen of kunnen bestuderen”	

A: “en wat is er dan voor nodig om omdat in juiste banen te leiden om dat op een goede manier je te ondersteunen” B: Dat is een hele goede vraag ik denk pioniersgeest (…) je hebt mensen nodig die daar ook voor openstaan en die intellectuele flexibiliteit hebben om Ja ja buiten hun eigen domein te kijken (…)	
“I'm in a lot of interdisciplinary projects right now we have we tried to do exactly that. The digital twin project is one of them” “I feel that right now we have a very good working environment, and it's a lot of fun to talk to our counterparts in Rotterdam. We’re not really collaborating on the things as the digital twin project wanted to do and try to do and promise to do, because it turns out that most of these were blocked down by legal, and or organisational hurdles” “I personally believe that this was never the really high level goal of the digital twin any way. I mean, I personally believe that (…) project being a convergent project was more about bringing us, computer science people, closer to the medical people. And that kind of worked because we span off a lot of side projects from it.”	• The project is seen as interdisciplinary and transdisciplinary. However, there is also some confusion about what these types of collaboration entail exactly. • The collaboration is going well, there is a good working environment • The collaboration is not taking place on the things that were originally intended due to organizational hurdles. • The overall goal of the collaboration is to bring people

“A: Would you describe this collaboration as being transdisciplinary. B: I guess so, yes,” “I’m not really sure to be honest because there's a very taxonomy between these things like interdisciplinary, multidisciplinary, transdisciplinary. It always confuses me, which is which, and also different people seem to be finding a differently. I mean what we're essentially doing is the applying of technologies which were developed in computer science to application problems in medicine” “as an academic discipline in computer science, we tend to be too focused on our own stuff. And that when connecting to other disciplines, there is a crazy amount of hurdles, which you simply don't have, if you just stay in your own domain.” “interdisciplinary work from a pure career perspective, is not very advice, because whatever we do in these projects will have less innovative results from a pure computer science perspective (…) So that's one. So that see things are super important super relevant, but hard to sell as an achievement to our respective academic communities. The second thing is how many hurdles you have in communication to overcome in the beginning, because they obviously use different vocabularies and have different	from the institutions closer together • Crossing disciplines means overcoming many hurdles such as being only focused on your own work • Some challenges to collaboration are (1) interdisciplinary collaboration is, in some fields, hard to sell as an academically desirable form of work, (2) a common understanding needs to be developed and expectations need to be communicated and reflected upon to become realistic, and (3) not getting credit for work that needs to be done but is or does not seem interesting or glorious. The first and third are based on how things are currently organized and valued in academia and would therefore

ideas about how stuff works. And especially if it's things like AI (…) So people maybe have much higher expectations to AI and much higher fears related to AI than are realistic here. First you have to find a common basis on what can be done and what cannot be done. And then of course third that even applying simple methods is often much harder than it seems. Because real life and real data is often way dirtier then we ever assume from an idealised academic perspective, and there's absolutely no glory in cleaning stuff up, but it's super important to do anyway (…) I mean this is just a crapload of work, and everybody just agrees that, you know, it's just work work. It's neither interesting nor innovative nor awesome, but it still needs to be done and nobody really thanks you for it. A: Okay, so then these challenges that you just mentioned, have you been able to overcome them or partially already in this collaboration or are these still challenges that you face. B: I think we are doing well with the communicating part. I mean we took a while to develop a little bit of an understanding of what each other needs and can provide and what they mean when they say certain things so that's working well. The aspect that nobody thanks you for doing stuff, I mean, this is not something which can't be overcome in this project and probably won't be overcome in the next coming years this is mostly how academic results are being evaluated by universities	need a change in attitude and perceptions. The second is going well since communication internally is going well and they have taken time to try to understand each other. • Another challenge to collaboration is the ambiguity which makes it hard to define goals. • Working with others helps to better communicate with them. Furthermore, a lot of different parties are involved in the project. If people are different or come from a different background it makes them more interesting to work with. • This project is seen as useful and having brought people closer. Greater alignment is thought to be
funding agencies (…) Yeah, and the third one, this is also a little bit, that this project still doesn't have access to data, right, so if you cannot even do the dirty work of cleaning data because we simply don't still not have access to it. And maybe somebody could have seen that coming before maybe not I don't know that it makes the project unnecessarily hard." "I think it's a good project because it brings us closer to each other" "I personally find it very interesting to work with medical people here because their problems are so different to ours, typically, I think I learned to better communicate with them" "Yeah, I think we should be doing more of these projects to have a larger alignment." "yes, I think what it makes right now, not super motivating to do too many of his project is that typically you don't really get a lot of recognition out of these projects" "it's a big project with a lot of different parties being involved." "And the problem is that in the end, nobody has, like, really really really strong personal stakes in it right for everybody, this is essentially just a side	achieved through more participation in these types of projects. However, the incentive to participate in such projects is not very big due to a lack of appreciation or recognition for doing so. • The commitment differs per individual team members • Being creative and having regular social interactions and discussions help deal with the uncertainty and ambiguity of transdisciplinary projects • It is recognized that, to enable a collaboration project such as this one, you need all different kinds of experts. To be an expert means being knowledgeable about a very specific things, which means knowing the details. So,

project. Few people, Maybe the postdocs not but from the PI's for all of these PI's this is a side project." B: "So essentially it's now down to us to make up. At least subjective or semi objective measurements for achievement. Then just go with that so basically now I would argue this thing is successful if they actually managed to do a better ECG analysis thing before, even though this was not the topic a year ago. And basically I tried to be creative and find something else." A: "And do you also do this in. By talking to others, just exploring this this community that emerged?" B: "Yeah, yeah, yeah, yeah. I mean I have a very very tight link with my direct partner in project two on the computer science side, the TU Delft side so I'm very frequently connected with him like hey, how is it going in that project or oh you are also as confused as we are" "But this is a problem in the general academic system right, you have to define your own goals, and the problem is all these things are you never know what is a good goal to have" "I personally believe that's the long term goal of this my digital twin is learning more about how to better work together and how to better function as an interdisciplinary group"	transdisciplinary collaboration combines many details so that a broader perspective can be realized. • Collaboration is new but went well • Challenges are related to differences in cultures between the institutions, the corona crisis, and different jargons. The latter necessitates multiple discussions to come to a common understanding (or even common language). This makes the collaboration more efficient. Corona makes it harder to come to a common understanding and thus needs more time. Normally, informal interaction would help to build a common understanding and communicate better.

"And to be fair, I mean all these people for having this project they're all good right i mean they all like experts in their field, but connecting experts from different fields, has never been easy, Right. I mean yes it would be awesome to have like the big unifying super expert who is expert at everything and have him in the project or. But, I mean, that doesn't really exist, right, this is not how being expert works right either expert in something small, or you're not really expert i mean you can't be the expert in everything, by definition, and in this project already consists of like basically professors of all their specialities who is supposed to be more expert than these people already right." "I think this is a new project, in terms of the content, and also field. And in addition to that, it's a new collaboration with a group of researchers that they are in Erasmus MC and TU Delft" "so far, I think it went well" "But however, I can imagine that this was a little bit slow. And part of it, it returns to the nature of collaborative work, when you have multidisciplinary work to do. And part of it also it relates to the different culture of conducting research in TU Delft and Erasmus MC"	• It is unclear what transdisciplinary collaboration is • Current collaboration is experienced to be multi-, inter- and transdisciplinary (to some extent) • Transdisciplinarity is seen as valuable • Transdisciplinarity is thought to make expectations more realistic • The team is much more diverse than in other projects • This project introduced a completely new way of working that starts with collaboration instead of having something in common from the start (concerning a similarity in field in some way). • People are open to sharing their thoughts and talk about their assumptions.

"A: Right. Okay. Okay. So there are some cross contamination, there's some cross collaboration. B: Yes, exactly." "What do you mean by transdisciplinary?" "So maybe I can call it something between the interdisciplinary and transdisciplinary, as you described, yeah, we are transferring, for example, some (…) knowledge between Erasmus MC and TU Delft. But at the end, it will not be for example, that I'm a medical doctor will be able to create a machine learning algorithm for a bunch of data that I'll be having Erasmus MC. So therefore, I think, yeah, in in some extent, we can call it transdisciplinary. But not completely it would be a transdisciplinary. programme." "A: Okay. And do you see the value of something being transdisciplinary? B: Yeah, of course, because I think it would be good to that we can work together, and also have the knowledge of the, for example, ai methods, you know, in healthcare, because maybe, at the end, I cannot, for example, myself, independently, make a AI model, but at least I know the terms and I know, the structure (…). And at least I know, if I went out, for example, do something, where should I start? And what should I expect from for example, from another researcher or a programmer if you have in our team? So for sure that it's valuable for our work as well." "now I'm working with people with much more diverse backgrounds (…)even that people that we are, are from Erasmus MC, they have different backgrounds" "I think it's not only the nature of this work, because also it's new in terms of the infrastructure of the the flagship, of the whole programme." "usually you start collaborating with a group of people, and you know, that you have in, you have something in common, you know, that, for example, you want to work in this field. And this group, for example, has expertise in conducting this kind of work. And so you do you have, you are not expected, you don't have expertise in everything. So you would ask another group that they know that they have expertise in that in that field. So you invite them to collaborate but in this work, you haven't you haven't you have not done so, we have just started to collaborate and so, now we are saying, Okay, what we are going to do together, and how we can use the knowledge that we have in both sides to make a common project. I think that's the difference." "what I understood is that they are different culture of doing research, and also different terminology and	• Time was needed to communicate with each other better • Due to the online meetings, it is always just one person talking and the others are listening • A common understanding is said to be necessary to collaborate. • The start of the collaboration was experienced to be difficult since the goals were not clearly defined and people had different expectations. • Open discussion of expectations, disappointments, and willingness to contribute (initiated by a leader) improved collaboration. • The collaboration is seen as (partly) transdisciplinary due to the collaboration of different disciplines that contribute all they know. These disciplines are not just sciences, but also ethics for example. • The different ideas people had about the project were made explicit by writing them down and sharing them with each other. Then, they brought these ideas together to a joint idea or common understanding of what a digital twin is. • This collaboration is new and it is unclear what people can expect from it. It is ambiguous. • A hurdle in collaboration is not knowing the others' expectations, but this can be counteracted by talking and discussing about it. • The collaboration has gone well so far. • Every field has its own language, so it takes time and

terminologies sometimes we use between the two groups of researchers. And because, for example, I have never worked before, with a group of just engineers from TU Delft, or for example, the people from TU Delft have not worked healthcare data before. So, I, sometimes we discuss about something and we think is clear, but actually from both sides, we understand. Okay, now, we are not in the same page, probably we need to discuss more and then agree first on the terms that we use and then topic more." this is a thing in the nature of the work. So we see for example, they are misunderstood or they have misunderstood something, but this is not just maybe, call it a tension, but what we have done is that we try to have more communication. So therefore, we had a every week, we're having a meeting just between both sides, and then every monitor post, like MPI meetings between different groups. So in this way we try to, to build this. Yeah, to make it much more efficient and effective collaboration." "A: Did that take a lot of effort to, to be open about about that to share things about assumptions or mental models? Or how people see certain definitions or not?" B: "No, no, no" "what you're trying to do during this programme and collaboration, to be on	effort to come to a common understanding or even be aware of a difference. Even though this happens unintentionally, it still delays collaboration. • Spontaneous and informal interactions help to clarify your point and come to a common understanding. This is currently not possible due to the online meetings and the inability to just walk up to someone for 5 minutes. You have to schedule a meeting which takes up more time and is a bigger hurdle than it needs to be. • Transdisciplinary collaboration is seen as the ideal form of collaboration, but right now it is still multidisciplinary. However, this is not weird since it takes
the same page, when we are talking about a project or doing something" "But yeah, we had to put invest time to communicate more with each other. And one of the reason also that we had to do that is that due to Corona we haven't seen many researchers in person. But it was supposed to be a convergence programme, which it is but we haven't seen many researchers in person just it was on a screen and I think it is quite different. Also, when you have a meeting with a large number of people, and also it's not easy to talk with everybody one by one, there is no opportunity like that. It's usually that one person talks on the other as you're listening. Yeah. So you you lose actually that interaction individual interaction between people". A: "informal interaction that would normally help." B: "Yes, exactly." A: "Do you think learning should get explicit attention?" B: "Oh, yes, I think. Yeah, because in this way…Now I have some ideas of this neural networks but I'm not the expert at all. But before I would not be able to collaborate with anyone on this at all. If I wouldn't have an hour some small basics, basic knowledge. So I think it is necessary to go to some level to be able to collaborate." "I think in the beginning it was very difficult. I think there were multiple reasons why I noticed that, what we had to do was not so well defined. From the	a lot of time to get to transdisciplinarity. What could enhance this transition is creating a new department that focuses specifically on this. • Miscommunication and a lack of communication leads to mistrust. • The idea of the project was to just get started and go from there. It was rather vague and uncertain what to expect. • The ethical flagship acts as an umbrella for all other flagships meaning it is involved in all others. → interesting structure that could be useful for providing explicit attention to learning • Collaboration has been good so far. People are enthusiastic and engaged and

start, and people had different expectations." "So there was some open discussion just about the people's expectations. Also, of how willing and how much they want to contribute maybe to this administration and what also there. Everyone was talking also about what their expectations were at the beginning and where their disappointment was because the Eric was most open (…) And then afterwards I think it went also better and everyone realised it was a real problem" A: "would you call the collaboration you've experienced so far to be transdisciplinary." B: "Yeah, I think. Yes. (…) It's about the concept but also what type of underlying models are there and what type of data models are holistic and the data is stored, about data privacy and also ethical issues. (…)" A: "And what would you describe transdisciplinary collaboration to be so what makes something transdisciplinary." B: "So to me, so if different expertise come together that everyone brings brings with what they know, like for example in the position paper and writing the proposal." A: "Right. Okay, so then how, how would that differ from multidisciplinarity, for example" B: "maybe I don't understand the difference." A: *Explains the difference* B: "so then maybe the most	behave proactively in asking for help as well as trying to incorporate long-term considerations when it comes to ethics, which is beneficial for the collaboration process and outcomes. • Collaboration is described as multidisciplinary • The collaboration involves people from a lot of different disciplines. • Relationships are formed better and faster when people are proactive and follow up on them. • In the beginning it was unclear what the roles were exactly. Furthermore, expectations of what for example the ethics team would contribute did not fit with the intentions of the ethics team and had to be
transdisciplinary part but I think is there is also the involvement of the ethics team." "So for example, one thing was that in the beginning, people were very different ideas of what is actually a digital twin. So, then, in the beginning also everyone wrote down what they think a digital twin is. And then we were brought this ideas together to get some joint idea of what is a digital twin." "it is a very new area and we don't really know what to anticipate. (…) and there are of course some, like, typical things between the, between me talking as a philosopher and he thinking in an engineer's way. So, you could say that during the discussion and also the writing up of the ethical analysis, often the thing I really want to have are not there, but you do know that it is because people don't really know the expectations you have. And, you can only, like, have more discussion and then to see how to make the adjustment. So far, I think it is quite smooth." "Yeah, I think it is really difficult because there are different jargons in each field, right? And sometimes when I say, yeah, so , like, one of the things I noticed is that when I talk about things like value, I am thinking about mainly things like autonomy, equality, fairness. My collaborator would think about 'oh, how	communicated. This was solved through practical inclusions where a postdoc of the ethics team was included in meetings and discussions. • This collaboration type is much more engaging and inclusive than they are used to. • Transdisciplinarity is seen as a tricky term. • Transdisciplinarity is the goal of convergence and is described to entail involving stakeholders beyond academia, creating a unified approach, and to be built on multidisciplinary contributions. • Effective transdisciplinary endeavors would mean having the specific distinct disciplinary expertise required for completing the project in the

could you make more use of the raw data.' Turning the raw data into valuable information. So, it's the value in his mind. And we spent like two weeks where we wrote like two sections, very long section, about what he called 'value creation process'. So, the value section. And, everyone is doing their best, but these things can happen" "doing these collaboration but this kind of mistakes, of course it is innocent and unintentional, but, it still delays the progress of the research. But, I mean, If we could work in the office, ?? we don't really get coming to the office every day, but you know in the lunch time you have a bit of chitchat and this kind of informal setting really helps you to clarify your point." "And whenever you want to discuss something, you need to arrange a meeting. So, it is surely not as spontaneous. So, it's truly tricky (…)A lot of time, actually, it is just five minutes, but when you are scheduling a Zoom meeting, usually you would schedule for at least 30 minutes I think. Because people be like, I don't really know how long it will be,m like, seven minutes. But then, you are blocking people's time, and it is a kind of burden for your collaborator, because you have to remember that 'at this time I have to do this research, I have to do that meeting'"	forefront while still developing a method that works for all of the involved parties. • Transdisciplinarity is thought to be more about how to collaborate than being a specific method of research for a specific context. • There are contextual differences to what is considered to be OK or not OK regarding experimenting with new technologies. So, the freedom of experimentation or exploration depends on the context and the invasiveness of the innovation. • A common language is important for collaboration, but before this can actually be established a space needs to be created where cultural differences,
"it would be easier for me to focus on things that I ought to do. If there could be some kind of support that, like, that you know working on similar projects or similar areas, to see be able to work in the same place. You know, you don't really need to know everyone coming in, but, say, three people are allowed to go to the office, and then they could socialize and discuss the research project in person. And create an informal conversation. I think that would be tremendously helpful." "I would say, from my observation, transdisciplinary would be the ideal. But, the reality right now is multidisciplinary. (…) But, in reality at least, I think part of the reason is that it is machine learning takes up a lot of time so, you can't really blame people that it's still like a multidisciplinary set-up." "the kind of research will… the kind of research that is in the project we want to do requires a lot of understanding from things like computer science, machine learning, that kind of thing, and also some medical knowledge like hypertension" A: "and what would you say would be needed to move from multidisciplinary to trans?" B: "I would say, perhaps, you would need to have a new department. Because, you know everyone has 24 hours. That's the thing that I realise, it is	assumptions, and biases can be openly discussed. If open conversations about these foundational levels does not happen, conflict that is happening concerning common language cannot be solves since it is taking place at another level.

a very important lesson. So, it is impossible for you to ask people who's already busy PhD and running research to retrain themselves with all of this" "I think a lot of problems start with miscommunication and lack of communication, and then mistrust." "the idea was to get started on that project and to figure out how to proceed. So our project is related to all of the different flagships, so there's the deep imaging flagship, the digital twin flagship there's a couple others. So our role as what we call an umbrella flagship, is to actually kind of get involved in all of them, and to look at the different kinds of ethical issues that arise" "the digital twin is a very big multidisciplinary scope wide scope project right if you need to you need a lot of different things from a lot of different places to get that to work. So yeah, we've, we've mostly been working with them as enthusiastic and engaged with the ethical issues and so pay well it's kind of taken off with that" "the one thing that the digital twin has done it's been very proactive with. From what I can tell because again I'm not as directly involved as pay wise I'm supervising, rather than and doing that work directly but we're getting into the point where we're working with them	

more directly next several months. But they've been very proactive in not only just reaching out, but also in trying to incorporate these kinds of ethical and long term considerations that we specialise in into their research project formation. So they've, they've, they've been very forward looking about the project as being something that's just going to be very long term. That's going to engage a lot of different difficult issues along the way. And so they've really tried to formulate an approach, I guess. And so that's, that's rather unique in the sense that, often, often ethics gets kind of added in when they realise they need to also talk about ethical issues. And so what happens is that it comes after the research question is formed, and the kind of research trajectory is mostly decided on. And then they're like okay so what kinds of ethical issues are we going to come across what now that we know what we're doing. But in order to forefront that you really need to start thinking about how to what at what points in your plans trajectory, are you going to come across issues and how do you plan on handling them proactively, rather than reactively. Right, and so that's that's one thing that they've really done nicely and they've really taken advantage of Pei-Hua as a resource in that respect." "And again that's it that's a trick that I have to pull a lot because we often get	

thrown into that service category. When it comes to collaboration. We just have something to offer them and then they take it and move on. And so, so yeah, so that's been a balance. It's to keep that collaboration from becoming unidirectional" "And so I think by writing together. There's going to be some interesting outcomes, as far as our project goes as well. What, what is it like to write with them. Yeah, yeah I don't know if I think this might be the first time either of them have written with engineers. So it'll be interesting to see. And and and that in itself is a collaborative endeavour as philosophers we don't often undertake. We're not encouraged explicitly to co-author in our graduate work and collaboration is, is often more around a field than around a team. Right, so it's competitive within the field. Yeah, we're all we all go to conferences together. But we're not necessarily a team and we don't work together, we work in. We each work independently together to contribute to a field right as philosophers, whereas this this is an explicit collaboration model is something a bit different in philosophical ethics." A: "Would you call the collaboration transdisciplinary?" B: "I think they are working towards that, yes. Okay, so transdisciplinary is a tricky term. In many cases it's actually explicitly meant to the meant to include stakeholders, beyond	

academia, and often we talk about it without referring explicitly for that so but I think they are also engaging stakeholders, but I'm not sure to what point that will become a transdisciplinary aspect, but they are trying to create an approach to the digital twin, which in itself is a trance, is a it's a multi disciplinary context so in order to create a unified approach, you're going to end up with a transdisciplinary outcome. If you do it effectively so I do think that that's, that's the goal, as far as establishing a method that's unique to the project. And that comes out of their multidisciplinary contributions." "+doing it effectively would be to be able to, to have to say, you know, in digital twin projects, then we would have this kind of methodology which includes these perspectives so. I mean, for me, doing it effectively would be having the component aspects, it's sufficiently explicit to keep part of the, the distinct expertise is required for completing such a project in the forefront, while still developing a method that works for all of you together right. So then I think the transdisciplinary method itself may end up being more of a how do we collaborate in this context, then a this is the method for this context." "From the results of this experiment or we don't have justification to do it, that kind of invasive procedure as an individual. So there's a higher level of	

justification that has to take place when it's an internal versus an external procedure. When it's a human, altering procedure, potentially, versus a, an augmentation or an addition to the body. These these kinds of factors come into play in different ways in these contexts so where things are totally allowable in exoskeleton research right now, They're not going to be allowable in smart knife research on the Delft campus, and the transition between one context to another, it's actually can be quite dramatic." "I think that's what needs to be opened up because what happens when you, when you come from a specific research culture. You have a cultural bias right, you have a certain set of priorities, things shift, like even authorship from one field to another so when you shift fields already there's this cultural shock from, what are our fields of attention. What are the most important issues versus the less important issues which things do we take care of at what point in our process those things shift from one context to another, and it's one thing when you move as an individual to a new lab and you have to acclimatise to that culture it's another thing when you're trying to actually bring two cultures together to work on a single line without a sharp transition point, right and then. So, so I think before common language could even be developed, you would need a space to	

negotiate those cultural aspects and to highlight the fact that the very, very biases, we have about what kinds of things are important, Because foundational level of how we think about how we should proceed through this research is going to come into conflict and those things don't get brought up explicitly in meetings right so you have a meeting everybody's sitting around the table. People don't always understand what it is that they're misunderstanding because they're not going down to that level, they're both trying to solve a problem at this level but there's conflicts happening down here that are affecting the way they're talking about it up here so I think it's more a matter of getting to those conflicts than necessarily before we can get to a language where that comes into play."	

