THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Navigating Sustainability Transformations

Backcasting, transdisciplinarity and social learning

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Cover:
Left and right foot of little Rut, 10 days. Impression in blue

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Abstract

Complex and persistent sustainability challenges necessitate transformations into futures that are fundamentally different to what was before. Such change processes cannot be planned in traditional ways; they require reflexive modes of governing where we collectively learn how to navigate uncharted terrain while exploring it.

The aim of this thesis is to contribute knowledge on how sustainability transformations can be navigated in practice. Such efforts are essentially transdisciplinary where actors across sectors, perspectives and disciplines are brought together around a complex issue, question or challenge of concern in context. By drawing from knowledge and experience on how systems develop and the possibility to influence how they should develop, such processes seek to both understand and address complex challenges by means of resolving problematic situations and transforming established systems, structures and practices. Efforts to navigate sustainability transformations in practice are far from straightforward; they require adequate conditions including methodological support to become meaningful as well as impactful.

This thesis builds upon a backcasting from principles methodology to support engagement with complex sustainability challenges and transformations. It recognises the transdisciplinary condition of reflexive governance and the contextual contingency of such practices. It is underlaboured with critical realism and a systems-based approach and approaches deliberate and purposeful attempts to navigate transformations as processes of transformative social learning. Further, the thesis puts key attention to issues of Education for Sustainable Development.

The thesis adheres to an ethnographic research tradition with qualitative/intensive research designs, guided by three interrelated methodological moves: (1) *initial engagement with cases* focusing on gathering experiences from participating actors and societal effects from backcasting processes in their wider governance and learning setting, educational as well as informal; (2) *conceptual development* to enhance backcasting processes in transdisciplinary settings, with focus on how

guiding principles for sustainability can be collectively negotiated, and; (3) *analytical deepening* to better understand and explain how and why experiences and effects are generated in backcasting processes with attention to their surrounding contexts. These three methodological moves resulted in five research papers, for which I dedicate this thesis to position and further discuss.

The main contributions of this thesis are: (1) a positioning of a principles-based purposeful, systemic, transformative and reflexive praxis with an associated and further developed backcasting from principles methodology. This methodology consists of a series of suggested steps, actions, guiding questions, qualities and features that seek to enhance the way complex sustainability challenges can be addressed to make efforts of navigating sustainability transformations in practice meaningful and impactful; (2) studies into a concrete curriculum model with transformational sustainability ambitions, Challenge Lab, whose curriculum design has been further conceptualised and mechanisms of learning empirically investigated. The curriculum design and associated mechanisms of learning may support the design, development, evaluation and comparison of educational initiatives that seek to create space for students to engage with complex sustainability challenges in their authentic societal context in open-ended processes together with societal actors, and; (3) an exploration of the necessity and potential value of comparing processes, effects and impacts from transformative, transdisciplinary and reflexive governance initiatives across contexts to better establish what works, for whom and why. Such knowledge moves beyond cumulation of knowledge on the particular methods and tools deployed in cases, into underlying features and mechanisms on which knowledge may be cumulated, generalised and transferred across cases and contexts.

Finally, navigating sustainability transformations in practice is as much dependent on our collective capability of stepping back to reflect by asking questions of why, as stepping forward to act by asking questions of how. This thesis introduces a further interest in exploring whether, how and to what extent backcasting as methodological frame may guide the concrete design of transdisciplinary sustainability-oriented initiatives and condition processes of transformative social learning.

Keywords: Sustainability, transformations, transitions, systems change, backcasting, transdisciplinarity, social learning, Education for Sustainable Development (ESD), reflexive governance

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List of appended papers

I   **Larsson**[1]**, J.,** & Holmberg, J. (2018). Learning while creating value for sustainability transitions: The case of Challenge Lab at Chalmers University of Technology. *Journal of Cleaner Production*, 172, 4411–4420.

Idea & conceptualisation, J.L., J.H.; Methodology, J.L.; Data collection, J.L.; Analysis, J.L, J.H; Writing, J.L.; Editing, J.L, J.H.

II   **Holmén**, **J**., & Holmberg, J. (2020). Beyonding, broadening and togethering: exploring capacities of guiding principles in navigating sustainability transformations. *Under review*

Idea & conceptualisation, J.L[2]., J.H.; Methodology, J.L.; Data collection, J.L.; Analysis, J.L, J.H; Writing, J.L.; Editing, J.L, J.H.