Table D.2: Quotes of the semi-structured interviews related to learning. 'A:' refers to the interviewer, 'B:' refers to the interviewee. Any reference to a person has been deleted. All Dutch parts have been put together in a randomized order. The same goes for the English parts.

LEARNING	
Statements	**Conclusions**
B: "wat we binnen Digital twin willen doen is eigenlijk vooral kijken van hoe hoe kunnen we nou concepten en mechanismes ontdekken die uiteindelijk zullen leiden tot een maatschappelijke impact maar niet binnen dit project maar de volgende project is dat we voorbereiding doen voor werk in een ander project." A: "dus eigenlijk te lessen die men in Digital Twin leert worden hopelijk dus overgedragen naar het volgende project" B: "ja" "En dan zie je dat instituten de samenwerking wat in de weg kunnen staan maar dat zijn hele goeie leermomenten want daar kom je achter in zo'n project en convergence zojuist dat die samenwerking vloeiend gaat is dan moet je ook goed weten waar zitten naar de barrières en daar kom je op zo'n manier achter" "Vind ik ook met leren in werk het kan niet zonder elkaar" "omdat je juist vind ik veel eigenlijk alleen maar kan leren als je een beetje uitgerust bent en als je een beetje losgescheurd bent dan is er pas weer ruimte in je hoofd om dingen te leren en vandaar dat hij afwisseling met bijvoorbeeld sport of andere activiteiten" "belangrijk is daarbij wel niet alleen maar in Dat hoor je natuurlijk wel vaker maar dat heeft er wel mee te maken en ook echt wel een soort van durf om ook uit te glijden" "ik heb het gevoel bij Wat je ook doet altijd ongeveer de hele tijd wel dingen leert Nou ja probleemgestuurd is natuurlijk prettig tenminste zeker als je ook gewoon in je werk bezig bent dan is het vaak prettig om iets nieuws te leren op het moment dat je denkt dat je dat nodig hebt en dat je ook weet waarvoor je het nodig hebt zodat je ook wat gerichter dat kan opzoeken (…) Ja dat ligt dat vind ik heel breed Ik vind niet een beste manier" "op gegeven moment kun je dat een beetje leren en weet je dat je nog wel dat er eigenlijk een soort van nieuwe manier of dat het vertrouwen risico's beheersbaar zijn zoiets kan je zeggen en dat daar dat je eigenlijk meer risico's kan nemen dan je denkt vaak en En juist dat is dat scherp hoe zeg je dat zo'n niet het scherp van de snede maar het punt van Vertrouwen Ja de grens van wanneer het wanneer er vertrouwensbreuk optreedt die is best wel vloeibaar en die is vlak vloeibaarder dan je denkt daar heb je	• Learning is currently not getting explicit attention but will in the near future. The benefits of making learning explicit are noted. An example is the effect it will have on students, namely it will enable them to develop a holistic way of working. • Learning is not getting explicit attention within Health & Technology. Another theme, Resilient Delta, has given learning and learning how to be transdisciplinary explicit attention and could therefore provide useful information on how to do that. Making learning explicit is seen as beneficial and provides learning opportunities. • Learning should be facilitated throughout a spectrum of theoretical to practical. Including cases, especially those that did not go well, so including failure, is beneficial for learning. • Writing together and partaking in a certain action helps learn about that action (in this case writing a paper together). Undertaking an action with others helps create a bond and strengthens collaboration. • Learning is said to be an inherent part of this project. However, giving learning explicit attention is also seen as interesting. • The main goal of this collaboration is to learn to work

eigenlijk wel ruimte in een watje kan verschuiven (…) Er is altijd gewoon meer mogelijk ook binnen zo'n onderzoek vraagt zijn diverse in het begin en weet je dat nog niet zo goed waar die liggen je worden steeds concreter En vervolgens als concreet zijn kan je ze steeds een beetje gaan verschuiven" A: "krijg leren momenteel expliciete aandacht binnen Digital Twin" B: "niet expliciet (…) Het lijkt me wel goed sowieso aan het eind van het project is dat belangrijk dan om een soort reflectiemoment in te brengen dan wat heb je nou geleerd van elkaar maar dat is meer achteraf leren (…) tijdens het project gebeurt natuurlijk altijd impliciet heel veel" "vorige week was ik op vakantie en toen was ik ook aan het mountainbiken en dan heb je als je in een bocht als je een bocht maakt heb je altijd het Ja je hebt altijd een soort Angst En dan ga je remmen en als je remt dan kom je altijd voor je ideale lijn af en als je van de ideale lijn of bent dan word je bocht wat minder vloeiend en dan ga ik wat minder hard en het wordt wat minder mooi maar het is wel het vergt ook lef om niet je remmen aan te raken en elke vorm van remming eigenlijk omdat je iets niet vertrouwt of iets niet durft dat daarmee zo'n eigenlijk zo'n ideale uitkomst daarmee verstoord wordt dat is ook wel pest toe te passen altijd op project Wat was er zo op	together. The lessons learned here have to be transferred to the next project (team). So, this team is making the first step in trying to build transdisciplinary collaboration. So, it could be said that a learning mindset is already partly integrated. • It seems that learning has not received explicit attention. However, learning is taking place implicitly through social interactions and dialogue in which one learns about what others are doing and what value people can add. • Truly learning about what others do takes time, effort, and interest. People need to be willing to listen to others and not intervene or talk about themselves. Understanding

wetenschappelijk denken denk ik omdat je door remmingen maar ja je verliest daarmee de Flow eigenlijk van een idee waar je mee bezig bent van onderzoeksvraag maar uiteindelijk en ja dat is niet alleen de Flow op dit moment maar ook achteraf dat je resultaat uiteindelijk minder overtuigend maakt dat het resultaat een beetje zwabberend bereikt wordt dat dus veel minder overtuigend dan een resultaat en een mooie boog en voor zo'n mooie boog heb je wel Ja moet je wel soms een beetje wat vertrouwen hebben en wat lef niet alleen in de andere m+aar ook weg die je gewoon in geslaagd bent persoonlijk of naar bijvoorbeeld een paper zelf aan het schrijven bent dat bepaalde ideeën ook gewoon goed zal zijn dus niet al te veel daarin zwabberen dus dat is wel een soort van leermoment" "binnen dit Digital twin ja dan ben je aan het leren ook de hele tijd" "Binnen Resilient Delta hebben ze echt een thema dat heet methodologie dus daar is juist het leren over transdisciplinair (…) Bij Health and Technology niet zo specifiek (…) dat zou je wel willen vervlechten daarin en ik denk wel dat er lerend dat er lerend heid is ook de support stuff er nu allemaal business developer het zij ingezet of worden aangetrokken en die zitten binnen ook ingebed in een instellingen Dus die kunnen er moeten ook van elkaar	what others do builds respect for them and what they do. However, this costs tremendous amounts of time and can therefore not be done with everyone. • Respect, taking time, and making space for others is essential for learning to take place. I.e., you need to be open to what others are saying and truly try to listen. • Learning is always taking place, no matter what you do. • Problem-based learning is a pleasant method for learning something. • Learning is also pleasant when it can be directly applied to something you are working on, so if it is relevant to your current work. • There is not one best way of learning something, it

leren dus die kunnen dan ook die aanpak van elkaar leren dus ook dus daar zou ook een kans liggen om die goed mee te nemen” Binnen H&T is leren nog niet expliciet, maar dat is vooral omdat men nog in de implementatie fase zit. Maar P2 twijfelt er niet aan dat leren zeker meengenomen en uitgewerkt gaat worden in concrete acties. A: “wordt er expliciet aandacht gegeven aan leren is er een soort Learning agenda naast een Research agenda bijvoorbeeld” B: “als hij er is dan is hij mij nog niet echt opgevallen wat je wel merkt Is dat omdat je gezamenlijk gesprekken gaat zitten voeren en je bent in dialoog krijg je wel veel beter zicht in over en weer wat je aan het doen bent en wat je voor elkaar kan betekenen dus in die zin wordt wel degelijk geleerd” “wat ik merk met de mensen die waar ik mee samenwerk in Delft ontstaat er toch een beetje een sfeer van toch wel wat respect voor over en weer voor wat men heeft gedaan en daarvoor moet je toch wel in detail gaan van wat er in een groep gebeurt (…) Je begint met uit te leggen wat je ongeveer aan het doen bent waar je goed in bent dus dat dat is toch een beetje het echte leren in mijn ervaring heb je uren voor nodig waar je in detail gaat zitten kijken naar wat doe je nou precies en dat hebben we ook gedaan met mensen in Delft we hebben echt	depends on the context. • Taking part in collaboration and stumbling across hurdles helps clarify the boundaries and makes it easier to learn about the project. • Learning is an inherent part of research. • Being open to others and other points of view is necessary for learning to take place. I.e., you need to be intellectually flexible. • It is thought that giving learning explicit attention would be beneficial. Currently people implicitly learn from each other through collaboration. • Learning is an inherent part of working. • To be able to learn effectively, one must be rested enough and also include a variety of

halve dagen besteed hebben aan Hoe los je dingen op Waar ben je nu precies mee bezig dus niet en niet alleen maar de overall picture maar ook details dus wat je merkt mijn ervaring is dat je dan pas echt leert waarderen wat men doet (…) maar ook echt uren aan besteden dus niet niet een pitch van 2 minuten om jezelf te profileren maar gewoon zeggen van Oké ik ga nu een uur lang of twee uur lang niet praten over wat ik doe maar ik ga luisteren naar wat jij doet en ik ga vragen stellen dat ik echt begrijp wat jij doet en ik denk dat we dat nog wel te weinig doen dat we nog teveel in Ik heb wel eens het gevoel dat we nog teveel in pitches zitten en te weinig op echt begrijpen (…) maar je kan niet aan iedereen tijd besteden” A: “wat zou een prettige manier zijn om iets te leren dus wat zou een fijne setting zijn of wat voor randvoorwaarde zitten daar aan om iets op een prettige manier te leren naar jouw mening of gebaseerd op jouw ervaring” B: “begint heel banaal met respect voor mensen heel simpel het is gewoon de tijd en Ruimte nemen om naar mensen te luisteren om te proberen te begrijpen wat te doen dus niet van tevoren je ideeën hebben over wat jij denkt dat ze zouden moeten doen wat ze zouden kunnen dus niet dus gewoon echt de tijd nemen om te luisteren dubbel dat is de belangrijkste Kijk als een van de partijen op dat moment eigenlijk bezig is om de ander te overtuigen dat hij het dat hij zelf briljant is gaat het niet werken ja	other activities in their lives. This helps clear one’s mind. • *[analogy of mountain biking]* To be able to come to a smooth learning curve, one must be able to accept a little bit of uncertainty and fear for the unknown or scary situations, because if you use your breaks you will divert from the smooth line and will never know whether you could have made it. You have to trust the process to let it work its magic for you. And yes, sometimes you can take it too far and you’ll fall, and that will only help you learn more, but often times you will be just fine and will have expanded your comfort zone and boundaries. So, for effective learning to take place, you need to be brave

Dus de belangrijkste randvoorwaarde is tijd en respect" Focus op leren gaat iets opleveren voor studenten, PhDs en postdocs. Je leert studenten meer denken op holistische manier. Het wetenschappelijk personeel (tenure trackers, hoogleraren), kijken naar het talent wat er nu is hoe kunnen we dat behouden. Leren en carrière mogelijkheden en perspectief bieden. Dus de mensen behouden die op die holistische manier (willen gaan) werken. "en ze [postdocs] moeten ook leren wat dat inhoudt en auteurschap en dat dat niet niet zomaar iets is dus dat is wel weer heel goed en dat geeft ook een band tussen de postdocs dat helpt heel goed en ook met de PIs." "voor mij is dat inclusief want je doet niks anders dan leren alleen dat is nooit zo benoemd maar dat is wel dat is wel interessant om dat eens te benoemen ja" "Dat zou best interessant zijn om dat te onderzoeken in het kader van leren en daar zou je dan verschillende blokken in kunnen doen van theoretisch tot wat praktischer maar het mooie is dat je als je nu iets opgestart dat ze dan nu gelijk kunnen proberen het toe te passen dus ook wel mooi als we wat ervaring ook minder leuke ervaring opdoen van Hey hier loop ik tegen aan dus dat je wat casus kan inbrengen wat zou je dan	and trust yourself and the process, as well as accepting failure as part of that process. You need to be brave enough to make mistakes, to go a little too far. • Eventually you will learn that the perceived risks in reality are smaller and you are able to do more than you thought. The boundaries of your comfort zone are more fluid than you might think. Once the boundaries are clearer, it is easier to know where to push yourself to be able to move them up and learn something new. • Learning currently is not getting explicit attention. A point of reflection at the end of a project is seen as valuable, but it may be more valuable to integrate learning throughout the
Komend jaar kunnen oppakken ofzo is Dat zou best wel interessant zijn om dat te doen" A: "Wat voor rol speelt leren naar jouw idee in die nieuwe vorm van samenwerking en binnen de convergence agenda" B: "Ja mooie vraag ik hoop dat ik me niet teveel herhaal maar ik zou ook hier weer zeggen dat je open moet staan voor het leren van totaal andere inzicht uit het al andere vakgebieden dus ja die flexibiliteit intellectueel die is denk ik heel belangrijk onderzoek en onderwijs en leren die zitten natuurlijk zijn natuurlijk altijd heel nou met elkaar vervlochten binnen universitaire context maar je hebt denk ik wel mensen nodig die openstaan voor een soort van generalistische blik" A: "krijgt leren momenteel expliciete aandacht en zou die dat moeten krijgen" B: "(…) Dat zou iets kunnen zijn om te verkennen of dat handig kan zijn Ik kan me daar wel iets bij voorstellen Maar je zou natuurlijk ook de samenwerking Als zodanig ook als een leerproces kunnen zien zet Of misschien niet van echt expliciet onderwijs maar kan misschien ook onderzoek dat je van elkaar leert in het werken en ik denk dat dat inclusief Heel belangrijk ook is meegenomen Maar dat is een goede vraag om te kijken Is dat voldoende die impliciete manier dat je door de samenwerking van elkaar leert of is misschien nog meer nodig wat	whole process. Learning is already taking place implicitly throughout the project.

aanvullende begrip van de andere discipline”	
A: “And it's or maybe something you would like to have more from leadership so would you specifically for learning is there any additional support that you would like to have or if there may be too much.” B: “Yeah so I think retrospectively, I think what would have been nice for me also to have maybe some conversations with the TU Delft supervisors or the because yeah they already know more than my supervisor, it was more that I was learning and I was teaching him but from their side, I could have gotten maybe some, some work. Yeah, the postdoc that I was regularly meeting, and he was not familiar with neural networks anything, so I was also learning.” A: “Right, so you would have liked to have some social interaction with someone who was more of an expert in neural networks then.” B: “Hmm. Right” “This is a this is a test right is that even possible or do we need separate ethics for different contexts and do we then need to better identify those different contexts so that we can do that.” “so failure actually has to be encouraged as a mode of improvement.” “So I think painting one’s project as an exploratory endeavour in these contexts	• The project is seen as a ‘trial run’ which can provide lessons learned for future projects. • Learning currently mainly happens implicitly and retrospectively. Adding an explicit and formal learning agenda to the project is viewed to be beneficial. • What way of learning works best depends on the nature of what needs to be learned. Low-level things can be learned by trying it out yourself. High-level things are often too difficult to grasp on your own and need social interaction and discussion to figure out. Furthermore, pressure (in for example the form of a deadline) or teaching others are

is really important, rather than as an outcome oriented Endeavour is one key thing, and to allow failure to count as success. In that case, because if it's exploratory than proving our hypotheses wrong it's just as important as proving them right. And so finding ways to integrate that all of the results as results. So rather than having a pre determined kind of set criteria for what will count as your success to be able to model your success on the actual results is, is important. So then then what you do is you have an orientation towards drawing the success out of every point of your project rather than saying, well, that whole year was a waste of time. There's never a waste of time right and if you have the right attitude towards your results. So highly transitional projects I think really means those kinds of setups.” “I don't think it [learning] was part of their original agenda, quite as explicitly as it should have been in the sense that they were very excited and they wanted to promote big exciting projects with likely exciting outcomes. But definitely the digital twin has taken a step back and focused on, on what the groundwork is that needs to be done before you can get to the point of implementing such technology and other projects as well, who were involved in convergence.” “There's also a very strong education wing in convergence. So, so there's definitely a mandate towards creating	mentioned as contributing to learning outcomes. Teaching others also makes you aware of what you do and do not know, which contributes to learning. • The lessons learned need to be written down and formalized and shared • A learning cycle includes introduction to a topic by someone else, material to read by yourself, social interaction to discuss the material, and trying to apply the material. So introduction – individual study – social interaction and discussion – application. • Learning took place during meetings and presentations. However, P9 enjoys informal social interaction better to learn something new, because it

educational programmes creating educational opportunities for students so that they can engage these convergence contexts, at an earlier stage and see them as the kind of contexts, they're going to be working in in the future where these things come together, rather than the silo approach to education that we've had. So, so there's the results of the explicit mandate of education itself. And then there's the implicit, a little bit more implicit mandate that part of the reason why we want to converge these different approaches is to, to learn from each other. At the right points in our, in our research process. So, so yeah, there's definitely that kind of interdisciplinary education happening at the researcher level as well as on the explicit educational level." B: "I get also some opportunity to learn on some small project, which, which I like." A: "Yeah, so you… What do you like most about that specifically so it's that it's a small project or…?" B: "Yeah, that's a. Yeah, it's that's short, so you'll finish something relatively quick which is nice, which in other projects is not so much the case. And that, yeah, you will learn about some methods that you were not using before, which is also nice." A: "And you didn't really learn a lot because it didn't feel relevant or were there more…how do you say it…more things that influenced it?" B: "Yeah, I	allows for more open and creative conversation. P9 also recognizes that in some cases, for example if something specific needs to be learned for a project, formal learning opportunities such as presentations and meetings, can be good to implement. • Learning can also happen by having an idea or a hunch and exploring that option through own exploration or conversing with other about it. • It seems that most people work and learn independently such as by reading papers or practicing code. Other times learning takes place within meetings. • Due to the intensive nature of this project, people spend more time on individual learning endeavors.
think the course was not relevant for all, for our fields" "So there has been, I think the one workshop and two talks, organised by the ethics team. And they point also the. They give a very different perspective on this development of the digital twin. Which, which is very nice and I didn't was not aware of before and this position paper also gives some opportunity to learn about other topics (…) So I'm learning about this I'm writing something and then I, and then someone else who's maybe more expert in this is revising it so through this position paper, you get more different perspectives and knowledge about different aspects of the digital twin" "I think it's a good project because it brings us closer to each other and maybe then the next one will avoid the pitfalls, because you have to start somewhere." "B: I prefer mixed things about them. So I prefer to have for example, a lecture or a very sorry an introductory introductory lecture by someone and then have some materials to read myself and then if I and then also work with the+m can otherwise I think the learning cycle is not complete. A: Okay. And you mentioned your learning cycle so that what that does it look like for you specifically learning cycle? B: You get knowledge about something. And then you can also	• Getting feedback and trying things out, trying to apply it or experimenting is important for learning • Different backgrounds and thus diversity provides different perspectives and learning opportunities • Learning has not gotten explicit attention as a goal for this project, but is thought to be beneficial. • Self-development of the researchers seems to be an implicit learning goal • Learning took place as a combination of individual self-study and social interaction and discussion thereafter. The individual learning was enjoyable since it could be done at the person's own pace and there was material to

use that knowledge. Otherwise, if you just know it was something and you cannot use it I think its not complete. When applied." "during this cycle, you get feedback. Where you don't have enough knowledge, and you have to learn again, and also very, cannot apply it very well. So then you have to go in depth, and try as you apply. So I think this is how you learn something." "I think the potential learning point here would be that it would give us a new perspective of conducting research using healthcare data. I think that's a good learning point here, because as a medical researcher, maybe we look at the research. From from a medical perspective, I think the new people and the different backgrounds and also insight (…) can help us to look at it differently. And maybe we can come up with new ideas to do research." "A: Has learning been explicitly mentioned as being part of the the convergence agenda or the digital twin project? B: No, I haven't seen any, anything in any documents with regard to that." "the aim is not just only doing the project, and then it's finished. We're going also to have the self learning and improvement during these two years."	experiment and try to apply it yourself. Social interaction was also enjoyed, but was thought to be more useful if the other person was knowledgeable or an expert about the subject as well so that it could be two-way learning. • Sometimes learning is formally organized if it is necessary for the project. P8 believes learning from other people will be increased once collaboration intensifies, which is now blocked by the absence of data. Furthermore, informal interactions, which can implicitly lead to learning, have decreased due to the online meetings as a result of the corona pandemic. • Giving learning explicit attention is thought to be good since it contributes to the development
"A: Do you think it would be beneficial to to have a learning agenda? Would you be more aware of both learning? B: Yes, of course" "So basically make it a formal process that lessons need to be learned and mistakes are being made, but then actually write down the experiences and basically formalise. The learning project does that, I think it happens implicitly that now three quarter year later everybody agrees that if you should ever do a project like that again that you know stuff like data needs to be there before duh. Right, but it wasn't really clear that this project was set up so the next one should definitely do that. I'm not really sure if anybody actually wrote that down formally as an advice to the next project, I mean, I think now everybody agrees to this. But yeah, maybe it would be good if somebody could have done the more formal experience management here learning management or however you caught it." "learning is ubiquitous to me I have a hard time anything right, so I really, I really prefer learning through engagement. So actual deliberation over issues with others, is going to encourage learning. Again the flexibility and the attitudes towards failure. I think are prerequisites for learning. You won't learn the things you need to learn unless you're willing to open yourself up to	of a common understanding which enables better collaboration. • Finishing things quickly is said to be enjoyable and contribute to learning. So, small short-term wins are beneficial for learning, as well as using new methods to learn about them. • Whether or not something is relevant influences the commitment to learning it and the learning outcomes. • Diversity, for example by introducing an ethics team, increases opportunities to learn. Furthermore, trying to write about something that is not completely your expertise and having someone else take a look at it also increases learning. So,

ideas you didn't expect, because then you've already pre determined what you're going to learn so that was on learning memorising. So, so I would say yeah, just being involved with an attitude with an attitude of humility towards towards learning itself, that you're going to learn more than just the results of your experiments." "I don't think there's been more than a day. I learned something, or how to do something or something about how things work or, yeah, yeah, I don't think it's a, I don't see that as a process that stops." A: "And what would you say or how do you prefer to learn something new, or how do you best learn something." B: "Hmm. Um, I absorb. Let it trickle down, and then attempt to apply it. I suppose. Yeah, take it in, allow it time to work with the rest of stuff, and then and then try to apply it in a new situation." A: "And do you do that in combination with with others so in." B: "Sometimes, yeah. Yeah, collaboration with others is a bit different than learning in the sense that it's usually co creation rather than CO learning. Yeah, so the level of collaboration that I'm typically involved in is people coming together and sorting out what to do next, so that we don't learn from each other. That's not the point of the coming together. So learning	learning can be increased by diversity, exploration, and feedback from others. • Experimentation and tests are a part of this new type of collaboration. These are needed to learn what does and does not work. • Failure is a mode of improvement • People's mindset towards the project should be one of exploratory endeavor or a learning mindset so that every undertaking can be seen as progress, even if it consists of 'failure' or disproving a hypothesis. In this way, something is never a waste of time. • Paying explicit attention to learning is thought to be beneficial. Up until now, explicit attention has not

tends to be independent. I suppose. But feedback from others is essential to that right, there's all sorts of feedback processes happening." "it depends on what it is you're learning, or want to learn I mean if it's low level technical stuff it's typically reading it up on books or nowadays when it's like coding stuff you'll read up on the internet. If it's more complex methodological things and you probably learn it from research papers, and then you typically don't get them so you need to discuss with your colleagues, I mean it depends on what kind of skill, it is I mean this low level thing is like oh, how does Python work. Yeah, just do a Python tutorial. Yeah, try a little bit yourself No, no, no big deal. But if it's something more like how does AI work. Yeah. This is probably sensing and discussion so what helped me a lot is when I'm pressured is deadlines, and mostly for teaching, I learned really a lot through teaching, and I don't know if that works for other people too. But learning by teaching actually is very, very effective. (…) if you try to explain something to somebody you very, very quickly realise when you didn't understand it. (…)if you explain it to somebody suddenly something which makes sense before, maybe doesn't because this is the first time we realised that you actually just memorise some random disconnected information nuggets but that you never really cared	been given to learning quite as much as would be useful. However, there is a mandate for making learning explicit when it comes to education of students and future generations of scientists. Implicit learning is also taking place by learning through social interactions. So, there is both implicit and explicit learning. • Learning is said to be ubiquitous and continuous. • Learning through engagement, or social deliberation, is mentioned to stimulate learning. • Flexibility and a positive attitude towards failure are mentioned as prerequisites for learning. Furthermore, an willingness open oneself up to ideas one did not expect is said to enhance

to connect these things and never really care to ask yourself why this makes sense and how these things actually are connected, which is something we naturally would exploit when explaining something to another person. Yeah, because it just makes sense to make a good conversation you always would explain stuff." A: "what were the conditions of how you learned this." B: "so, it's from a meeting I attend to (…) I learned about this from one of the presentation they have during the online meeting" A: "E: alright. Is that a way you enjoy learning new things? Is that a good way for you to learn new things or is there maybe another way that you enjoy more?" B: "I prefer private chit chat, to be honest." A: "Yeah?" B: "because, you notice when people are having their presentation it is already formulated. So, you would be rude for you to just say 'oh ???' So you always ask whatever question you wanted to ask. So, I personally prefer private chit chat. But, of course if it is like a formal talk that's about a particular subject your co-worker work on, or whatever. Then of course it's still meaningful to have a more formal setting, iw oudl say generally prefer this kind of informal environment. Yeah." A: "because it enables you to go back an forth and ask questions at the very moment and have a more, maybe more relaxing open or creative conversation maybe even?" B: "Yeah, yeah. And also, like, I guess a lot of time	learning opportunities, since it prevents you from predetermining outcomes. • People should have a humble attitude towards learning, to be aware that you will learn more than just the results of the experiments. • Taking information in, thinking about it again, and trying to apply it are the steps that are described to be involved in learning. This process can be enhanced through social interaction and feedback.
you know the reason that you have this particular question has somethignt o do with what you are working on recently. So, it has a lot of about yourself" "we philosophers are meant to be critical about ourselves, and sometimes you just have the hunch that 'ther's something wrong here, but I can't tell why'. And you go to the argument and then say 'I don't know why I don't like this particular bit' and your friends can help you. (…) And then things like experiments test if the hunch is correct." "I think, I would say.. but I really don't know about the reality because I only sit on their meetings. But, I guess, people mostly working indepedentl, like reading papers and doing coding. And then exchange their progress during their weekly meeting or bi-weekly meeting. So, they are a?? learning, one is learning from your own research, the other is from the meeting." "in this kind of research intensive innovation I think people usually spend much more time in individual learning." A: "And did you learn about neural networks just by reading about or so conversing with someone about it, or" B: "mostly reading it I also followed an online course, from, from Coursera, they have a deep learning specialization so I follow this about neural networks and then I also, I have regular meetings with	

my supervisor, and then I tell him what I learned, and in this way, he's also learning. (…) Like the online course because I could do it at my own pace and then you can pause the videos and so on so I did like the format. And then also, there is a lot of good resources so there are books and tutorials online for this subject, where you also with example code so you can actually try out the code and then manipulated and learn in this way, so I did like it like this. Yeah" A: "And how about talking with your supervisor or colleague about it, you mentioned that as well. Do you enjoy that, too, or is that not necessarily for you, a part of the learning" B: "no I do like it, but my supervisor is not so familiar with it, so it's not that he can teach me something. It's more that we have a conversation and then he asked questions. And then if I don't know the answer, because I didn't read about this then I will look up for the next time. So it's, yeah, it's not the like so two way learning." "it's a little bit comes also directed for my supervisor that. Okay, we want to learn about machine learning, so I started reading and I do it a little bit with his guidance but by myself, so I'm not. I don't have the feeling at this point that I'm learning so much from other people off the project for example which I would, which I think might start once we started collaborating on some data which we are not doing at this point because there's no	

data yet, so this makes it also the collaboration a bit more difficult." B: "In the past I was having regular lunch with my Delft counterpart. That was when we could still meet in person. And then we were just exchanging what we were doing, which was nice. I don't know if it just led to so much learning but it was, it was nice and then when it was everything online then we stopped because we had already enough online meetings. Yeah, then it's not so relaxing. To do it, like you don't want to." A: "So, scheduling another meeting to just informally talk to someone doesn't feel relaxing anymore because, yeah, I understand." B: "Yeah" A: "Do you think learning should get explicit attention?" B: "Oh, yes, I think. Yeah, because in this way…Now I have some ideas of this neural networks but I'm not the expert at all. But before I would not be able to collaborate with anyone on this at all. If I wouldn't have an hour some small basics, basic knowledge. So I think it is necessary to go to some level to be able to collaborate." "I think there's two major things to learn. One is the organisational pitfalls of these projects. And these things, I think simply need to be written down and somehow formalised into a report which is being shared and you know experiences are repeated"	

Table D.3: Quotes of the semi-structured interviews related to leadership. 'A:' refers to the interviewer, 'B:' refers to the interviewee. Any reference to a person has been deleted. All Dutch parts have been put together in a randomized order. The same goes for the English parts.

LEADERSHIP	
Statements	**Conclusions**
"wat moet hier aan besluit uit gaan komen of wat moet hier echt besproken worden en dat helpt de voorzitter en het bestuur heel erg" "Enerzijds formeel maar ook gewoon mondeling van dit bedoelen ze ermee is dat is en dat miste voorheen nog wel." "eigenlijk een soort twee petten op dus Enerzijds draaide ik mee in het Health en Technology team en wat ik zeg maar mee de adviseur voor Richard Goossens dus de overkoepelende directeur maar ook zat ik aan bij bestuursvergaderingen en organiseerde ik de werkgroepenen dat geheel Dus ik weet wel wat er speelt maar ik heb natuurlijk wel een andere rol en dat vind dat vinden ze soms ook spannend denkt van Jennifer kunnen we niet vragen dus altijd weer een beetje vertrouwen krijgen dat je niet alleen dingen van mensen vraagt maar dat je ook ze helpt en dat is ook het idee van het convergentie bureau is dat we juist de thema's faciliteren en voor hem een linking-pin" "Enerzijds dat dat ze het niet allemaal zelf doen hoeven uit te vinden anderzijds meer vanuit perspectief convergentie dat je daar nu vorm dat je een oplossing pakt en dat de diensten niet door drie dingen apart worden benaderd en dat je dus ook een mengsel is van Wat is goed voor de instellingen en wat wilde de thema's en daar is het goede oplossing in vinden" "de thema's natuurlijk al best wel op gang dus daar zit wel een redelijke autonomie in" "bij zeg maar die diensten verdedig ik of breng ik juist de praktische dingen vanuit het thema's in en vice versa als ik dan de thema spreek geef dan ook af en toe aan van ja maar Realiseer je dat dus leuk dat je wil maar er zit natuurlijk restrictie aan zijn beide kanten probeer ik uit te leggen waarbij we diensten echt op zoek gaan naar waar de loopholes zitten maar ja ergens houdt het op voor ze natuurlijk ook logisch En in die zien zijn de thema's wat Wilder zeg maar ik ga gewoon lekker aan de slag Misschien moet je dan af en toe heel even kaders meegeven maar als je dat dan wel weer uitlegt en tegelijk zijn ze natuurlijk ook afhankelijk van financiering uit the board dus we moeten wel een beetje door een bepaald hoepeltje heen springen alleen je moet het niet te ingewikkeld maken en dan helpt het om het uit te leggen"	• Being practical and getting concrete helps leadership • There is a mix of formal and informal leadership (actions) • A leader figure has a dual role as they had one foot in the governing level and another in the community level. A leadership role changed which was weird for people as they now thought they could not ask the leader figure for certain help. So it took some time to build that trust again. To help this along, it was important to not only ask things from team members but also support and facilitate them, to be a linking-pin. • Leadership needs to make sure that people do not lose sight of the overall goal of convergence. Furthermore, it needs to balance the interests of the institutions and the convergence themes. So, it is a balancing act between the overall goal and more detailed goals and interest of parties involved. • The themes of convergence are all fairly autonomous. • Leaders play an important role in increasing awareness between collaborating parties about boundaries and realistic goals. Leaders provide direction and clarity and increase awareness. • Leaders should be brave enough to act beyond the

A: “ben jij dan inderdaad degene die opstaat om dan zoiets te regelen dus er wordt eens geroepen van We hebben hier behoefte aan maar dan komt er een stukje van Oké ja maar hoe dan” B: “Ja dat is wel in elk geval op een bepaald niveau mijn rol” “en iemand als petja is dat binnen Health and Technology daar zij degene die dan Oké dat wordt op bestuurlijk niveau iets wat bedacht ja Oké maar hoe gaat het nu echt doen zij heeft die secretaris rol en ik spar weer met haar en soms” “Ik zit bij elke agendapunt van wat voor aandachtspunten zijn en wat in elk geval besloten moet worden is dan herhaal je dat nog eventjes maar dus in die zin heb je wel als bestuurssecretaris heb je wel veel informele macht of invloed als je het zou noemen Je kan dus ook helpen om een vervolgstap te creëren” “ik heb formeel geen zeggenschap over de thema's maar het ceb wel” A: “dus ze willen op zich dus wel iemand in het bestuur hebben die met een been in zo'n onderzoeksteam staat en met een been soort van in het bestuur” B: “Ja ja” A: “En hoe kan men daar dan goed mee dealen Dus hoe kan men het beste dan die cultuurverschillen overstijgen eigenlijk” B: “(…) Enerzijds om dat er dat	hierarchical structure. • Leaders also have a dual role when it comes to their focus. Namely, it should be both external and internal. However, this is difficult to find in just one person, making distributed leadership all the more important. • A leader for convergence needs to have good networking skills and dare to set up the new collaboration. Leaders needs to have guts. • Currently, leadership is rather reactive when it comes to external relations. This should become more proactive. • Leaders need to have experience and vigor. • In the pioneering phase, a leader with vision and who
kritisch te benoemen dus vanuit zet je zegt van Hey jongens Neem wel de tijd ervoor om dat te doen en ook dat te faciliteren (…) vanuit een onderzoeken als ondersteuner die een beetje zei van ja die EUR die zijn langzaam en daar hebben dus wel geïntervenieerd op bestuurlijk niveau dat we zeiden Hey Tuurlijk het moet snelheid hebben maar convergentie is belangrijkst (…) dus daar hebben we qua proces even wat scherp paaltjes gezet en heeft de bestuurder dus ook wetenschapper aangesproken van je doet het hartstikke goed maar convergentie is het uitgangspunt dat is dan even van bovenaf van onderaf is het is echt de wetenschappers die elkaar gaan vinden ja dan gaat er iets ontstaan en dat kan je natuurlijk faciliteren met support staff en daar hen in helpen en ook in activeren” “en dan is het dus ook als het een issue is die buiten hun eigen invloedssfeer is dan moeten wij eigenlijk gaan helpen kijken of we die hobbels weg kunnen nemen of in elk geval kunnen verzachten” “Ik denk dus leiderschap bij zo'n thema dat dat zo'n wisselwerking tussen soort wetenschappelijke directeur en meer secretaris operationeel ondersteuning dat dat een hele mooie mix is ik denk wel met een thema bij instelling dat het goed zou staan en wetenschapper ook als een soort boegbeeld staat en die zou dan eigenlijk het verhaal moeten doen En die	dared to be a little wild was needed. After that, a connector was needed with a more personal focus. • A leader figure has a great social network with strong ties which has proved useful in connecting people for the convergence efforts. These strong ties are based on good will and thus past experiences and trust. These ties not only safe time but also make people more willing to help you out. • What is needed from leadership changes as the project itself changes • A leader figure views themselves as a leader but also describes how leadership is distributed where their role is more content based and of someone else is

uitstraling en je moet een enorme veel steun een rechterhand die zelfs nog misschien nog wel meer is dan die rechterhand maar goed 10 juist die operationele en verbindings dingen regelt en doet en daar moet zo'n soort lekker heen en weer gaan beide en beiden hebben bepaalde leidersrol eendjes formele leider en de andere is een informele leider of heeft informele invloed dus ik denk dat zo'n tweemans of vrouw schap heel belangrijk is en dat ze elkaar dus ook aanvullen" A: "en als je dan hebt over operationeel bedoel je dan meer het opbouwen van sociale interacties dat soort dingen of bedoel je daar iets anders mee" B: "Enerzijds meer die secretaris rol dus dat je echt wilde ideeën die er zijn als je gaat kijken van hoe kan je daar dan ook echt handen en voeten aangeven maar ook strategisch meedenken met de iets andere met een iets andere blik strategisch van Hoe krijgen we mensen mee dus dat je het echt handen en voeten gaat geven zeker wetenschappelijke directeur die is al over the place die zo heel enthousiast heeft ideeën" "daarnaast moet je ook wel zorgen dat die dus zo'n wetenschapper dus niet los zinkt van van de thema's of de wetenschappelijke projecten die er zitten wetenschappelijke directeur zit of in het project en gaat dan teveel dat heb ik ook al gezien en dat zie ik vaker dat gewoon een valkuil dat is dan hun eigen onderwerp dat ze dat teveel als	to provide an overall vision. • Leadership in the context of convergence needs to believe in the holistic approach themselves, needs to be able to connect people so they can discover what is needed in a bottom-up way. • A connecting type of leadership where one has ambition, provides vision, and connects (to) people is an appropriate style. • A leader must be prestigious and be able to deal with different interests. • Leaders constantly have to deal with different view points and commitments to ideas. This takes up a lot of time and energy, especially since it all has to currently take place online. • Leader figure is very motivated, enjoys their role, and
voorbeeld nemen dus je moet wel wat tegengas (…) Dus er moet wel een bepaalde macht of invloed kunnen hebben en dat ook spuien zodat je het in evenwicht houdt" "Ja is wel een boegbeeld dit moet wel een wetenschapper met bepaald aanzien zijn op dat vlak en ook dat alle instellingen zich wel vertegenwoordigd voelen door die persoon of gehoord voelen door die persoon dus die persoon moet echt wel convergentie vaandel hebben" "In sommige gevallen kan het lastig zijn want mijn formele leidinggevende dus van de tudelft is dus de bestuurssecretaris dus dat kan best ingewikkeld zijn dus dan moet iemand hebben die daar niet die dat niet ingewikkeld vindt of daar die los van hiërarchie durf te opereren" "Dat is ook mensen zijn die extern gericht zijn heb ik misschien nog niet gezegd Maar je zou kunnen zeggen dat zo'n secretaris die moet ook intern het bij elkaar houden (…) maar dat is best ingewikkeld omdat als iemand aantrekt die daar gevoel heeft die misschien weer niet zo goed de interne dingen snapt dus daar moet dan wel stevige rechterhand of counterpart tegenaan staan" "dus echt zo'n netwerker maar ook echt ja vernieuwende soort samenwerking	believes the project is an important cause. • Leader figure views themselves as a leader • Being a leader consists mainly of having expertise in that specific field, but it also entails organizing for example meetings and having a facilitating role. • Leadership means having a vision and ambition, but also being able to inspire and engage followers. Not just the individuals, but also be able to take their qualities and valued into account in trying to find the best way to collaborate. • Leader figure is aware that any collaboration or project does not follow a linear trajectory. Therefore, being able to adjust to changing circumstances is an

durft op te zetten (…) We hebben wel mensen met wat lef nodig” “het is nu een beetje reactief moeten meer naar proactief in de externe relatie” “veel ervaring een beetje stevig dan kan je daarna weer vaak heb je in de pioniersfase daar zitten we natuurlijk nog gingen heb je iemand met veel visie en een beetje wild nodig en daarna heb je dan weer de verbinder of de meerpersoons persoonlijk omdat het dan soms net nog even wat kan schuren maar dat is hier natuurlijk in die zin wel ja je moet het is wel spannend omdat je nieuwe directeur bij elkaar moet brengen maar ik mis soms een beetje de pioniers Ik vind het soms iets te weinig pioniers dus het is wel een beetje lief” A: “Dus iets meer dat lef” B: “Ja het is nu nog wat lief mensen die echt knapper durven door te hakken” P2 heeft in alle drie de instellingen een goed netwerk. Dat helpt heel goed in een convergentie rol. P2 weet bij wie hij/zij moet aankloppen voor welk onderwerp. Dit scheelt veel tijd. Daarnaast zijn mensen erg bereid dingen voor je te doen wanneer je veel good will hebt opgebouwd. De rol van P2 gaat veranderen met de verandering van de fase van het project.	important skill for a leader to have. Additionally, leaders need to be able to communicate with a diversity of people. • It is important for leaders to show up with clear outcomes of a project. • • It is beneficial if a leader has experience in dealing with different interests so they are better able to put themselves in someone else’s shoes. I.e., leaders need to be empathetic. • Currently, there should be more people with a pioneering mindset and people who dare to be decisive. • For this project, there should be an interplay between two (or several) leaders of which one focuses more on content and the

“Ik werkte al samen met tudelft bij de afdeling IO met Richard Goossens dus ik had al best ervaring met communicatie tussen verschillende vakgebieden en verschillende expertises en ook persoonlijk heden en dat heeft mij denk ik ook heel erg geholpen en ik sta daar ook heel erg open voor” “en dan begint er een periode van Ja echte uitdaging omdat eigenlijk niemand precies wist hoe moet zo'n flagship hoe moet het eruit zien en hoe moet het functioneren” “de PIs die 8 die als die dan weer op die projecten zitten die kunnen dat dan ook beter aansturen” “En dan blijkt dus ook nog dat ik had het net over die communicatie tussen de postdocs moet ook de aansturing door de PIs van depot straks ook nog verschillend is om dat in sommige afdelingen is er veel meer en hiërarchische structuur en aansturing en bij andere weer veel meer wordt veel meer vrijheid gegeven Dus wat je merkt is Sommige post opzeggen Oh ja nee dat moet ik eerst aan mijn supervisor vragen en andere gaan gewoon aan de slag en dan moet de PI vragen van jou hoe gaat het nou eigenlijk Nou en daar moet je een balans in vinden”	other more on operational things. The first is a formal leader should have a high status and much expertise to be a sort of figurehead and emanate prestige. This person would need a strong right hand to support them, which would be the person that has a lot of informal power and is the connector with the community. This interplay and complementation is extremely important. You need someone with a vision and someone to make that vision concrete. Having multiple leaders provides multiple perspectives which is beneficial. So, there is diversity and interplay within the distributed leadership. • A leader should not be authoritarian or

"wat Ik Dan Altijd Deed bij de individuele projecten dat hebben nu ook gedaan is dat we hebben een management Team overleg geïntroduceerd" "het is wel belangrijk voor om structuur te geven dat mensen weten wie doet wat en wie is Waarvoor verantwoordelijk" "Bleek ook weer dat sommigen bij alles wat wij voorstelde en ze de vrijheid in gaven toch weer naar hun eigen PI gingen van ja mag ik dit wel doen en mag ik hier wat zoveel tijd aan besteden en dat soort dingen en dat is helemaal niet erg maar dat is wat je leert" "omdat het zo'n grote en diverse groep is moet je dat wel heel nauwkeurig aansturen dus je moet ze niet frustreren maar je mag wel wat van Ze verwachten" "nou waar je tegenaan loopt is überhaupt een gastvrijheidsovereenkomst dat is altijd nodig om te kunnen samenwerken naar dat blijkt dat die niet toepasbaar zijn op deze convergentie situatie Nou dan geef ik dat weer door aan de mensen van de convergentie Richard en dergelijke Nou zij zijn ermee bezig maar ja wij moeten ook door dus wij doen het ook naar dat zijn en zo kun je nog tig dingen noemen en dat is niet erg maar dat frustreert de posters wel want dan kunnen ze niet aan de gang dus daarom hebben we ook die position papers meteen naar voren	top-down and be unaware of what goes on in the community. • To enable learning to take place, leaders need to invest time and effort, be ambitious, have a vision, have vigour, and be able to inspire and persuade others of their vision. • Having multiple leaders is especially important to ensure that the expert leader does not lose sight of the overall goal and dives too deep into their own project or interest. There needs to be a balance. • It is beneficial if the expert leader has a lot of prestige and is respected by all institutions. People need to feel that this leader is a good representation of them and feel heard by them. • Leader figure has experience in

geschoven omdat we wisten ze willen allemaal heel graag met die data aan de slag" P2 ziet zichzelf als leider en beschrijft zijn/haar rol als zodanig dat de leidende rol hierin niet is om een visie neer te zetten (dit doet Richard Goosens die op 'hoger niveau' zit), maar om H&T inhoudelijk neer te zetten, het vorm te geven, en het te realiseren. Ervoor te zorgen dat er echt content en financiering voor komt. P2 geeft Richard ook leidend advies en stuurt en ondersteunt hem in het nemen van besluiten. Nodig van leiderschap: Iemand die gelooft in een holistische benadering. Verbinden. Dat is essentieel. Dus van bovenaf roepen dat het zus en zo moet en het werk en de community daarin niet meenemen gaat niet werken. Je moet verbinding met de community zoeken en bottom-up vanuit die community ophalen wat daar leeft. Dus of als programmadirecteur zelf of als support office (waar zij in zit) in verbinding staan met in dit geval de onderzoekers. Want zij moeten het gaan doen. Verbindend leiderschap waar je een visie en ambitie neerzet, maar goed de connectie houdt	working with people from different backgrounds and personalities. P3 also states they are very open to these differences. • A real challenge for leadership was the fact that it was very unclear how to structure the flagship or how it should function. • People that are part of a project group are better equipped to provide direction and guidance to that project. This suggests that leadership can be found at multiple places within the collaboration. I.e., leadership is distributed. • A balance needs to be found between letting people do their thing, checking in on them, and having them report to a leader (a PI in this case) or ask them for permission.

met het veld. Visie, ambitie, en verbinding. Je kan autoriteit uitstralen door het werk wat je al gerealiseerd hebt, door wat je hebt opgebouwd. Aanzien. Je moet goed om kunnen gaan met verschillende belangen. Er spelen er veel door elkaar heen. Niet alleen onderzoekers, maar ook bedrijfsleven of gemeentes of provincies, om hen ook als partner te betrekken. “en dan zeg je nee we gaan het toch op deze manier doen maar je moet ze wel de vrijheid geven” B: “ik heb wel gemerkt dat het wel heel belangrijk is omdat je ze toch moet aansturen want anders dan zijn het zijn ze aan het overleggen met een open eind Dus er moet wel een senior bij zijn” A: “en dat aansturen is dat dan dus vooral om en zijn doel te geven of een visite geven of wat Wat zit er dan specifiek in die aansturing” B: “nou vooral toe te werken naar het definiëren van deliverables milestones een tijdslijn” “Het is niet dat je daar [het niet maken van een tijdslijn] op afgerekend wordt maar het is om een structuur te geven aan het proces van het schrijven van het analyseren Ja en dan merk je ook dat dat weer anders wordt opgevat dus het is constant dat je tenminste Ik vind constant Het kost heel veel energie vooral ook omdat het Teams is”	• Introducing team meetings from formal leaders helps set up structure and start up communication. • It is important for people to know who is responsible for what, to provide structure. • • There are several leader roles and these roles differ. For example, one role is more on the governance level, another can be more of a secretary or administrative role. The leaders discuss and consult with each other. So, there is distributed leadership and leaders discuss among each other. • The are formal and informal leaders • It is sought after in some leader roles to have people with a dual role or perspective where they have one foot in a research team and the other in the board • To counteract cultural different, leaders have to critically address those differences, take the time to do so and facilitate discussions about the differences. They also need to remind people of the overall goal of convergence and make this explicit and clear in the process. This is done more top-down. Bottom-up leaders can facilitate and support team members and activate and engage them to meet each other. • The teams are pretty autonomous, but if an issue arises that is outside of their sphere of influence leadership needs to step in to try and find a solution or at least diminish the issue.
“Ik doe het omdat ik het gewoon om ontzettend belangrijk en leuk vind” A: “zou jij jezelf als leider omschrijven binnen Digital Twin” B: “Ja” A: “oké en wat betekent het voor jou om een leider te zijn van Digital Twin” B: “het betekent dat ik ben vooral inhoudelijk een leider dat wil ik ook zijn dat is wel een hele goede vraag ik wil altijd graag inhoudelijk leider zijn maar ik moet je eerlijk zeggen al dat voorzitter van al die meetings en het organiseren etcetera dat heb ik wel gehad. Maar dat hoort ook bij leiderschap maar ondersteunen ik daarin daarbij dat zou gewoon heel fijn zijn want dan kun je weer veel meer de inhoud in en leiderschap betekent gewoon dat je visie hebt en dat je een ambitie hebt en dat je die wil gaan bereiken maar ook iedereen daarin mee moet nemen en dus de En ieder op zijn eigen kwaliteiten en waarden daarin mee moeten nemen maar ook moet leren hoe ze bij dat doen we kunnen komen op de beste meneer in die omgeving in samenwerking met anderen. En dat dat niet is dat Dat zeg ik ook constant ze denken allemaal dat het rechte lijnen zijn maar dat is helemaal niet onderzoek is is dat niet Je kunt niet precies voorspellen hoe zo'n traject loopt en dat loopt altijd anders en dat loopt altijd anders ja en dat is de lol vind ik de lol van onderzoek doen en ook van deze functie en leiderschap betekent ook dat je ontmoet kunnen gaan met mensen	

van verschillende met verschillende achtergronden en mensen zijn sowieso verschillend" "vind ik dit dus de implementatie dit is uiteindelijk laten zien dat je met al het geld al die kennis al die mensen dat je ook echt iets gaat bereiken" Als leider helpt het om ervaring te hebben opgedaan in zo'n speelveld. Je gaat je meer verplaatsen in anderen, wat willen zij. Ervaring + kunnen verplaatsen in. Breed blikveld. Wat je niet moet doen als leider is autoritair zijn en dingen van bovenaf opleggen, zonder het besef van wat er speelt in de community. Dat werkt voor de wetenschap niet. "Maar leiderschap doe je dus ook met anderen dus het is niet Dat wil ik wel heel expliciet zeggen je hebt leiders nodig maar leiders en leiderschap betekent wel heel veel dat je dat je toch wel heel veel zelf moet doen maar je moet niet uit het oog verliezen en openstaan dat je dat wel met andere doet ook met andere leiders en dat is wat ik en nou ja dat is ook omdat ik natuurlijk wat langer mee draai heel erg zien dat heel veel leiders doen het alleen maar voor hem zelf en niet om uiteindelijk bijdrage te leveren met zijn allen Dus dan gaat het vaak om de persoon er niet om de inhoud en mij gaat het echt om de inhoud"	• It is clear that there are several leader roles within the Digital Twin project: there are the 'trekkers' and there are the PIs. However, sometimes these different leaders would not be on the same page when it came to the freedom postdocs could get. So, coordination between leaders (of different levels) is needed to make it clear to the team members what to expect. • The group is diverse, which necessitates more precise leadership and direction. However, a balance needs to be found between intervening and letting them loose. As a leader you do not want to frustrate the team members but you should also be able to expect

"Ik heb altijd al wel multidisciplinair samengewerkt" Rol van leiderschap m.b.t. leren: dit echt realiseren, dat vraagt best wel wat. Het is iets anders dan gezamenlijk onderzoek doen. Veranderingen op het niveau van HR, behoud van je talent, mogelijkheden voor financiering om personeel langer of vaste aanstellingen te geven. Ambitie en visie zijn nodig. Je hebt ook echt daadkracht nodig richting de colleges van besturen. Decanen hierin meekrijgen. Zij zijn degenen die uiteindelijk die de bovengenoemde veranderingen kunnen realiseren. Krachtig kunnen zijn. "Het is ook een soort leiderschap wat bij jou past natuurlijk en iedereen doet dat op mijn eigen manier wat ik zelf heel belangrijk vind is wel om te proberen eigenlijk mensen in je team uiteindelijk een eigen verantwoordelijkheid eigenlijk betrokkenheid en daarmee ook een eigen verantwoordelijkheid Voor het project onderdeel te laten nemen en dat betekent ook dat je als leider niet alleen maar op de inhoud moet gaan zitten" "Ja en wat zachter probeert bij te sturen zeg maar ja is dat vind ik wel belangrijk dus eigenlijk het opwekken van engagement van betrokkenheid van projectmedewerkers en daarmee ook	something from them. • Leaders should be able to inspire engagement and involvement in their team members, which in turn inspire responsibility. Leaders should sometimes slightly adjust if needed. • To inspire responsibility and engagement, a leader should first get to know the team members and what their goals are. Then a leader can see how those goals fit with the overall goal and what 'free space' can be offered to the team members. In enabling this free space, or in other words giving them autonomy, it is important for leaders to keep the overall goal in the forefront to ensure that what people are doing contributes to the overall goal. So, a

een verantwoordelijkheid geven in het project en dat is bij phds wat makkelijker dan bij postdocs omdat phders is ook een eigen belang hebben die moeten nog een proefschrift afleveren terwijl postdocs die hebben Ja die hebben gewoon een contract afloopt is dat is altijd lastiger vind ik postdocs managen” A: “En hoe ga je daar dan mee om of hoe probeer je dat die verantwoordelijkheid die betrokkenheid te stimuleren” B: “nou door ze ja en dan moet je eigenlijk eerst iemand goed leren kennen en kijken van wat wil je nou eigenlijk want wat is zijn manier van werken wat deze manier van onderzoek doen Welke vragen wil hij oplossen want er zijn altijd project vragen die mensen op willen lossen Maar die niet altijd passen in een wat groter geheel van de eigen wetenschappelijke interesse (…)en vervolgens te kijken van Hoe kunnen we nou ruimte bieden zodat het gewoon heel goed past in jouw project ook naar de toekomst toe en dan gaat het wel met afwisselen van hoe zeg je dat het aftasten van Waar zit je de ruimte en wat super belangrijk is daarbij is om de onderzoeksvraag van het project wel heel erg helder te hebben en te houden en dat ook wel en wel op de voorgrond te houden maar die moet dan wel wat een belangrijk is is dat hij dat je daar ook de ruimte inziet dus ja het is gewoon een hele heldere definitie van de onderzoeksvraag van het project dat je die voor ogen hebt. En dat je daarin ook	long-term vision of the overall goal needs to be kept in mind. • However, instead of actually calling it an overall goal but more the overall research question. Goals namely often change due to changing circumstances and new insights, but the overall research question often remains constant. • Having this distributed leadership enables P4 to experiment more and thus learn more. They each have different and complementing roles, which works very well together. • As a leader you need to be able to adapt to the changing and uncertain circumstances. In this project specifically, data was needed to continue work but
weet van er zoveel ruimte en als jij wil focussen op een financiële beloning in plaats van op sociale beloningen dan kan dat zolang het maar past in het bijvoorbeeld de onderzoeksvraag naar lange termijn motivatie” A: “Oké dus dus dan is het het eind doel inzicht houden maar wel” B: “Nou het is niet zozeer het doe maar meer onderzoeksvragen daar is wel verschil want een doel dat kan variëren dat weet je nooit precies maar het is vooral de onderzoeksvraag dat die dat je het onderzoekt doet wat de hele tijd onder die onderzoeksvraag geschaard kan worden want die Doelen naar die veranderen soms is dat eigenlijk altijd wel Doelen in het begin van de projecten die een klein beetje ambitieus zijn en die haal je misschien niet door een te hoge ambitie maar ook door inzichten tijdens het werk dan verandert ook je Doe een klein beetje maar de onderzoeksvraag die blijft meestal wel heel lang constant” A: “wordt het ook op een manier begeleider zegt over de dialogen gehad is dat door een bepaald persoon ingezet of op wat voor manier zijn die dialogen vormgegeven Of is iemand die dat heeft geleid” B: “niet voor zover ik weet het is meer een beetje organisch gegroeid aanvankelijk een paar ideeën een paar partijen die bij elkaar zijn gaan zitten (…) ik heb niet echt het idee dat daar en heel veel sturing op heeft plaatsgevonden”	none was yet available. However, people needed to have some work and so P3 came up with an idea to put them to useful work without the data. • To ensure that meetings are fruitful and contain concrete deliverables and milestones, a leader or at least a senior is needed to guide the meetings. • Leadership is not a solo activity: even though much of leadership relies on you yourself as a leader, but a leader is never alone in their leadership. They have followers and there are other leaders to exchange ideas with. A leader needs to be open to others. Leaders should not be in it just for themselves but also be aware of the greater value for others.

“Ik denk het is in zijn algemeenheid dat je wetenschappers moet laten gaan en ze zullen de dwarsverbanden wel vinden die voor hen interessant zijn en als je dat te zeggen gaat sturen dan mijn zorg dan een klein beetje toch dat je dan moet ik dat zeggen een gedwongen huwelijk wordt zelden een goed huwelijk Ik geloof niet dat ik denk dat je mensen zou moeten proberen te enthousiasmeren voor de ideeën dat mensen het eens kunnen worden over bepaalde principes en dan denk ik Ik heb wel het gevoel dat je dan best wel een klein beetje kan laten gaan” “ik denk wat ook wel ontzettend belangrijk is is dat je misschien ook een aantal afspraken maakt over (…) een aantal principes waaronder je wilt werken” A: “is er ook eventueel een soort supervisor of een leidend persoon of een leider hierin die hier een rol in heeft ofzo moeten hebben naar jouw mening” B: “Ja ik ben niet Ja ik denk dat het handig zou zijn als maar dat proces loopt al over en weer wat beter begrip hebben van wat er speelt” “Ja en overal leider denk ik zo heel vervelend zijn want dan loop je het risico van gedwongen huwelijken en zo en zo zitten wetenschappers niet in elkaar wetenschappers moet je aanspreken op hun interesse en hun verantwoordelijkheid dan werkt het als	• Leader figure has much experience in working in multidisciplinary contexts • Leader figure sees themselves as a leader and also experiences that others see them as a leader, because the team members listen to leader figure’s feedback and implement it and also come to P4 for advice and if they have questions. • Leader figure has much experience in being a project leader as well as being a leader for diverse teams from both academic and non-academic fields. • Digital Twin felt a little like sink or swim in the beginning, because it was very vague and no one knew what to do. • Shared goals are a way to build bridges between disciplines
je zegt van gij zult samenwerken en ik kan je dan beloven dan gaan de hakken in het zand” “een soort informeel circuit Misschien zou je dat informele circuit wat kunnen ondersteunen met dat algemene met een soort bibliotheek van Wat doet iedereen dat zou misschien wel handig zijn” “Digital twin Ja daar heb je een Tweetal leiders eentje uit de tudelft en eentje uit Erasmus maar zijn toch twee groepen PIs die gezamenlijk acteert ik heb niet het idee dat daar echt een Nee het is meer een collectief dan dat er echt iemand boven komt drijven en zegt van wij gaan het zo doen ofzo” “maar dat gaat toch allemaal vrij naja informeel doe ik het tekort want is wel degelijk formeel wordt ook regelmatig vergaderd” “Ja dat vind ik wel leuk om te leren en ook belangrijk om te weten ik gebruik het een klein beetje als een test punt van Hoe ga ik er nou mee om voor mezelf zeg maar in de andere projecten en dan vind ik het juist wel heel erg fijn omdat ik het samen met Regina doe want anders zou het mij veel te veel tijd kosten dan zou ik het misschien niet waard vinden om te doen want ik verder ook wel leuk vind is de rolverdeling bij ons zelf [other lead] die zit er veel inhoudelijk erin dan Ik wil het gewoon toepassen (…) heel prettig dat	and fill the space between them. • There are multiple formal leaders in Digital Twin, but the whole is more seen as a collective workforce in which not one person is in complete charge. It could therefore be said that Digital Twin has distributed leadership that is both formal and informal and is non-hierarchical. • A leader of scientists should be accepted by those scientists, which mostly happens based on their expertise and status. Only when the scientists accept to follow the leader, can the leader be an actual leader. So, followership is important. • A leader should not intervene too much. I.e., scientists should get a lot of autonomy from their leaders.

[other lead] eigenlijk inhoudelijk betrokken is en ik kan een beetje dingen uitproberen over projectmanagement en interdisciplinaire samenwerking en een klein beetje over data" "Ik vind wel met Digital twin je werd ook een klein beetje in het diepe gegooid eigenlijk was het vind ik het project een beetje groot moet ik zeggen Ik was als katalysator liever begonnen met de helft van alle medewerkers omdat ik denk dat je dan iets minder tijd kwijt bent aan het projectmanagement en aan elkaar leren kennen en iets meer tijd kan steken in het ontdekken van nieuwe richtingen" "ik snap ik wel de bedoelingen de snelheid van de convergence maar het zorgt ook wel eigenlijk die grote die zorgt ook wel voor een iets vertragend effect voordat je erachter bent van wat je nou met elkaar kunt doen ja dus dat is is dat heeft ook echt wel tijd gekost dan zijn we nu pas zo'n beetje achter en nu is het alweer bijna een jaar verder" "Ja ik heb ook zelf nog nooit een project gehad met zoveel postdocs want ik vind ook sowieso een gezeik om ze te managen omdat ze korte termijn traject hebben en het valt altijd in een moment van hun leven dat ze veel bezig zijn met andere dingen met een gezin of met hun huis als je je ergens wil vestigingen bepaald gebied en inhoudelijk"	• As a leader, leader figure tries to help people get out of their comfort zone and expand their boundaries to learn more. However, to be able to get people to cross that line a leader needs to be able to build trust, show them the added value of expanding their boundaries, and allowing for failure. Furthermore, doing it with others makes it easier to cross boundaries. • Leader figure believes it would be beneficial for collaboration if there was someone who would invest time in everyone individually, to see how they are doing, and to check whether what they are doing it still in line with the overall goal. • Leadership is distributed in this project.
A: "en hoe probeert men dat dan dus hoe probeert men die brug tussen of die ruimte op te vullen" B: "Nou dat doen we dus heel sterk door die gemeenschappelijke Doelen" "waar ik wel veel van geleerd heb is het management zelf dus eigenlijk in nou Ja vooral te vragen van wat kom je nou brengen en wat kom je halen en ik vind het altijd leuke vragen om te stellen maar om die op elke niveau te stellen binnen zo'n project" A: "zie jij jezelf als een leider binnen Digital Twin" B: "ja dat hangt er een beetje van af hoe je leiders noemt bel als iemand die probeert om het project tot een geheel te brengen Dat is eigenlijk mijn voornaamste taak en dat is ook een taak die altijd bij leiders paste lijkt mij dus in die zin wel" A: "Heb je het idee dat anderen ook zo naar jou kijken dat ze jou in ieder geval benaderen als een van de leiders van" B: "Ja" A: "en op wat voor manier merk je dat" B: "aan de ene kant hoe Er wordt omgegaan met feedback die ik geef Dus dat ik dus dat het niet alleen serieus wordt overwogen maar vaak wordt overgenomen en aan de andere kant Ja Ook als het gaat over eigenlijk beslissingen die niet alleen op individueel niveau zich voordoen maar op collectieve niveau dat mensen dan ook altijd vragen aan mij om advies daarin"	• A challenge for leadership is ensuring that what comes out of the project is relevant for all parties involved, so aligning interests and formulating shared goals. • A leader of this project, according to leader figure, is supposed to ensure that people not only focus on their own interests but also keep the overall goal in mind. Leaders should facilitate the formulation of shared goals, and ensure that people regularly think and talk about added values of themselves and others. This can be done concretely by (1) giving a presentation wherein every work package was asked to express their added value, individual interests,

“Ja ik heb dat wel vaker ik ben projectleider al heel lang in verschillende projecten sinds 2012 denk ik dat ik mijn eerste grote interdisciplinaire project met ook meerdere Team Partners had dus ik ben net wel gewend Meestal ben ik projectleider in mijn eentje Dus voor het eerst dat we met zijn tweeën doen” “ook in het project waar ik in zit ben ik het heel erg gewend om samen te werken met mensen van heel veel verschillende disciplines dus zowel wetenschappelijke disciplines als buiten wetenschappelijke sectoren” “De Uitdaging is wel wat ik eerder al zei ik vind de uitdaging vooral er iets uit te halen Wat voor iedereen relevant is dus dat je een samenwerking maakt die waarbij je iedereen overeenstemming heeft over de Doelen in het begin Maar ook dat de uitkomst breed gedragen worden en niet voor een groep interessant maar voor meerdere groepen interessant en dan zou ik het liefst een uitkomst hebben in plaats van allemaal uitkomsten samen maar dat weet ik niet of dat haalbaar is” A: “Oké en wil nu je dat zo schetst dat dat [TUD en EMC beter laten samenwerken] dus het doel is van Digital Twin Hoe zie jij jouw rol daarin als leider” B: “nou om juist te zorgen dat mensen niet op een eigen interesses blijven maar samen dingen gaan doen dus een beetje naar	and expectations, (2) formulating shared goals and make contributions of everyone to those shared goals and the overall goal clear, and (3) writing a position papers together so people have to make their ideas, intentions, and contributions more concrete and discuss it between themselves • P4 believes that a general leader would work well, so someone who is less focused on content and more on keeping track of everything and people’s contributions. Leader figure believes that it would be beneficial for leaders to have a little more distance from the team to make it easier to see whether what people are doing is still contributing to the overall goal.
elkaar toe trekken en ook dus Samen nieuwe stappen eigenlijk de onderzoeksdoelen formuleren die ze niet in hun eentje kunnen formuleren en ook om na te denken de hele tijd over wat zij aan een ander hebben en wat zij kunnen bijdragen dus echt wel het het samenbrengen” A: “Ja en hoe probeer je dat concreet te doen door middel waarvan probeer je dat te doen” B: “concreet Wij hebben laatst een presentatie gehouden die kan ik je volgens mij hebben jullie die al 2 weken geleden en toen had ik aan iedereen gevraagd ook om inderdaad We hebben vier work packages in Digital twin om aan iedere work package heb ik gevraagd wat Breng jij nou naar de andere woordkaartjes toe en wat haal je uit het hele project voor jezelf en wat is het doel van jou individuele project dus dat waren wel vragen die expliciet naar samenwerking toen eigenlijk jouw rol in het grotere geheel maar ja en dat is dan weer geformuleerd dus dat is prettig en dat is één stap. Verder hebben we een half jaar geleden geprobeerd met het hele clubje gemeenschappelijke Doelen op te stellen en dat was de eerste stap dus jouw rol ten opzichte van de algehele doel en dat een beetje bijstellen en een derde concreter activiteit is het schrijven van een gemeenschappelijk position paper waarin eigenlijk alle mogelijkheden van een Digital Twin dus dan heb je het over de potentie beschrijven vanuit iedere discipline en Samenvoegen in een paper dus dan zie je	Being more focused on content it thought to make it harder to take a step back and look at the greater picture. • Leaders should have a dual role of on the one hand being knowledgeable on the content and on the other hand keeping the overview and overall goal in mind. However, P4 believes that this overarching role is more important for this project specifically. • Leadership differs per person and per context. Despite that, leader figure believes that it is important for a leader to give autonomy to their team members to increase their responsibility and engagement. • When it comes to stimulating dialogue, leadership is not thought to

ook heel erg duidelijk van het kiezen Welke sowieso Welke onderwerpen jij dan ziet als relevant binnen jouw expertise maar ook Uiteindelijk hoe dat in die paper terecht komt in de structuur als geheel dus je schrijft met zijn allen maar het is 1 tekst." "Nou ja eerlijk gezegd denk ik dat binnen Digital twin eigenlijk gaat om een Een groep mensen wetenschappers dat je voor deze om die goed te kunnen leiden zou ik dit geval ook wel een wat meer algemene manager Die zou volgens mij wel heel goed werk kunnen doen dus en wat minder inhoudelijk betrokken maar echt kijken naar het overzicht moet wel goed weten van wat kan nou iedereen bijdrage maar dat kan je ook gewoon aan mensen vragen en dan vertellen ze dat en dat moet je wel snappen maar goed dat kunnen de meeste mensen wel" "Dat is bij de Digital twin heb ik het idee dat het iets Belangrijker is dat die leiders juist een klein beetje afstand nemen om te zorgen dat al die mensen die ogenschijnlijke allemaal met hetzelfde bezig zijn dat ook concreet doen dat is misschien ook op die manier en dat kan je veel beter doen wanneer je een klein beetje afstand hebt van de inhoud dan wanneer je zelf ook een rol hebt in de inhoud" A: "Ja oké dus een beetje de dubbele rol van Enerzijds dus inhoudelijk er wat van	have been strong or present. It happened more organically. • P6 generally believes that scientists need to be let free and autonomous to figure out the necessary links for themselves. Strong leadership that tries to force something on them would not work. A leader of scientists should enthuse people for the vision or a general idea, facilitate a common understanding, and then rely on the autonomy of the scientists. • Leaders should also ensure there are agreements or principles on which the collaboration is based. • Leaders should play a part in facilitating dialogue to get to know what others are doing, but this is
af weten maar anderzijds dus ook meer overkoepelend kunnen bekijken dus het grote geheel en in detail" B: "Ja en dat overkoepelende dat is hier wel belangrijker denk ik dan bij andere projecten" "Ja de grens van wanneer het wanneer er vertrouwensbreuk optreedt die is best wel vloeibaar en die is vlak vloeibaarder dan je denkt daar heb je eigenlijk wel ruimte in een watje kan verschuiven en wat ik heel sterk merk als projectleider is dat ook de projectmedewerkers Dat is niet altijd weten we gaan vaak een beetje soms heel erg ijverig om die grenzen op te zoeken en ja wat ik altijd probeer te doen is juist mensen over de grens heen te laten gaan (…) Er is altijd gewoon meer mogelijk ook binnen zo'n onderzoek vraagt zijn diverse in het begin en weet je dat nog niet zo goed waar die liggen je worden steeds concreter En vervolgens als concreet zijn kan je ze steeds een beetje gaan verschuiven en dat is wel heel prettig om dat samen met mensen te doen en dan moet je ook zomaar met iemand doen want als jij dat doet als enige als projectleider en die andere durft dat niet of die daar het nut niet van in dan kom je dan maak je niet juist die essentiële of die vernieuwde stap dus in die zin is dat dus een soort van wederzijds vertrouwen eigenlijk het verleggen van de grens"	currently already being done. • An overall leader is thought by P6 to not be beneficial for an academic environment as it would intervene and force the scientists too much. Leaders should appeal scientists to their interests and responsibility • It might be helpful from leadership to provide an overview of what everyone is doing to make it easier to know who to reach out to and support the formation of informal links. • Formal leadership organized meetings • Leadership can help develop a common understanding by providing opportunities for open discussion such as seminars or meetings where differences in perceptions and assumptions are

“maar de 3e PIs dus mij Samantha en Maartje organiseren ook allerlei workshops voor de anderen voor alle postdocs een programma en alle PIs om ethische onderwerpen te kunnen bespreken dus Enerzijds verzorger wij lezingen vanuit de ethiek maar anderzijds zijn ook vaak brainstormsessies waar er medisch technische postdocs punten kunnen aangeven waarvan ze zelf denken dat er ethische uitdagingen zouden kunnen liggen” “de mensen die het grote geheel organiseren doe dat echt op een hele fijne manier geeft ook iedereen de ruimte” “Ik denk ik denk dat het belangrijk is mensen die inderdaad die pioniersgeest hebben Dus die minder gehecht zijn aan Ja maar zo doen we dat in mijn vakgebied en in mijn vakgebied wil ik een van de beste worden en dan ja moet het zo puur mogelijk binnen mijn eigen vakgebied blijven zijn vakgebieden waar dat ja waar je aan dat carreer Suicide gaat als je het niet op die manier conformeert zeg maar dus is belangrijk ook dat het mensen zijn die of überhaupt niet in een vakgebied werken waar dat soort strikte normen gelden of die zich daar niks van aantrekken en zeggen van Nou ik steek mijn nek hier uit en ik ga voor de toekomst zeg maar dat is heel erg belangrijk Rondom de perikelen mogelijke perikelen die Ik noemde is het	concretely addressed. As of now, only the ethics department seems to be taking up efforts in that respect. • There is a clear formal leader of the Digital Twin flagship. • There seems to not be much leadership concerning an overall goal. • Leadership should provide perspective, an overall goal, vision, and be able to connect people from that vision to form a shared goal. Leaders should facilitate processes to enable people to connect and formulate a shared goal. Furthermore, they should keep oversight and check in once in a while and intervene if necessary. • There is leadership on different levels of convergence. There is a formal
denk ik heel erg belangrijk dat je mensen hebt in leiderschapsrollen die open-minded zijn die zich ook bewust zijn ervan dat er dit soort significante verschillen tussen vakgebieden zijn Ik merk regelmatig dat niet iedereen ook in een hoge positie en dan heb ik het niet over convergence specifiek maar in het algemeen dat je soms ook mensen die zijn zich helemaal niet te realiseren dat dit zo anders gaat in een ander vakgebied” “ik denk dat het heel belangrijk is en het gaat natuurlijk voor alle Academic leaders dat je een veilige inclusieve diverse werkomgeving hebt waarin diversiteit Welke verschillende manieren van onderzoek doen verschillende typen persoonlijkheden universiteit kwijt demografische achtergrond enzo Nou ja dat is natuurlijk altijd belangrijk” B: “wat mij goed lijkt is iemand die (…) met iedereen een praatje maakt van hoe gaat het en ook misschien meteen dat de gemeenschappelijke belangen ook duidelijk maakt en dat proberen wij een klein beetje te doen met die meetings maar die zijn altijd in grote groepen dus nooit individueel en individueel heb ik daar niet de ruimte voor en [other lead] ook niet dus iemand die dat zou doen Dat lijkt mij heel erg dat lijkt me erg leuk” A: “dus iets maar dat persoonlijke en weer even een beetje een iteratie van Waar zijn we ook weer mee bezig daar doen we het ook alweer voor en zitten nog op de	‘top’ leader and there is a formal leader of the Digital Twin flagship specifically with a co-leader. So, there are different levels of leadership, it is formal and informal, and leadership is distributed. • Leadership has provided an abstract vision and idea of collaboration but has not been concrete in how to do this. It is sometimes unclear who is leader of what and what the goals are. • A very strict, hierarchical, and top-down approach from leadership will not work in this context. Scientists are too stubborn for that and/or want to be mostly autonomous. However, a leader should also not be too distant. So, a balance needs to be

juiste lijn" B: "Ja dus iemand die individueel eigenlijk langs alle deelnemers gaat om het project Ja dat lijkt me super goed voor erbij en hoe dat heet dat weet ik niet maar dat lijkt me wel heel leuk en heel nuttig" "Ik denk in zijn algemeenheid dat als je wetenschappers bij elkaar zet dan moet de leider moet op basis van kennis geaccepteerd worden als leider door zijn collega's (…) dus het is heel moeilijk om minder wetenschap traject echte leider te zijn je krijgt die rol of je krijgt het niet en als je daar te hard doorheen fietst als je zegt van ja maar wacht even kijken in deze manier van werken zou in het bedrijfsleven natuurlijk voltrekt onacceptabel zijn dat gaat niet werken (…) als je in wetenschappelijk metier leiding geeft aan een bepaalde activiteit dan dan moet je in het leidinggeven laten zien dat je inhoudelijk ook weet waar je het over hebt kan je kan je kan heel goed leidinggeven in andere organisaties puur op procedurele aspecten rondleiding geven is vaak soms op inhoud soms op procedures dus je kan procedure zijn ook belangrijk maar in de wetenschap wordt voor het leiderschap eigenlijk altijd afgerekend op deskundigheid (…) Ja dat leiderschap krijg je" "dan moet je denk ik niet want teveel in in willen interveniëren want dat dat gaat vaak niet goed dus"	found between autonomy and providing direction. • It is up to leaders to ensure the organization and facilitation of opportunities for learning. • Leadership needs to provide a vision for where they want to go, invest time and energy, emit their commitment, and explicitly mention their expectations from others. • There is distributed leadership. The leaders of the ethical part of the projects organize both lectures and brainstorm session of which the latter enables the postdocs to share their thoughts and issues. • Leadership gives people space • Leaders for transdisciplinary contexts need to have pioneering mindset, be able

"dus daar zijn van bovenaf een aantal meetings georganiseerd werkgroepen en dat soort dingen" "wat we ook wel in het Digital twin proberen Is dat wij met de postdocs zulke soort seminars (…) lezingen waar je probeert Ja ook gewoon iets uit te leggen over je eigen waar je dan in eerste instantie Probeer deze uit te leggen van Ja dit is wat ons betreft ethiek (…) Als je kan beginnen met een soort dialoog van Kennen jullie deze problemen of hebben jullie heel andere problemen is het die zin hebben nou een serie van een aantal bijeenkomsten gepland daar geweest en nou ja doe maar gewoon concreet over dingen te gaan praten en uitleg te geven hoop dat je daar gaandeweg wat meer van die komen language gaat ontwikkelen" "vanuit de ethiek Project eigenlijk lange tijd de enige geweest die dit een beetje probeerde te stimuleren" "Ik geloof dat [other lead] Steegers wel een van de flagship leiders is Ik moet eerlijk zeggen dat ik ook niet meer precies weet wie dan de andere Met hoevelen zodat zijn wie dat verder nog zijn is ook omdat ik haar vanuit andere projecten ken Dat zij dan inderdaad wel die bijeenkomsten organiseert en zorg dat mensen samen dingen gaan doen	and dare to look outside their own domain, focus on the future and the great good, and are open-minded for and aware of differences between disciplines. • Leaders need to provide a safe, inclusive, and diverse environment where diverse work forms are practiced and valued.

maar heel veel zicht heb ik daar niet op eerlijk gezegd” B: “Nou ja ik bedoel er is gewoon niet zo heel veel naar mijn ervaring of beleving niet heel veel sturingen niet heel veel Ja leiding waarvan je echt het gevoel krijgt dan Oké we gaan met elkaar wel ergens heen” A: “Ja want dat is dus wat leiderschap voor jou betekent dus die” B: “ik vind dat wel soort van ja soorten perspectief een soort route en een soort mensen samenbrengen met het vanuit een idee Dit is Waarvoor staan of dit waar we heen willen of dit is het gezamenlijke doel en hoe gaan we dat doen” A: “zijn er nog andere elementen van een leider die je graag zou willen zien binnen de convergence agenda” B: “Ja ik ik vind dat denk ik wel het belangrijkste en verder het faciliteren van dat soort processen maar dat heeft ook met een visie te maken op die processen en nou ja en meer proces in de gaten houden hè meer vinger aan de pols idee bijsturen ingrijpen waar nodig” “volgens mij is Richard Goossens is een soort Ik weet niet precies hoe dat heet maar hij is iets Hij is de baas Dus voor mij zou dat dan is het Richard denk ik het meet het aanspreekpunt Wat mij betreft en binnen de Digital twin zal ik [other lead] als leider zien maar die is vast nog wel iemand vanuit tudelft die daar Co	

leider is dat is dan weer dat je mensen ook al kent” “Ik denk af en toe wel soms wel erg hoog over en erg abstracte erg algemeen en van jongens Ja we gaan leuk allemaal samen werken als divisie maar hoe en wat dan precies vind ik dan weer wat minder Helder” “totaal hiërarchisch We gaan jou vertellen hoe je moet doen dat werkt gewoon niet en is ook niet productief uiteindelijk niet efficiënt en niet los van dat het niet werkt mensen moet zich zo over het algemeen niet laten aansturen of zijn ze veel te eigenwijs voor (…) tegelijkertijd ook het te vragen zijn of teveel open laten zeker naar jongere mensen toe die samen moeten werken met mensen waar ze helemaal niet van weten hoe en wat is teveel afwezigheid of te hoog over of te teveel loslaten en zeggen van door jullie het naar en is denk ik ook niet goed” “wat ik via via wel mee krijg is dat ik soms wel chaotisch overkomen dus ik denk soms wel van ja nou soms inderdaad wel die heeft nou de leiding over wat Wat is nou eigenlijk het doel Wat is nou eigenlijk Ja de vraag of het eindproduct waar naartoe gewerkt wordt” “Maar ik denk dat het aan de leiding van deze project is om dit soort dingen te interneren je hoeft het niet helemaal zelf te organiseren maar je moet er wel voor	

zorgen dat iemand het organiseert Welk wel op manier dat er ook wel echt een beetje nagedacht wordt over Wat werkt Wat wil je ermee en wat werk te doen dus daar nog een beetje een visie op hebben want Waar wil je heen waar wil je naartoe hoeveel tijd en energie wil je erin insteken hoe belangrijk vind je het dat kun je ook uitstralen (…) tegen mensen moeten zeggen we verwachten ook van jou dat je hier ook tijd in investeert”	
B: “Everybody knows that I'm chairman of postdoc meetings. Usually, everything comes to me first. If anybody wants to do something, or any question from anybody, I mean, also from PI’s or some, from the administrators in the in the team, come back to me first. Okay, what we are going to do is going to do that one is, yeah, but what I'm trying is that you distribute their responsibilities to not doing all the things by myself. Okay. And that's what I'm trying to do.” A: “And how does it feel to be in such a position? Do you do you enjoy it? Or would you rather have a different position?” B: “No, actually, I have I have been doing this also during my PhD, even there. Yeah, I was leading the project, because you are usually in your PhD, you are you're leading the project. So I was involved with reporting with a different group of pupils. So I'm enjoying to do this.” “So usually when you want to distribute tasks, so it could be relevant to all of the other people. So that could be a challenging, who would like to, for example, take that responsibility to do the task” “I mean, there are some also administrative activities in this in this job is different from a normal PhD project, first of all, is a postdoc project and also, there is also a bigger picture, this is this project. I mean, this flagship is just one part of the whole programme.” “And you mentioned that there are some challenges when it comes to being in the role that you're currently in. Such as it takes time, and you have to convince people, so, how do you overcome those challenges that you face? B: Yeah, usually, I try to have a separate meeting with people and talk with them about for example, if there is a problem or what you can do, what's your suggestion? And, yeah, if there was anything, but yeah, so far we I have done this.” A: “And you mentioned that [other lead], Eric and Valentine are basically leaders of of my digital twin. Can you describe some some actions from them that made you feel like they were leaders.” B: “Eric suggested to start this post sec meetings	• Leaders should create better incentives and/or build stronger recognition for people partaking in inter- and transdisciplinary collaborations. • To help stimulate and facilitate learning, leaders should be aware of the needs of the project as well as the individual (development) needs of the team members and support and facilitate opportunities for both. Leaders should be aware and not selfish to see that their current team-members not only benefit from learning in the short-term, but also in the long-term for other projects. • To help develop a learning mindset, leaders should make learning and explicit goal, provide opportunities for learning, believe in it themselves, and be supportive of the learning endeavors their team members want to undertake. • Having high personal stakes, initiating a lot of work or projects, and recognizing the value of a project for your own work are seen as part of being a leader. • In general, a leader can be said to be

and then he also attended in the first series of the postdoc meetings and even for example, What, what he suggested me and Eric to do was that to have a meeting. And in one of the postdoc meeting we just called the postdoc meetings how to work together. And we, for example, I asked Eric to join this meeting and then give a presentation, what's the expectation of PI's from both sides in this position and also I wanted to To see what postdocs feel about the project and the way that we in collaborate in these projects. So I Actually during December that we had that meeting, and there was a postdocs talk yeah asked me to remain the the leader or the chair of the meeting for the post for the postdoc meetings. And then also, you see that your [other lead] also lead the management team meetings with Valentine And then they also provide us the information that we need and then and also they follow the actions and also help and facilitate also Some activities that we have" A: "What do you think leadership can do to help develop this [learning] mindset?" B: "I think the first one that the first thing is that you explicitly explicitly say it. I think this is very important. And, and also to to give the possibility to people that are working to do so (…) I think if a leader would like to do so, not, not only they should live in, believe it in. And also, they should say it very direct to people, and also try to make it to happen, or if for	someone to help organize and structure the project in such a way that it can achieve its goals. • Very strong leadership is not seen as beneficial for community formation and exploration. • The kind of leadership that is appropriate depends on the context and the goal one wants to achieve. For the completion of the project as was initially planned, leadership should be very clear, be on top of everything, provide steps, and manage schedules. For the formation of communities, leaders should provide opportunities for collaboration. • P5 feels it is necessary for a leader to provide clear goals and see whether what
example, an individual would like to take a course or something they also support it. I think that's the important thing." A: "I was wondering if there's someone that you consider to be a leader of your project team." B: "Yeah, of course. So I think all the postdocs could potentially lead this project. Yeah, why not? But not because I see that they are more interested. And some others. I see that for example, maybe less motivated. Or Yeah, you know, what that could be, I think Also if people like it or not." "I summarized information what I learned for my supervisor and then he would also give some ideas of what to look into more." "at the end University and academic works is about unguided innovation and creativity" "if the goal is like make innovation happen, happen in an transdisciplinary environment. Oh well, how would you even break that down into smaller tasks, what would you order people to do is uh maybe it's okay to let people have some freedom and to figure some things out by themselves. (…)there is also no concrete metrics on how you measure success here (…) So essentially it's now down to us to make up. At least subjective or semi objective measurements for achievement"	people are doing is still contributing to the overall goal. So, a leader should go both into detail and keep an overview. • Being a good leader of this project consists of the ability to communicate well and communicate with a diversity of people, a willingness to be a leader, being able to plan and manage, and being able to adapt their approach depending on the situation. Furthermore, having experience in multidisciplinary teams and thus an awareness of multiple interpretations would be helpful. • There are formal leaders that are also viewed as leaders and are therefore also informal leaders. • Leaders are proactive,

"Yeah, and maybe this is something leadership could collect into an into some kind of experience report like problems which are not supposed to be repeated for the next project like this" "I think at least there should be a person who is somewhat made responsible for being aware that there should be a learning mindset, and kind of takes care of that a little bit, I think, right now we don't have that. But if there's at least one person who says like look, your job is a little bit to memorise, formalise, and somehow transfer lessons, lessons learned, whatever that might be that already might help. Because there are lessons to be learned. And right now the lessons learned, are basically in our heads, which is okay, because it's the same group again doing the next project which is not too unlikely, while people kind of rely on these lessons learned, but they're not really externalised. So if somebody would be responsible for that. That would probably be helpful" A: "And it's or maybe something you would like to have more from leadership so would you specifically for learning is there any additional support that you would like to have or if there may be too much." B: "Yeah so I think retrospectively, I think what would have	communicate expectations, facilitate, provide necessary information, and follow the actions taken by the team members. • A good leader adopts a learning mindset towards their own leadership and is open. Furthermore, they should be able to adapt to different situations, and have social skills to be patient and listen to others. • A challenge for leadership in this project is to align all different points of views, expectations and ideas into one joint vision as well as dealing with the fact that the level of commitment differs per individual. • Working without clear leadership is what this person is used to. I.e., this person is used to being autonomous
been nice for me also to have maybe some conversations with the TU Delft supervisors or the because yeah they already know more than my supervisor, it was more that I was learning and I was teaching him but from their side, I could have gotten maybe some, some work. Yeah, the postdoc that I was regularly meeting, and he was not familiar with neural networks anything, so I was also learning." A: "Right, so you would have liked to have some social interaction with someone who was more of an expert in neural networks then." B: "Hmm. Right" "and at the Erasmus MC also, we only had one medical doctor working there, so only he has some expertise at what data is relevant, even while I work as a statistician I cannot. Formulate clinically relevant research question, It's not. It's just not possible. So, then this one medical doctor, he took also the lead and arranging things with the data but it was not possible for him to do everything because there's a lot of steps, as well, that you have to write proposals and get in contact with people obviously legal department. So then, this was distributed a little bit but that in the beginning the people were not wanting so much to join in this process, and helping with this administrative task actually. Yeah, so this was a problem and the beginning and now that things are going better. People are more taking on	and thinking for themselves. • A leader figure opened up the discussion by being open themselves, which enabled others to be open as well about their expectations, disappointments, and willingness to contribute. This improved collaboration afterwards. • Addressing people directly increases their engagement, but this needs to be balanced with being kind and good at communicating. • A good leader needs to not only be clear and practical and formulate the next best thing to do, but also show an interest in the individual and have their best interest in mind. They should be patient and never lose their temper. Furthermore, good

tasks that come, come up, but it is difficult because nobody is expert" A: "a good leader of your project team, what would that person do or not do your opinion?" B: "I think you mean that the characteristics of a person to be to lead this project to me. Yeah, I think Yeah, this is a maybe very cliche things that everybody should do I yeah, first of all, it should, should be able to communicate clearly and well with other people. I mean, in not only to postdocs for example also to people with a level above us I mean the PI's, and also first of all, and thats important, willing to do So. That's I think that's the most important one. And also be able to plan, manage (…) I mean, that's also Everyone in this position i think should be able to also To change the approach Depending on The situation So it's not something that is very for example 1234 you have to do this and have to do this and then you will be successful in leading this. So, because of that, for example, somebody could be Success winning a leading position and also not successful in leading another project. It's also the methods of different factors or variables that are in place." A: "is there someone you see as a leader?" B: "Well actually we have leaders now. And so we have the leaders from this side and also leaders from the other side. yes, and we see them as a leader."	leaders are able to engage people and distribute tasks. They are kind but also direct. • Feeling confident you can fulfill a leader role depends on personality, experience, whether or not you get the time to build it up, and whether you feel you can handle the responsibility. • Everyone is their own leader and responsible for their own things in academia. • The structure in academia is not very hierarchical. • Leadership in academia consists more of guiding and supervising than ordering people what to do. Leaders in academia rely on the autonomy of others and them taking responsibility for their work. • Inspiring leaders in academia could work well.
A: "Okay, so it's formal but also informal." B: "Yes." A: "What do you think would be needed from a leader specifically For The context of the digital twin project or just convergence in general, is there a specific characteristic or specific style that would suit this context? Or that is needed within this context that wouldn't necessarily be needed elsewhere." B: "Maybe what I can say is experiencing Working in multidisciplinary projects can be very helpful In this project" A: "so an awareness that there's several interpretations of the same thing." B: "Yes, exactly. Yeah. Yeah." "[other lead] and Valentine. Yeah. And, yeah, and they are also, they are the leader of this whole flagship I also have this, and then [other lead] is very involved. So, she will follow up on, on projects, and, yeah, and give her input." "Eric Boersma made a presentation about different versions of the digital twin. And that it's very new and this is why it's a bit unclear of how to get there. And that, yeah, we have to work all together to to be able to, to create a digital twin. And he also understood that he understands also our own expectations or goals that we also want to produce something. So for our academic CV for future work opportunities so he says there should	• Having autonomy also means having creative freedom and allows people to sidetrack and explore • If you are unsure yourself, it is nice to be told what to do so that you do not have to figure it out yourself. • Based on this, it could be said that a fitting leadership style in academia would be to provide an overall direction or overall goal, but mainly trust on the autonomy and responsibility of the team members. • It may even be the case that strict leadership that sets very clear goals is not even possible in a transdisciplinary environment because there is too much ambiguity and unclarity about what needs to be done. Furthermore, there are also no concrete metrics on

also be room for this. So we have to find a balance" "So there was some open discussion just about the people's expectations. Also, of how willing and how much they want to contribute maybe to this administration and what also there. Everyone was talking also about what their expectations were at the beginning and where their disappointment was because the Eric was most open (…) And then afterwards I think it went also better and everyone realised it was a real problem" A: "Do you think people felt comfortable doing that." B: "No I don't think so. Yeah, but it was very directly addressed by so people had to answer to this." A: "Okay, so just because he was so direct about it upfront about it." B: "Yeah, but he was also kind, so he's also very good. I think communicating, and it's very good skill to have." A: "Could you describe an experience you had where you felt you had a good leader and it doesn't have to be within this project but just at some point in your life where you felt like, oh, I, I see this person as a leader, and they, I see them as a good leader, because…" B: "yeah, maybe my previous supervisor or PhD supervisor she was. I think also, Yes, so she was very clear and practical and always. Yeah, know what, what would be the next best thing to do. And also she had my best	how to measure success. • Leadership is thought to play a role in making the lessons learned explicit so that a next project does not have to reinvent the wheel. • Leadership is thought to play an important role in developing a learning mindset by making it explicit. • This person is an informal leader and got this role by first being proactive themselves and then later being asked by a formal leader to stay in this role, which means leadership is distributed in the network. • This person has experience in leading and enjoys it. • This person delegates and distributes tasks. • A challenge in leadership is to
interest always in mind so she was, I had really the impression she's, she was a little bit taken care of me." A: "Are there things in general that you feel like a leader never should do." B: "I'm not sure maybe. Yeah I think of maybe to lose their temper." A: "What would entail being a good leader. Do you think." B: "Yes, I think if you are able to find a way, like to find what to do next. And to to engage the people to distribute tasks. And to be kind, but direct also." "So basically it's hard measured performance metrics is which are typically connected to some kind of scientific output and projects like this one here only created limited scientific output so from a strategy point of view, as a researcher, especially when you're early in your career and are very ambitious. These projects are not necessarily advised to do. So maybe from a leadership perspective, one could maybe have stronger incentives for these things, or stronger recognition of being part of such initiatives." "[a leader figure] seems to be one who has higher personal stakes in it. So I mostly work with him, and a lot of stuff I'm working on comes from his initiatives so as far as I'm concerned that means a little bit of leading. I think because he's	ensure that the delegation of tasks and responsibilities is relevant for others as well as making sure those people actually perform the tasks, so convincing them. It takes a lot of time. This person tries to overcome these by giving people individual attention and scheduling individual meetings. • In this project, there is not just administrative tasks but also a larger overall goal that needs to be taken into account in leading. So, leaders need to have both a detail and overall view. • This person believes everyone in the team could lead the project, but actually leading also depends on a willingness to lead. • This person's supervisor, or in other words a

one of the few people who kind of recognise that he can use this project in order to get some of his own stuff done." "I mean leadership is typically somebody or who is here to organise and structure stuff so that the goal can be achieved with higher reliability or something like that" "if the goal is to have people connect an interface which is other and build their personal communities and, you know, maybe go on some side projects and start working there, then this is kind of working out right now, mostly because there is no strong leadership, because it's a result of a lack of strong leadership, we now do other things together, which might actually be in the spirit of the project. (…) we don't really have data there's no real leadership right now going on which forces us to do something specific or actually stick to the plan." A: "What would you say generally would be good for a leadership to do so what kind of behaviours, what kind of characteristics would a good leader have." B: "again depends on the goal you have as a goal is a successful completion of a project as promised, the leader should be on top of all the things like project plans and steps and schedules and you know all that stuff is behind schedule. (…) which right now we don't have at all. So nobody's actually having control over the workflow. And if the goal	formal leader, would provide some directions as to what would be promising areas to look into and learn about. So, leadership can influence what people learn. • P8 would have liked for leadership to facilitate social interaction with someone with expertise on the subject P8 was learning about. • The informal leader is a good leader because they are proactive, efficient, direct, clear, and distributes tasks, and makes goals and actions concrete. • A good leader for Digital Twin needs to be practical and be able to formulate clear next steps. • Formal leaders can influence the emergence of informal leaders by encouraging enthusiasm and not

is to indeed realise this project plan. This is indeed what leadership should do. But as I was saying before, I don't really believe that this is the actual goal we are having here, and if the real goal is actually to facilitate communities, then the leadership should probably create more opportunities for people to collaborate and use their synergies between them. And I'm not sure if that's really happens a lot right now. I think it happens in subgroup one where we kind of organised ourselves. (…) I'm not really sure what leadership should be doing here" "if I had to be the leader. I would say let's first clarify the goals here, because they're still very unclear. Right. And after we clarified the goals, which might be actually make the stuff we promised or you know do maybe something else. Check out if what we're doing right now is actually serving the goal." "And the big challenges the leadership here has is to align all these different expectations ideas into a joint vision, which is somewhat hard, I guess, especially then from the PI's that you don't always get a 100% commitment." A: "So how do you experience working without clear leadership." B: "It's kind of what we do all the time right. working order when (??) I got hired to to Delft you know as an assistant professor having like a group leader, he told me like, Look,	shooting down initiatives or ideas. • One of the formal leaders is very involved and follows up on people and provide their input and feedback to people, which is considered to be good. • Another leader figure explicitly addressed the fact that everything is very vague and unclear and it is unclear of how to get to the end goal of building a Digital Twin, but one thing is sure: they have to do it together. Furthermore, this person was aware of the individual needs and expectations of the team members and makes room for that. A balance needs to be found between focus on the individual and focus on the overall goal. • Out of necessity, someone took on an

your job is to sit down, create something genius, be present and invent, invent something cool like okay cool how am I supposed to do that. Heck How should I know you figure it out, like, okay." "you're kind of your own leader right academia is not a strictly hierarchical thing anyway (…) this is how it kind of always works you're always responsible for your own things and making up your own plans. (…) I don't order my PhDs around, and neither am I ordered around even so technically I do have a supervisor and even though I'm technically supervisor for my students, I mean I'm more guiding and giving tips but in the end they're responsible for their own stuff. (…) having a lot of freedom is a great power, but it comes as a responsibility that you have to figure out what to do. And it's super awesome because we have an extremely creative freedom on what we do because typically nobody orders us around and tells us what to do because it's on ourselves so you know you can do essentially whatever you like, but it also means that if you don't know exactly what to do. Well, tough luck, then you need to figure it out. So sometimes it would be way easier if just somebody would tell you, now you do this, Now you do that and you just follow orders. I mean I think this is what kind of very strict leadership would do. But academia is not a strict leadership environment anyway. It's	informal leader role as there was no one else with their expertise in a specific field. He was accepted as a leader figure due to his expertise and the necessity of having a leader figure. This person could not do it alone and tried to distribute tasks, but not everyone was willing to take on administrative tasks in the beginning. People were unsure since they were not experts. • Formal leadership stepped in by organizing meetings and explicitly stating that the situation is not ideal but people will have to work with what they got. People were asked directly to take on tasks, which helped. • Formal leadership influenced the formation of informal leadership.

more, I guess you can also have a more inspirational leadership thing but this would be more like motivating people and stuff it's not really telling people what to do and how to do it." A: "Because scientists like to be more autonomous, or not?" B: "Yes, they like to be more autonomous. (…) So, and the whole culture would also support that. problem with that is that sometimes you might actually benefit from having somebody tell you what to do" "it [autonomy] allows for a lot of creative freedom and it allows to sidetrack, like, we actually do with this project." B: "so my supervisor was, you know, a good leader. You could feel it, because, she was she was young, but at the same time, working with very senior people (…) And then, the other point was that she was also trying to improve her leadership role. It was not just that she was trying to do so. But also, she was looking. Yeah, she was following courses and these kinds of things to improve it. So yeah, I think she was a good leader, and potentially will be also better." A: "Okay. So basically, just adopting, like a learning mindset towards her own leadership made her a better leader, because she was open to seeing how she could improve is that correct?" B: "Yeah she was open to me, and also I think she could also adopt herself very well with	• Leaders can help to make new connections and building communities. However, leaders are not thought to be helpful in building better communications due to their own workload. It is more up to the people themselves. • Implementing a department that focuses on both sides (medical and technical) and on educating the next generation would be helpful. • To help stimulate learning, leaders should set clear goals to ensure that their followers know what the leader expects of them so they know that the work they are doing is serving the overall goal and is relevant. • It is important for a leader to make people feel

different situations, and different cultures. I think that's also also very important. And the other thing is that she was social. I think, yeah, it will be difficult if somebody is not social and want to lead a group. In that case, yeah, for example, maybe sometimes you need really to talk a lot, or listen a lot of somebody and then work and then be patient. So I think if somebody is not very social, would be a challenge to lead a group or lead a project." A: "This is again, the the willingness that you talked about earlier, right? The willingness to to lead?" B: "The willingness, and I think there are two different things. Sometimes you are willing to do but you are not enough social? Yeah, you need to get all of that social capacity to listen to all these for example complaints, or you follow them" A: "So what do you think leadership could do to help stimulate learning?" B: "(…) part of that is it's if you lead projects, well, and the people in your projects that people are working on a project would like to contribute more. And if it's necessary to learn something, because they have this feeling that the project is going in the right direction. They would like also to learn in line of the development of the project. I think this is one part, and the other part is that if also the leadership support people in the in the group to learn what they need, not only for the line of the project in nothing,	comfortable, confident, and support their team members. This can be done by giving them individual attention. This goes beyond just providing feedback, but it also entails being open to others and trying to cater to their individual needs. • A good leader sets clear objectives and also gives you autonomy because the people 'on the ground' know best what does and does not work. So, a good balance has to be found between giving autonomy and direction, as well as taking the context of the people 'on the ground' into account. • Good leaders are decisive and stick with their decision despite inevitable backlash. They need to be confident and clear in the
nothing the line for the project and also for self development. (…) if there is a leader (…) but they are thinking about, only about the project, not the self development of the people that are working in that team. I think, Yeah, they cannot simulate learning very well. But if they think that okay the future also of these people that they are working this project is important, and they are not only a group of people that they are working for me" A: "okay, and, and how would you say you evolved from the the situation you sketched earlier to where you are now so people are taking on more tasks so what was needed for for that to happen." B: "Yeah, so, there was also some extra meetings about this, about how to collaborate, and about the expectations so yeah there were so because there was also by the supervisors This was seen that it was not going so good (…) in particular I think Eric Boersma, he said, Yeah, it's not maybe ideal how it is now but it is like this so you kind of have to have to work with it now. And the kind of lead the medical doctor that he took the lead as one of the postdocs, he also started to directly ask people to take over tasks" A: "Did you see him [the medical doctor] as a leader?" B: "Yes, and I was also happy that someone was doing this because it was necessary." A: "Yeah, yeah, I understand. Do you still see him as a leader figure?" B: "Yeah"	direction they choose. They need to keep engaging with their team members to diminish the backlash. • If conflict arises within a group, a leader needs to be an arbitreur. • It depends on the project whether it is best to have someone from the outside to provide a fresh perspective and not be so attached to 'the way things have always been done', or whether it is better to have a leader who is an insider of the team who knows the difficulties and potentials of the project. It sounds like a combination of both would be best to reap the fruits of both styles. • Leaders should be honest and supportive • It would be beneficial for this

A: “and that just evolved?” B: “I think that his supervisor pushed him also. So, at the first meeting I wouldn't say that he was immediately taking the lead by himself, but I think it was also from his supervisor and, but it fits. It fits him so now I know him better. I think he's, he's very good at it also.” A: “What makes him good at it?” B: “Yeah so I think what is good is that he is a very proactive. He's doing many things. Yeah, he's very efficient. Also, and he is direct at the being very. Yeah, to distribute tasks, but also to make things clear. So, if there's some tasks that he will also say okay at what, what is the deadline who will do it. How will you do it. So, I think he's good in his role.” A: “And maybe more in general, what do you think, within the context of this digital twin team, what would a good leader have to be able to do or what kind of behaviours should a good leader within this context… What should they do? As a good leader.” B: “Yeah I think someone who is very practical, maybe, and knows. Okay, what, what can we do, and because it's very unclear. In the beginning it was very unclear what we will do then is that okay then we contact that person and ask that person. Or we ask him, just to find…Yeah, the next step.”	project to have leadership that is knowledgeable in both medical and engineering sciences to be able to bridge and communicate between them. • Leaders were able to appoint team members and let them ‘roam free’ to see what they would come up with. I.e., leaders gave team members a lot of autonomy. • A challenge for leader was that one the one hand they had to observe but on the other hand they also had to help new ‘recruits’ get started. This resulted in some people having a rougher start than others. • Leaders have an influence in setting up connections. • Leaders need to provide a clear scope of what can
“So my counterpart was very willing to, to do things but then his supervisors were breaking him so they were saying no, you should not invest so much time into writing this proposal but you. You can do better something else. So then, I think he wants a little bit more in the background.” A: “And let's say you were asked to become a leader of your research group, what would what would you say” B: “No I don’t like to. It's not my personality, I think” A: “Okay, why not.” B: “Yeah. Sorry I like, I'm not I don't have experience in it, and then I will feel quite insecure, too. Yeah, so if I would have maybe slowly built up to the place of a leader I would feel more comfortable, then all of a sudden to become it. And yeah, also the responsibility. This is also something that, yeah, maybe it will be a bit too much for me.” “I think a supervisor could help in making new connections. (…) But, in terms of this building up better communication, I don’t really think that contacting the supervisor would be of much help, because they are also overworked and overloaded” “You know, if we could have a department who got people from both sides and then educate the next	be expected from their team and what the scope is of their project. So, leaders need to provide clear boundaries and expectations. • Leaders need to find a balance in collaboration to ensure it does not become unidirectional • To help develop a common language and increase openness and awareness, leaders need to be attentive to the conflicts that can happen on a foundational level, so concerning cultural differences, assumptions, and biases, which can be done by not dismissing these conflicts as being based on different personalities, but trying to find patterns and trends. Leaders also need to be flexible in their own research approached to

generation, then perhaps we could have proper data-driven medical researcher." A: "what could a leader or a supervisor do to stimulate learning?" B: "I think setting a clear goal is very important. Because, there is a, you know, a power hierarchy, so, if the supervisor didn't set it clearly like what he wanted to do, then the cost of the experiment would eb like… they would have to spend a lot of mental energy to get a kind of research topic the supervisor would want to see. It is truly an unnecessary mental labour." A: "The supervisor that you currently have, do you also see them as a leader?" B: "In the ethic one, we are more like a collaboration, so our relationship is not that hierarchical. I don't know if if this is typical, but she's a very nice person and when I have like a question I can ask her. But, because she's also very busy and philosopher has to work independently, so we don't really talk to each other that much. But I do now, from her intentionally, from her help I think because she knows that it's my first time to be in the Netherlands, so she actually invites me for coffee regularly, fairly regularly. But, when thinking about one month or so, so she wants to make sure that I feel comfortable to talk with her. And, you know, give me all sort of advice and support. In sense of research, because you know it is a lot of ?? in your brain, you just cannot really outsource particular parts to your collaborator. So,	adapt to changing circumstances, seeing their method not as a fixed method but as information. • As a leader you need to be able to respond well to changes and the unexpected. Being a leader also entails developing the individual expertise of your team members in a way that allows them to contribute their unique talents and perspectives. This is needed due to the ambiguity and uncertainty of the new project, making it unclear what expertise, perspectives, and knowledge might be important. Leaders need to provide the space for people to be able to make their (unexpected) contributions, which in turn means creating a space where failure is accepted and even
yeah. In my case it's not that clear. Like, the hierarchical structure I mean." A: "OK. Clear. You do say that your supervisor provides support and makes you feel more comfortable and really tries to…yeah…make you feel confident." B: "yeah, I think it is really important, because I didn't know that, in some teams people are afraid of their supervisors." A: "Why do you think that is?" B: "I mean, I heard about those things, I mean like, perhaps their super biases(??) are very easy going or maybe they are also burned-out by their own work. So, it's just typical for you to see them and to get any feedback from their … you know to get any feedback for your work." "If there's a leader then, and also a good leader, then you have very clear objectives, you follow the leader So, of course you want some autonomy in your research, but at least you know you are doing exactly what your leader wants you to do." "in sense of leadership I would might someone who could make a decision in a way that they knew that they are going to be criticized but ???? but they are willing to accept the fact they cannot please everyone. And, they know that they are doing the good thing. (…) decisive movement but still engaged with all those people who criticize them. And, yeah, stick to it."	encouraged as a mode of improvement. Leaders need to be open to different realities to be able to allow for emergence. This is especially important due to the newness of this project and how this asks of the team members to be creative and innovative. • Leaders should view their team members as points of feedback for points of conflict and how the project is going. • Leaders need to provide security for their team members. You need to take their context into account and build a safe environment where failure is accepted. This security does not lie in any room or in attitudes. Once security is established, people feel free to be

"setting a very clear research agenda, like, clear enough but still allow people to use their own ??? to do the research. They are more suitable to do. And also, facilitate the communication within the group. I think that is very very important, because I think this…. I think a lot of problems start with miscommunication and lack of communication, and then mistrust (…) when there's conflict happen within a group. You need to be an arbitreur." "sometimes it will be better to have an outsider to be the leader, because…the person would be less attached to the project. But, sometimes it would be better to have someone who is already in the team, because the person knows everything about the project. The difficulties and the potentials and everything." "I wouldn't say there's one universally good leader that I've had, that I can identify specifically but I think the quality that unites people who've been good leaders are willing to follow have been the…that they lead projects in a fashion that allows for individuals to shape their own contributions. And they take on. They take on the details themselves as well. Right, so they don't lose touch with the kind of labour involved with an acting some of the ideas that they have right. So, so some leaders have been very great	creative and innovative. Leadership really is about material security as much as it is about open creating an atmosphere of open mindedness. You can be as open minded as you want but if people are afraid of being fired, they're not going to tell you things that are risky. So, risk needs to be mitigated. This is also true for the leaders themselves: they need to feel secure as well to be able to provide a safe environment and have room to fail. • Projects need to be painted as being exploratory in nature and not be outcome oriented. Leaders can help paint this image. • The number of leaders has changed over time.

with allowing independent research, but then they lose touch with how much work, the group level work takes up, and yet they still expect them to meet a certain standard of criteria for their independent contributions, it ends up being just way too much, right, because they work at that level because they have all sorts of people working under them. But the people working under them can't work at that level because they don't have anyone. So those those small daily details. Get, get forgotten by by leaders often and I mean the good ones have remembered, and put in the time to do that right to figure out how to do things and have have done check ins on. So this, this might be a complicated thing for you to learn, check in on how it's going. And then we can adjust, right, the ability to adjust goals as well. According to needs, and glitches, is so it's something, but also the that's countered with a strong exemplary more of an exemplary model rather than a do it for you model, right, so here's how I did it. Or here's me doing it. Here are the kinds of things that you can accomplish. Let me show you what I'm doing, so that they're transparent about what they're doing so that you can see how to go ahead and do those things later on" A: "Would you call that 'getting involved' or 'relationship building'?" B: "I think it's humility." A: "Humility." B: "Yeah, I think it's a recognition that you also went	• Good leaders allow individuals to shape their own contributions and they take on details themselves as well, so they do not lose touch with the labor involved 'on the ground'. So, good leaders have found a balance between giving people autonomy and being engaged in the work itself to stay aware of what it takes and entails. • Leaders need to be able to adjust goals to changing circumstances and need to be transparent about what they are doing and how they did it. • Good leaders are humble and recognize the road they took to get to where they are now and how many failures it took. They have an awareness of the skills they developed and the mistakes they made

through all of that at one point you also had to learn all of these things, And you also were wrong. Many times, and, and when we are living in a world created by our successes. We forget about how the failures actually allowed us to get there too that we had to make those mistakes and do those things wrong. So, yeah, It's humility and, yeah, in your own development of skills so So, an awareness of the fact that you had to develop these skills that you have that they were not innate and or blessed upon you because you were born into the right family right and so there there's definitely a leadership potential, to forgetting the ladder that you climb" A: "What role do you think leadership can play therein [in stimulating learning], or should play possibly" B: "as a point of stability. So, a leader is necessary in the sense of having someone in charge. Who knows the components of these kind of ongoing shifts and projects, or someone who at least can contact out right so a point of referral. So you need a, you need a hub point, I think, as a leader and is in this convergence, initiative and projects themselves. (…) So administratively we need leaders are just like literally the person who you can contact to find something out. So situational awareness is important. And, and also, that kind of point of stability is really key. As far as active leadership, I would say, keeping the lines of engagement, open, not just communication but engagement. So	to make it to where they are now. • When it comes to learning, leaders can act as a point of stability or hub, to provide clarity, so people know they can go there if they want to find something out. Furthermore, leaders need to keep the lines of engagement open to enable deliberation between people to create learning opportunities.

there's, I guess there's communication, you know, then is the the kind of point of contact thing and then keeping the lines of engagement open as well so that people have space created when they need it for deliberation over even find points of detail, where things are not rushed past but stopped and thought through." A: "Would there be certain characteristics that you would be looking for in search for that leader? No matter if they come from inside or outside the team." B: "Honesty and being supportive." A: "So, someone who is knowledgeable in the medical field but also in the more engineering and data scientist field and is able to speak both languages basically, and is honest and genuine about what can and cannot be done and why." B: "Yeah yeah yeah" "So there's kind of two key areas that we were looking at and so we brought in postdocs that could look at the different issues arising. And those two key areas and then we just kind of sent them out into the world to see what kinds of connections they could make with the projects as they were starting up so it's a bit of a difficult project in the sense that we're supposed to be observing, but those other projects had to get started as well. So some of them had a rougher start some of them were a bit less organised	

or less ready to talk about the ethics issues than others" A: "How did that go with Pei-Hua? Was there someone who helped in that respect or was it just the way this team was put together basically or was there a certain supervisor or leader figure?"B: "that same leaders, the team leaders did some work to explicitly reach out in their process and ask for advice but also she, she made connections among the postdocs." "So, so in one way, we, we have to limit ourselves to the kinds of issues we can tackle within the scope of this current project, which also has, I think a beneficial effect in restricting the kinds of things services we can offer people because we don't want to become a service. We want to be engaged in the project. And those are different things, right. (…) And again that's it that's a trick that I have to pull a lot because we often get thrown into that service category. When it comes to collaboration. We just have something to offer them and then they take it and move on. And so, so yeah, so that's been a balance. It's to keep that collaboration from becoming unidirectional" A: "And what do you think the role of a leader might be in this process [of developing a common language and increasing awareness and openness]." B:	

"attentiveness to those kinds of ground level conflicts as being important. So, so not reducing them to individual personalities when it comes to collaboration right but trying to find the patterns and trends towards in perspectives that might highlight the presence of these kinds of, of conflicts that you're not used to looking for. And flexibility in your own research approaches, so you have to. I mean, we have to think about our own processes as being a scientific method, and therefore somehow stable, but in actuality those get reformed all the time. so lots of people who are working in these projects have already dealt with that kind of change. And it'll be, they'll have to keep up that flexibility so someone who has experience with already transitioning to new models and new ways of thinking and again if you're working in digital twin technology or nanotechnology you're used to massive shifts in the kinds of approaches you take, and this would be another shift right so rather than two well formed approaches coming together what you want to do is conceive of your own approach as being information. And therefore, and so something new can promote that transdisciplinary attitude towards research methods, and, and prioritizations" B: "you have to be able to prepare and respond well to the unexpected and also to develop the individual expertise of	

your team members, in a way that allows them to contribute what might be unique, from their perspective right so you have to open up possibilities for people to make unexpected contributions from their own perspective. In response to changing situations but also to contribute their, their unique perspective and experience and expertise, because in these kinds of situations you're never actually quite sure beforehand, what's going to be important. So you have to be prepared to pick up on cues, and for people to step up when they have something to offer. So to create a kind of space where even Junior contributors and almost especially junior contributors because they have, they're in that kind of transformative period as well they might be more. They might more easily pick up on things that could be different in a context for example but yeah, picking up on allowing people the space to do that to step forward with an idea. And that also means creating a space for people to be wrong. And to fail without being criticised so failure actually has to be encouraged as a mode of improvement. So you have to have a very progressive attitude towards failure is opening up new potential realities rather than dismissing all cases, because when you, when you see failure is something that needs to be dismissed and overcome, then you already have a pre determined ideal about what counts as success. So what you need to do is reinterpret failure as opportunity or not.	

And then allow it as a possibility, rather than immediately just dismissing it right" A: "otherwise you cannot implement or otherwise you don't give emergence, any space." B: "Yep to happen exactly. And I think on these teams that really comes into play because we've brought in postdocs to do a job that's never been done before. So we're asking them to do something that we're asking them to be creative, innovative, individuals, and you can't ask them to do that and at the same time say you specifically have nothing unique to contribute to this process, right. So, it has to be both ways you have to draw from the postdocs who bring in for their own perspective because they are the ones going through the convergence, process, and trying to navigate this space so they're the ones who have a really intimate perspective on what it's like to be in the middle of that situation so I think that they they are very important resources for us in this impulse round. So good leaders will will use them as, as feedback opportunities for how the convergence process itself is going and also for identifying points of conflict, through their own failure to understand, right, it's not that they're that there's a good reason why they're failing to understand some things because there's no clear path towards understanding. So they also don't have any markers for success. To meet right so this because it's that transitional process it becomes it's it's very important to really deep dive into what's happening	

and why and to not be dismissive of possible wrong turns." "money really is just security. It's another form of saying security so the postdocs need to be in a position where they feel safe about success, so that they, so you do need to you need to give them success criteria that are not dependent on them understanding the convergence process itself etc because they're also in that position where they have two years to get some stuff out there and get another job right so so they have many levels of transition happening in their lives that you can't forget because they don't have that security they also won't have the security to fail in front of you, so you have to actually create a buffer around your team. And in order to create that space and I think this is something that people really forget the buffer doesn't exist in a room. It doesn't exist with positive attitudes. It exists with real term security. So however you can create that security, underlying the project. I think that's your first step you need to make sure they can get the things done that they need to get done to get the job that they need to get and then they can start being creative and innovative around that. Right. But until they have that actual security they don't have the rest and so. So leadership can only go so far. Ever leadership really is about material security as much as it is about open creating an atmosphere of open mindedness. You can be as open	

minded as you want but if people are afraid of being fired, they're not going to tell you things that are risky. So, so, risk… What do you call that… like Buffer risk. I don't know what it is but mitigation, I guess, risk mitigation. So when you, When you work against the risks riskiness of it would be a really key factor. I think that's super important. But then that also means that the, the team leader has to have that security. In order to create it for others, right, so they also have to have the room for failure in their overall projects. So I think painting ones project as an exploratory endeavour in these contexts is really important, rather than as an outcome oriented Endeavour is one key thing, and to allow failure to count as success." "digital twins started off as a fairly specific project just one of the four flagships but now it's connecting now they consider themselves a strategic flagship where they're connecting other flagships as well so they've actually shifted positions since the opening portals. So there are more leaders now than there were."	

APPENDIX E – CONCISE RESULTS OF SEMI-STRUCTURED INTERVIEWS

Table E.1: Statements concerning collaboration and their significance based on the semi-structured interviews. The numbers refer to the candidates that concur with the statement. G = governance level, L = lead of Digital Twin project, PD = postdoc, PH = philosopher, PI = principal investigator. G, L and PI refer to leadership positions.

COLLABORATION	
Statements	**Significance (How many and who said this or something along those lines)**
The collaboration is going well	1 2 3 4 5 6 7 9 10 11 12 2G 2L 2PD 3PH 2PI 6EMC 5TUD
Creativity is beneficial for this collaboration	1 2 5 2G PI 3TUD
Informal social interactions are important	1 3 5 6 9 10 G L PD PH 2PI 3EMC 3TUD
Different expectations pose a challenge to collaboration	3 7 8 9 11 12 L 3PD 2PH 4EMC 2TUD
The online environment poses challenges to collaboration	3 7 9 10 L 2PD PH 4EMC
The time constraint (2 years) poses a challenge to collaboration	4 L TUD
Differences in levels of commitment poses a challenge to collaboration	5 PI TUD
Differences in leadership styles in teams pose challenges to collaboration	3 L EMC
Cultural differences pose challenges for collaboration	1 3 7 G L PD 2EMC TUD
Calmness and a willingness to listen to others makes collaboration easier	1 G TUD
Willingness to contribute is beneficial for collaboration	8 PD EMC
Collaboration can be blocked by institutions and institutional differences	1 4 5 10 G L PH PI EMC 3TUD
Clarity and concreteness are important	1 2 3 10 2G L PH 2EMC 2TUD
Open discussions are beneficial for collaboration	1 5 8 9 10 11 12 G 2PD 3PH PI

	3EMC 4TUD
People need to be open to sharing	4 7 10 11 L PD 2PH 2EMC 2TUD
People need to dare to speak up	3 10 L PH 2EMC
Iteration on assumptions and expectations is needed	11 PH TUD
Getting out of one's comfort zone is beneficial for this collaboration	1 G TUD
Long-term collaboration/commitment helps this collaboration	1 G TUD
Trust is important	1 9 G PD EMC TUD
Reciprocity is important	1 10 G PH EMC TUD
Clear added value is important	1 G TUD
Connection between people, projects, and the institutions is needed for this collaboration	2 3 4 5 11 G 2L PH PI EMC 4TUD
People need to be proactive in making connections	11 12 2PH 2TUD
Understanding others and their language is essential. I.e., a common understanding and common language are needed	2 3 5 6 7 8 9 10 12 G L 3PD 2PH 2PI 6EMC 3TUD
Knowing what people can contribute needs to be known	2 10 11 G 2PH EMC 2TUD
Shared goals are needed for this collaboration	1 6 10 G PH PI 2EMC TUD
Increasing awareness of who one has on their team is beneficial	2 G TUD
Increasing awareness of differences (perspectives and assumptions) is beneficial	10 11 2PH EMC TUD
Working towards diversity is beneficial	2 G TUD
The collaboration is time consuming	2 3 4 6 7 9 10 G 2L 2PD PH PI

	5EMC 2TUD
The collaboration is experienced as vague, unclear, or ambiguous	3 5 9 10 12 PD 2PH PI 3EMC 2TUD
The collaboration is said to involve people from different backgrounds, so it is diverse	3 4 5 7 8 10 11 12 2L 2PD 3PH PI 4EMC 4TUD
Working together makes (later) collaboration easier	3 5 10 L PH PI 2EMC TUD
The collaboration is more bottom-up than top-down	6 7 12 PD PH PI 2EMC TUD
The goal of this collaboration is to learn to work together	4 5 6 10 12 L 2PH 2PI 2EMC 3TUD
The collaboration is seen as complex	3 11 L PH EMC TUD
The collaboration is seen as multidisciplinary	2 3 7 9 12 G L 2PD PH 3EMC 2TUD
The collaboration is seen as interdisciplinary	1 5 7 G PD PI EMC 2TUD
The collaboration is seen as transdisciplinary	3 5

	L PI EMC TUD
There is confusion or uncertainty about what the different types of collaboration entail and which one applies	5 6 7 12 PD PH PI 2EMC 2TUD
Transdisciplinarity is seen as the goal	2 9 G PD EMC TUD
Transdisciplinarity is seen as valuable	6 7 PD PI 2EMC
The collaboration is seen as partly or moving towards transdisciplinarity	1 4 7 8 G L 2PD 2EMC 2TUD
Transdisciplinarity means letting go of boundaries	2 11 G PH 2TUD
Transdisciplinarity involves holistic thinking or a broader perspective	2 5 11 12 G 2PH PI 4TUD
Transdisciplinarity is about involving academic and non-academic fields	1 2 3 5 12 2G L PH PI EMC 4TUD
Transdisciplinarity is about integrating knowledge	2 10 G PH EMC TUD

Transdisciplinarity develops synergy	2 3 11 G L PH EMC 2TUD
Transdisciplinarity is about building bridges	4 6 L PI EMC TUD
Transdisciplinarity involves solving problems that could not be solved by any one domain	11 PH TUD

Table E.2: Statements concerning learning and their significance based on the semi-structured interviews. The numbers refer to the candidates that concur with the statement. G = governance level, L = lead of Digital Twin project, PD = postdoc, PH = philosopher, PI = principal investigator. G, L and PI refer to leadership positions.

LEARNING	
Statements	**Significance (How many and who said this or something along those lines)**
Learning is not getting explicit attention	1 2 4 6 7 12 2G L PD PH PI 2EMC 4TUD
Learning will be getting explicit attention	2 12 G PH 2TUD
Learning is happening implicitly	4 5 6 7 10 12 L PD 2PH 2PI 3EMC 3TUD
Learning is happening constantly	10 12 2PH EMC TUD
Learning is happening retrospectively	4 5 L PI 2TUD
Making learning explicit is seen as beneficial for the project	1 2 3 4 5 7 8 11 12 2G 2L 2PD PH PI 4EMC 5TUD
Failure is beneficial to learning	1 4 11 12 G L 2PH 4TUD
What method works best depends on the context and the nature of what needs to be learned	5 10 PH PI EMC TUD
Teaching others is a good way to learn	5 PI TUD
Pressure is a motivator for learning	5 PI TUD
Learning takes place during meetings	9 PD

	EMC
Learning takes place on a theory basis, self-study	1 5 6 7 8 9 G 3PD 2PI 4EMC 2TUD
Learning takes place on a practical basis, applying it	1 5 6 7 8 10 G 2PD PH 2PI 4EMC 2TUD
Experimentation is beneficial for learning	7 8 12 2PD PH 2EMC TUD
(Informal) social interaction is beneficial for learning	5 6 7 8 9 10 12 3PD 2PH 2PI 5EMC 2TUD
Getting feedback from others is beneficial for learning	7 8 12 2PD PH 2EMC TUD
Expertise contributes to the value of social interaction in learning	8 PD EMC
A focus on learning will help develop holistic thinking	2 G TUD
Taking part in an activity helps people learn about that activity	3 L EMC
Learning is inherent to research	3 4 11

	2L PH EMC 2TUD
Main goal of the collaboration is to learn to work together	4 L TUD
This project is a learning project	4 5 L PI 2TUD
Enough rest is needed to effectively learn	4 L TUD
A clear mind (e.g. through variation of activities) is needed to effectively learn	4 L TUD
Trust is needed for effective learning	4 L TUD
One must expand one's boundaries / go beyond the comfort zone to learn	4 L TUD
One must be brave to learn (accept a little fear)	4 L TUD
Clear boundaries make it easier to seek out learning opportunities	4 L TUD

Learning about others, what they do, and what their value is takes time	6 PI EMC
Respect is essential for learning	6 PI EMC
Taking time is essential for learning	6 PI EMC
Diversity is beneficial for learning	7 8 2PD 2EMC
Self-development of the researchers is important	7 PD EMC
Learning can be formally organized if necessary, for specific project knowledge	8 9 2PD 2EMC
Individual learning is more enjoyable when it can be done at one's own pace	8 PD EMC
Making learning explicit contributes to developing a common language	8 PD EMC
Achieving short-term goals has a positive effect on learning	8 PD
	EMC
Relevance influences commitment to learning	8 10 PD PH 2EMC
Creativity stimulates learning	9 PD EMC
Openness is necessary for learning	6 9 11 12 PD 2PH PI 2EMC 2TUD
Problem-based learning is a pleasant method for learning	10 PH EMC
A learning mindset should be developed	12 PH TUD
A humble attitude is beneficial for learning	12 PH TUD

Table E.3: Statements concerning leadership and their significance based on the semi-structured interviews. The numbers refer to the candidates that concur with the statement. G = governance level, L = lead of Digital Twin project, PD = postdoc, PH = philosopher, PI = principal investigator. G, L and PI refer to leadership positions.

LEADERSHIP	
Statements	**Significance (How many and who said this or something along those lines)**
Leadership needs to be concrete / provide concreteness	1 3 6 8 12 G L PD PH PI 3EMC 2TUD
Leaders need to be practical	1 8 G PD EMC TUD
There is formal leadership	1 3 6 7 8 10 G L 2PD PH PI 5EMC TUD
There is informal leadership	1 6 7 8 10 G 2PD PH PI 4EMC TUD
Trust makes leadership more effective	1 2 4 2G L 3TUD
Duality in leadership	1 2 3 4 5 6 7 8 9 12 2G 2L 3PD PH 2PI 5EMC 5TUD
➔ One foot in governing level, one foot in the community	1 12 G PH 2TUD
➔ Expect things from team members, but also support and facilitate them	1 3 G L EMC TUD
➔ Balancing between the overall goal (overview) and the individual goals of institutions/individuals (detail)	1 4 7 8 9 G L 3PD 3EMC 2TUD
➔ Top-down leadership (for overall goal and vision) and bottom-up leadership (for support and facilitation)	1 7 G PD EMC TUD
➔ One focused on content, another focused on operational things	1 2 2G 2TUD
➔ One focused on content, another focused on the overall goal	4 5 L PI 2TUD
➔ Internal and external focus	1 9

➔ Visionary (pioneer) and connector (personal focus) ➔ Providing autonomy and giving direction ➔ Short-term and long-term focus ➔ Direct and kind	G PD EMC TUD 1 G TUD 3 4 5 9 12 2L PD PH PI 2EMC 3TUD 7 PD EMC 8 PD EMC
Leadership needs to provide support	1 7 9 G 2PD 2EMC TUD
Leadership has a facilitating role	1 3 4 5 6 7 8 10 G 2L 2PD PH 2PI 5EMC 3TUD
The team is (fairly) autonomous	1 5 G PI

	2TUD
Leaders need to provide direction	1 G TUD
Leaders need to provide clarity	1 3 5 6 8 9 12 G L 2PD PH 2PI 4EMC 3TUD
Leaders play a role in increasing awareness	1 G TUD
There is distributed leadership	1 2 3 4 6 10 11 2G 2L 2PH PI 4EMC 3TUD
Leaders consult with each other	1 G TUD
Leaders need to explicitly address differences	1 G TUD
Leaders need to intervene if necessary	1 10 G PH EMC TUD
Status/prestige/expertise is beneficial for leadership effectiveness	1 3 6 8 G L PD PI 3EMC TUD

Interplay between different leaders and styles of leadership is important	1 3 G L EMC TUD
Diversity in leadership is beneficial	1 10 G PH EMC TUD
A leader should be brave / have guts	1 10 G PH EMC TUD
Leadership should be proactive	1 7 8 G 2PD 2EMC TUD
Experience is beneficial for leadership	1 2 7 2G PD EMC 2TUD
A leader should have good networking skills	1 2 2G 2TUD
Leaders should be decisive	1 9 G PD EMC TUD
Leaders benefit from a pioneering mindset	1 10 G PH EMC TUD
Leaders need to be able to connect people	2 9 10 12 G PD 2PH
	2EMC 2TUD
Leaders need to have ambition	2 3 G L EMC TUD
Leaders should provide vision	2 3 10 G L PH 2EMC TUD
A leader must be open to different backgrounds and interests	3 7 8 10 12 L 2PD 2PH 4EMC TUD
A leader must be open in communication	7 8 12 2PD PH 2EMC TUD
Leaders must be aware of differences	11 12 2PH 2TUD
A leader must be able to deal or communicate with a diversity of people	2 5 7 G PD PI EMC 2TUD
Leadership must believe in holism	2 G TUD
Leadership must stimulate bottom-up discovery	2 G TUD
Leaders need to be empathetic	2

	G TUD
A leader should be aware of what is going on in a community	2 6 9 G PD PI 2EMC TUD
Leaders must have vigor	2 G TUD
Leaders must be able to inspire and engage others	2 3 6 G L PI 2EMD TUD
Leaders must invest time and effort	2 3 10 G L PH 2EMC TUD
Ambiguity is challenging for leadership	2 4 G L 2TUD
Formal leadership helps start up processes (e.g. communication)	3 L EMC
More diversity necessitates more direction from leaders	3 L EMC
Leaders should be able to adapt to changing circumstances	2 3 4 5 7 9 12 G 2L 2PD PH PI 3EMC 3TUD

The online environment is a challenge to leadership	3 L EMC
Leaders need to take the values and interests of individuals into account	3 4 7 9 2L 2PD 3EMC TUD
Formulating shared goals is a challenge for leaders	4 L TUD
Leaders need to be less involved on a content level, more overarching role	4 5 L PI 2TUD
A leader should give autonomy to their team members	3 4 5 6 9 12 2L PD PH 2PI 3EMC 3TUD
Distributed leadership contributes to learning	4 L TUD
Leaders should help people get out of their comfort zone	4 L TUD
Leaders must allow for failure	4 12 L PH 2TUD
Leaders should keep the overall goal in the forefront	4 5 L PI

	2TUD
Leaders should build incentives for this type of collaboration	5 PI TUD
Leaders should recognize the value of others	5 PI TUD
Strong & harsh leadership is not beneficial for this project	5 6 2PI EMC TUD
Leaders should provide opportunities for collaboration	5 7 12 PI PD PH EMC 2TUD
Aligning different viewpoints is challenging for leadership	5 PI TUD
Leadership should not be (very) hierarchical	5 6 2PI EMC TUD
Leadership plays a role in making learning explicit	5 7 10 PD PH PI EMC 2TUD
Leadership plays a role in developing a learning mindset	5 7 12 PD PH PI EMC 2TUD
Willingness to lead is beneficial for the effectiveness of leadership	7

	PD EMC
Leaders should follow up on people and stay on top of things	7 8 10 2PD PH 3EMC
Leaders should have social skills	7 PD EMC
Leaders should adopt a learning mindset to their own leadership	7 PD EMC
Leaders need to be direct	8 PD EMC
Leaders need to provide others with feedback	8 9 2PD 2EMC
Leaders need to make others feel comfortable	9 PD EMC
Leaders need to make others feel confident	9 PD EMC
Leaders need to be confident	9 PD EMC

Leaders should be honest	9 PD EMC
Leadership has a role in developing a common understanding	10 PH EMC
Leadership should value diversity	11 PH TUD
Leadership should provide a safe and inclusive environment	11 12 2PH 2TUD
Leaders must be humble	12 PH TUD
Leaders must be transparent	12 PH TUD

APPENDIX F – THEORETICAL BASIS FOR EXPERIENCES AND A NETWORK PERSPECTIVE

In this appendix, work that had previously been done in relation to the literature study but was later found to be outside the scope of this Master Thesis Project is presented. The reason for it is that it might provide a theoretical basis for people interested in exploring (1) the influence of perceptions and experiences on learning, or (2) a network perspective to learning and leadership.

THE INFLUENCE OF PERCEPTIONS AND EXPERIENCES ON LEARNING

Learning was found by Bos et al. (2013) to be greatly influenced by the perceived value of what is to be learned. I.e., knowledge acquisition depends on the perceived utility of the knowledge. However, whether or not people obtain information from other people does not just depend on the utility of that information (Nakayama et al., 2019). The utility has to outweigh "the cost associated with obtaining knowledge from the direct interaction with the environment" (Nakayama et al., 2019, p. 1). Therefore, it could be said that the easier and more comfortable it is to obtain information, the more frequently it will be done, even with information of which the utility might not be or seem as high.

Introducing ease into the system to stimulate a certain behavior reminds of the Fogg Behavior Model (see Figures F.1 and F.2). This model explains how the right combination of a trigger or prompt, motivation, and ability results in a desired behavior (Fogg, 2009). What is particularly interesting about this model is the threshold the trigger has to overcome, constituted by the level of motivation and ability combined, to be able to successfully guide the person towards the desired behavior. The model specifies that the easier something is to do, the higher the ability is to do it, and thus the lower the motivation has to be to perform the behavior once prompted. Naturally, it would be preferred to also have the people be motivated to perform the behavior, but it is also logical to think that in the very beginning, performing a novel behavior induces stress and anxiety due to uncertainty. Therefore, increasing the ability to perform a behavior by introducing simplicity and comfort into the system may be a smart first step into inviting people to perform a desired behavior, such as knowledge sharing to increase learning.

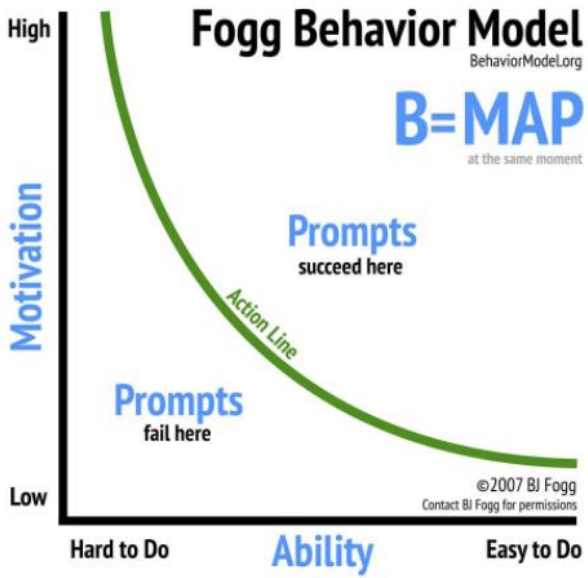

Figure F.1: The action line of the Fogg Behavior Model where a high enough combination of ability and motivation combined with a prompt results in the desired behavior (Behavior model, 2021)

Kahneman (2011) also mentions simplicity, or cognitive ease, to have an effect on our perception of whether something is true or good (see Figure F.3). As Figure F.3 shows, cognitive ease leads to experiencing something as familiar, true, good, and effortless, which in turn leads to accepting it as the desirable and the truth (Kahneman, 2011). Therefore, the ability to stimulate repeated experience, a good mood, a clear display, and prime an idea, contributes to the ability to influence a learning experience.

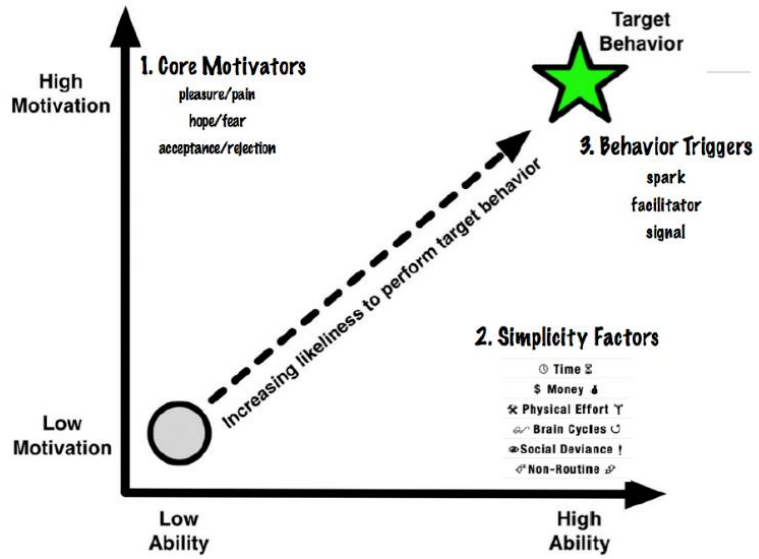

Figure F.2: The three factors of the Fogg Behavior Model (motivation, ability, and trigger) and their subcomponents (Fogg, 2009).

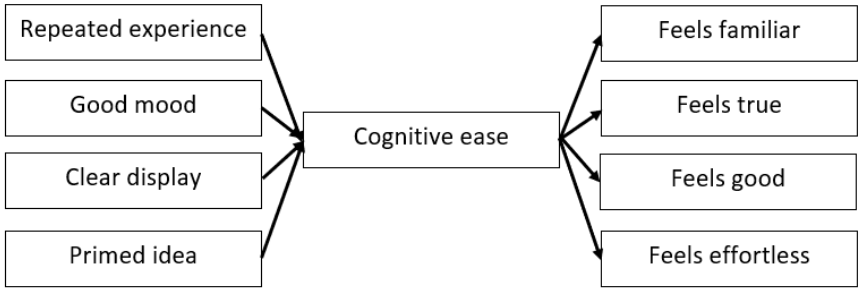

Figure F.3: Conditions that contribute to cognitive ease, which in turn influences our perception of what is true and desirable, as proposed by Kahneman (2011).

In their model of informal and incidental learning (see Figure F.4), Watkins & Marsick (2021) portray an experience, problem or opportunity to be the trigger that initiates the loop where (informal or incidental) learning can take place. However, this trigger, the interpretation thereof, and the examination of alternatives and selection of solutions (three consecutive states in the model of Figure F.4), are all influenced by the mental models of the person or people who experienced the trigger in the first place. This notion is underscored by Enserink et al. (2010) who state that a problem definition is never neutral as what is included and excluded in the definition is based on the perceptions of the problem formulator, and each different problem formulator has different perceptions and experiences and thus produces a different problem definition. Clinging too hard to mental models or perceptions can impale you to learn anything new and look at a situation objectively (Watkins & Marsick, 2021). Therefore, introducing multiple viewpoints, preferably from 'outside' the situation that brought about the trigger, is of great importance for improving the learning experience.

Buckley & Nimmon (2020) found that the opinion of trusted and respected colleagues influences the perception of the other participants concerning the usefulness of the session. Additionally, individuals are most likely to consider (new) information as true when coming from individuals that are respected, familiar, dominant, bold, considered 'the same', seen as influential, or seen as knowledgeable (Nakayama et al., 2019). Consequently, the type of information spread by these types of individuals has an effect on group performance (Nakayama et al., 2019). Making sure these individuals are well-informed and up-to date is therefore beneficial for the performance of the whole network. Furthermore, Buckley and Nimmon (2020) found in their study that participants sought out people with more knowledge than themselves in areas which the participants viewed as important. This is an important notion, since now it seems that knowledgeability is not the only driver to seek out someone for information: the perception of the relevance, utility, and importance of the knowledge of that person is of influence as well. Therefore, changing the perceived value

and importance of others' knowledge and work may increase social interaction with the goal of procuring information, which increases the amount of (novel) knowledge shared, which in turn increases diversity of knowledge available and therefore reveals more opportunities for learning.

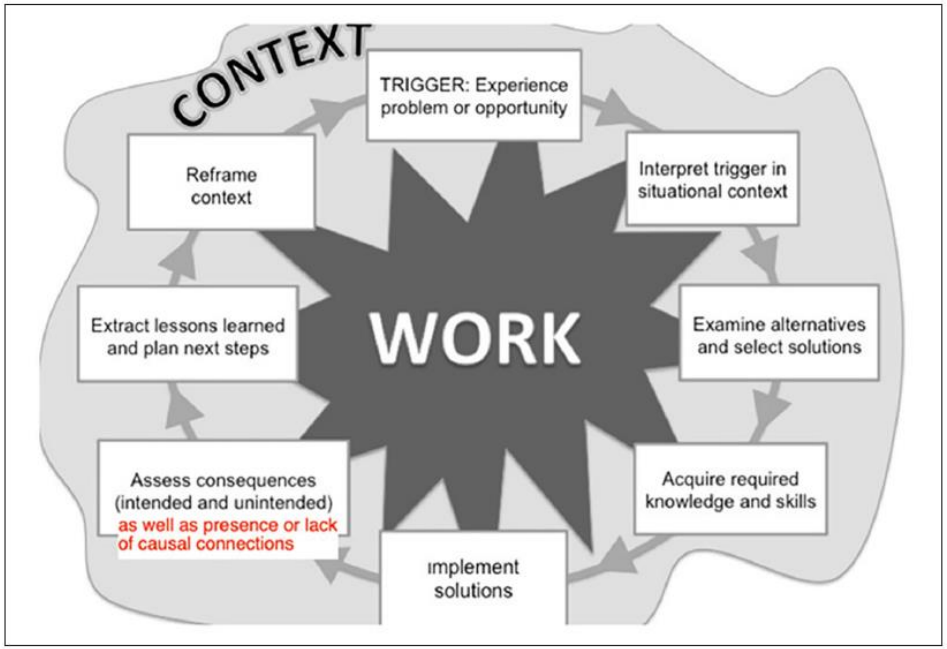

Figure F.4: Watkins & Marsick's model of informal & incidental learning (Watkins & Marksick, 2021, p. 91).

The ability to accept feedback, especially negative feedback, as well as the ability to share sensitive information was found to be dependent on whether or not the other party was regarded as both credible and trustworthy (Buckley & Nimmon, 2020). Credibility was described by one participant to be influenced by their social reputation, connectedness with that person on a personal level, a feeling of comfort and safety with that person, and whether or not that person was seen as a role model. Thus, it could be said that credibility needs to be combined with "feelings of psychological safety" (Buckley & Nimmon, 2020, p. 24) to provide an environment that enables people to be vulnerable, open up, and thus provide learning opportunities. Building onto that, several participants mentioned psychological safety as well as respect as building blocks for collegial relationships (Buckley & Nimmon, 2020). These collegial relationships in turn provide safe opportunities for knowledge sharing so that learning can take place.

Experience is believed to play a crucial role in learning (Vince, 1998; Kolb et al., 2001). Not only do our experiences influence our perceptions, they influence learning and learning processes directly as well. The Experiential Learning Cycle (ELC), proposed by Kolb et al. (2001) and portrayed in Figure F.5, consists of four stages of learning: "immediate or concrete experiences are the basis for observations and reflections. These reflections are assimilated and distilled into abstract concepts from which new implications for action can be drawn. These implications can be actively tested and serve as guides in creating new experiences" (Kolb et al., 2001, p. 3). These four stages are also linked more explicitly to experience by Vince (1998) and can be found in Figure F.6.

Vince (1998) points out an important simplification of reality present within the ELC. Namely, that experiences are currently not seen as being influenced by social (power) relations, as well as the assumption that people who have the experiences are able to and actually speak up and share those experiences. Sometimes, this is indeed possible. However, it needs to be kept in mind that, in order for experiences to contribute to learning, an environment in which trust and psychological safety are present and openness and honesty are valued is necessary. Furthermore, the ELC only takes past experience into account, not current experience. This may pose a problem as evading current experiences also avoids dealing with confrontational or uncomfortable feelings or situations in the moment (Vince, 1998).

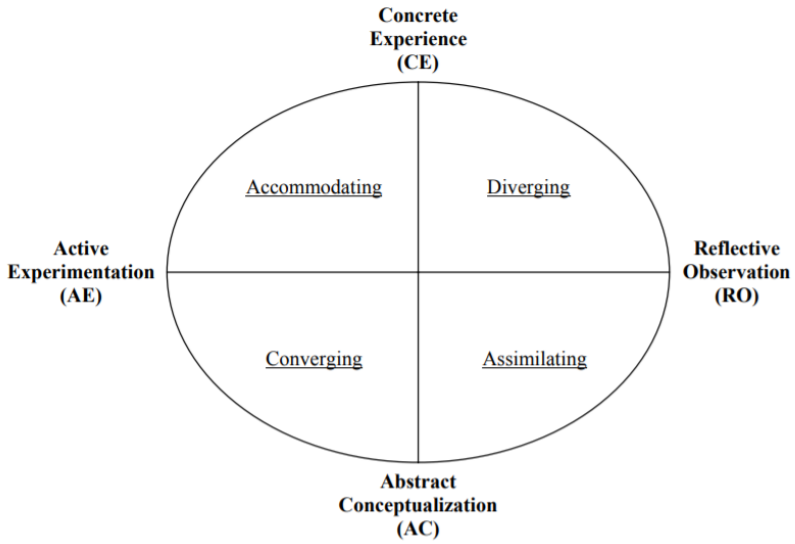

Figure F.5: The Experiential Learning Cycle and Basic Learning Styles, as proposed by Kolb et al. (2001)

Figure F.6: Kolb's Experiential Learning Cycle expressed explicitly in relation to experience, as proposed by Vince (1998).

Besides learning stages, the ELC in Figure F.5 also proposes four basic learning styles that each combine two consecutive steps in the ELC: diverging, assimilating, converging, and accommodating (Kolb et al., 2001). Since each person has their own learning style, it is important to keep cycling through the learning cycle to accommodate all the different learning styles, to ensure that effective learning is taking place for all team members. These different learning styles or learning preferences can be attributed to, for example, "Personality types, early educational specialization, professional career, current job role, and adaptive competencies" (Kolb et al., 2001, p. 7), but will not be further discussed as they are beyond the scope of this master thesis. What is interesting to note, however, is that the ELC contains both converging and diverging processes, which again underlines the importance of incorporating both modes of thinking in learning processes.

LEARNING FROM A NETWORK PERSPECTIVE

Social interactions and boundary spanning have been said to contribute to more effective and fruitful learning opportunities due to an increase of diversity. However, the question remains in how to discover the people, or nodes, in the (socio-technical) network that possess the potential to positively influence learning processes. Furthermore, organizations can be seen as "systems of distributed knowledge rather than centralized knowledge" (Ahern et al., 2015, p. 746), which is also mentioned by Araujo (1998) to be the case. Both statements show support of applying a network perspective to learning.

Imagine we would draw out the network of the Digital Twin team. Based, on what has been said previously, we would be looking for the characteristics or elements listed below. Note that a 'node' means an individual. A connection between nodes, also referred to as a 'link', represents some sort of relationship between two individuals.

- Structural holes. Structural holes, meaning the missing potential links between existing networks of nodes, mark the places of potential for increasing diversity in shared knowledge (Burt, 1997) and thus learning opportunities. These places can be referred to as the boundaries between the existing separate networks.

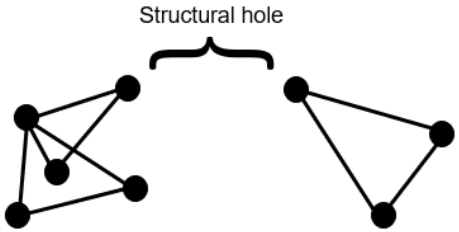

Figure F.7: Example of a structural hole between networks

- Bridges. Bridges are nodes that, from the perspective of one network, are the only nodes that provide a connection to another network. They are great sources of novel information, which increases learning opportunities and reminds of the important notion of experimentation introduced earlier by Ahern et al. (2015). Spanning boundaries, by for example forming bridges, is emphasized as well by Csermely (2017) who states that the nodes that form bridges between networks are often the creative nodes. These nodes are dynamic, unpredictable, and often change their links within and between networks, resulting in new and creative connections and information. Due to the nature of creative nodes, they do not belong to any one system and can therefore provide an objective view of problems and be free from both the opinion of others and the pressure of the network cores (Csermely, 2017). However, there needs to be a limit to the extent of diverse connections and creativity present within the system (Csermely, 2017). Too much diversity is detrimental for creativity – when will it ever be enough. Too much (individual) creativity will be demolishing for the network as a whole, since individuals will more likely pursue their own ideas than disseminating proven ones (that are not their own). A network needs just a few creative nodes to come up with novelties, which can in turn inspire the masses to copy those creative endeavors (Csermely, 2017).

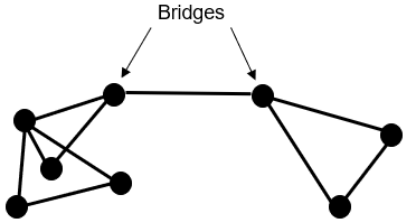

Figure F.8: Example of bridges between networks

- Bonding: Bonding indicates high level of trust and much knowledge sharing, which in turn indicates high chances of social learning (Wenger, 2000). Bonding can be identified by close collaboration networks marked by a high number of links between nodes, often based on a high level of proximity or similarity (Burt, 2000), based on for example culture, gender, intelligence, education, background, geography, or interests. Networks in which there is much bonding between nodes can be regarded as a community. As has been stated before, communities are positively related to (social) learning opportunities (Wenger, 2000; Dohaney et al., 2020; Talebizadeh et al., 2021). Csermely (2017) adds that highly connected nodes, or nodes with many bonds within the network, that can be found in a hub in a center of the network are nodes that distribute known responses to known problems. I.e., their behavior is predictable and steady. This reminds of the exploitation of known resources and processes for learning opportunities as a safe basis to fall back on, as introduced by Ahern et al. (2015). Moreover, familiarity plays a role in learning as well. Familiar nodes, which from a network perspective can be translated to nodes having numerous connections to other nodes, were found to have an impact on the motivation of nodes connected to them to attend (learning) activities (Buckley & Nimmon, 2020). Therefore, ensuring that highly connected and thus highly familiar nodes attend or even organize learning activities would then result in more people joining the activity, thereby increasing learning potential.

Furthermore, the presence of a familiar colleague creates a comfortable environment, allowing learning to take place more easily (Buckley & Nimmon, 2020).

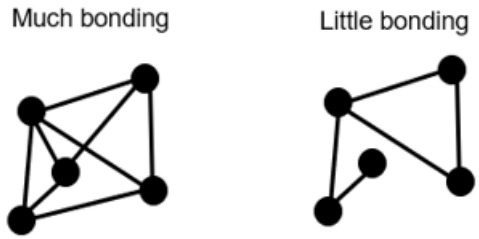

Figure F.9: Example of bonding within a network

- A base of support: Learning is not just about what takes place in the room: the social networks the participants are a member of influence the process of learning before, during, and after the session (Buckley & Nimmon, 2020). Participants "reported going to colleagues in their network for reassurance, feedback, or advice" (Buckley & Nimmon, 2020, p. 23), which implies that social network relationships have an effect on the participants' learning in informal settings. Therefore, building in processes for advice, feedback, and reassurance from these social networks is crucial for enhancing the learning experience, and thus also for dealing with complex and novel situations (Buckley & Nimmon, 2020). Furthermore, this suggests that the smaller the network and the more limited the diversity of the network, the less learning can take place (Buckley & Nimmon, 2020).
- Power, status, and credibility: individuals who are perceived as having much power, high status, and/or high credibility greatly influence knowledge transferal and thus learning (Ipe, 2003; Nakayama et al., 2019; Buckley & Nimmon, 2020). Specifically, Ipe (2003) reported a study in which it was discovered that "(a) individuals with low status and power in the organization tend to direct information to those with more status and power, and (b) individuals with more status and power tend to direct information more toward their peers than toward those with low status and power" (p. 347). Buckley & Nimmon (2020) found that the opinion of trusted and respected colleagues influences the perception of the other participants concerning the usefulness of the session. How the individuals that are perceived as powerful, having a high status, and/or credible depends on the basis on which the links and nodes in the network are drawn. Furthermore, other factors that influence perceptions that influence learning as mentioned in a previous chapter may also be taken into consideration when drawing the network.

Important to note is that drawing a network can be done in many different ways, as has briefly been touched upon above. For example, the network of the same team might look different based on whether the links drawn are professional or personal in nature. From a professional perspective, a link between node A and B might mean there is mutual respect or possibly a consisting communication channel through work email. From a personal perspective, node A and B might not even share a link since they do not communicate outside of work and do not consider each other friends. Moreover, Ahern et al. (2015) introduce the idea that between every two people there are two possible knowledge links: one from A to B, and one from B to A. The existence of one does not automatically result in the existence of the other. Additionally, the two people themselves can be seen as sources of knowledge. Therefore, for every two nodes, there are four potential knowledge elements. Based on this insight, drawing a link between two nodes as a simple line does not specify the direction of the link, nor does it take the nodes themselves as individual sources of information into account. Therefore, the way in which networks are drawn has a great impact on the identification of meaningful characteristics that can truly have an effect on learning opportunities and learning outcomes.

LEADERSHIP FROM A NETWORK PERSPECTIVE

"A community in a network is a set of nodes that is densely interconnected while loosely connected to the rest of the network" (Javadi et al., 2018, p.

97). Mostly, communities are formed around nodes with many connections to other nodes (Javadi et al., 2018). These highly connected nodes are referred to by Javadi et al. (2018) as leaders. In line with that, Chen & Wang (2008) state that a higher centrality of the node, meaning a higher number of nodes connected to that node, results in more influence of that node in the network. Kwok et al. (2018) explain how "possessing and sharing expertise and fostering relationships" (p. 3) adds value to the social network and increases the status of the person enacting them, which results in the person becoming a more central node. Therefore, it can be said that leaders are often central nodes or nodes with high degree centrality. This high degree centrality can be obtained through possession and sharing expertise and relationship building.

In a dynamic social network, stability is a valuable asset and is found more in high degree centrality leader nodes than in non-leader nodes (Javadi et al., 2018). Therefore, stimulating community formation around leader nodes in a dynamic social network, as is the case in the Convergence Agenda, provides the stability necessary for safe exploration and experimentation.