III   Holmberg, J., & **Larsson**, **J**. (2018). A Sustainability Lighthouse— Supporting Transition Leadership and Conversations on Desirable Futures. *Sustainability*, *10*(11), 3842.

Idea & conceptualisation, J.H.; Methodology, J.L.; Data collection, J.L.; Analysis, J.H, J.L; Writing, J.H., J.L.; Editing, J.H, J.L.

IV   **Holmén**, **J**., Adawi., T., & Holmberg, J. (2021). Student-led sustainability transformations: employing realist evaluation to open up the black box of learning in a Challenge Lab curriculum. *International Journal of Sustainability in Higher Education, 22* (1)

Idea & conceptualisation, J.L., T.A., J.H.; Methodology, J.L., T.A.; Data collection, J.L.; Analysis, J.L, J.H; Writing, J.L.; Editing, J.L., T.A., J.H.

V   **Holmén, J.,** Williams, S., & Holmberg., J. (2020). Same, same but different: Comparing sustainability transition labs across process, effects and impacts in practice. *Manuscript to be submitted*

Idea & conceptualisation, J.L., S.W., J.H.; Methodology, J.L., S.W.; Data collection, J.L., S.W.; Analysis, J.L, S.W; Writing, J.L., S.W.; Editing, J.L., S.W., J.H.

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[1] Pre-marriage.

[2] I use the acronym J.L. throughout the contribution report to avoid confusion with J.H. (John Holmberg).

Related publications not included in this thesis

Journal publications

I   McCrory, G., Schäpke, N., **Holmén, J**., & Holmberg, J. (2020). Sustainability-oriented labs in real-world contexts: An exploratory review. *Journal of Cleaner Production*, *277*, 123202.

II Fazey, I., Schäpke, N., Caniglia, G., Hodgson, A., Kendrick, I., Lyon, C., Page, G., Patterson, J., Riedy, C., Strasser, T., Verveen, S., Adams, D., Goldstein, B., Klaes, M., Leicester, G., Linyard, A., McCurdy, A., Ryan, P., Sharpe, B., … **Holmén, J**., … Young, H. R. (2020). Transforming knowledge systems for life on Earth: Visions of future systems and how to get there. *Energy Research & Social Science*, *70*, 101724.

Conference papers and proceedings

III Holmberg, J., Andersson, D. & **Larsson**[3], **J**. (2015) Challenge Lab: a transformative and integrative approach for sustainability transitions. *Conference paper presented at the 6th International Sustainability Transitions Conference (IST-15)*. Sussex, UK

IV Holmberg, J., **Larsson**, **J**., Andersson, D. (2016) Students guiding societal transitions - examples from Challenge Lab at Chalmers University of Technology, Gothenburg, Sweden. *Conference paper presented at Engineering Education on Sustainable Development (EESD-16).* Bruges, Belgium

V   **Larsson**, **J**., Holmberg, J. (2016) Backcasting from sustainability principles – a case from a regional climate policy process in West Sweden. *Conference paper presented at the 7th International Sustainability Transitions Conference (IST-16).* Wuppertal, Germany

VI Holmberg, J., & **Larsson**, **J**. (2017) Challenge Lab – Learning by engaging in society's sustainability transitions. *Proceedings for the 10th Researching Work & Learning (RWL) International Conference Series.* Grahamstown, South Africa

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[3] Pre-marriage.

VII   **Larsson**[4], **J**., & Williams, S. & Holmberg, J. (2018) Guiding systemic change – a cross case analysis of 'transition labs' in Canada and Sweden. *Conference paper presented at the 9th International Sustainability Transitions Conference (IST-18).* Manchester, UK

VIII   McCrory, G., & Schäpke, N., **Larsson, J**., & Holmberg, J. (2018) Governing sustainability transitions: contrasting experimental arenas through the lens of Agenda 2030. *Conference paper presented at the 9th International Sustainability Transitions Conference (IST-18).* Manchester, UK

Book chapters and reports

IX   Sterner, E., Nordborg, M., Olsson., D., Ferring, J., & **Holmén, J.** (2020). Klimatet – en ödesfråga där fakta, värderingar och känslor möts. In Flesner, K.K., Larsson, G., & Säljö, R. (Ed.), *Känsliga frågor, nödvändiga samtal.* Studentlitteratur

X   Holmberg, J., & **Holmén, J.** (2020). Medskapande Omställningsarbete – Backcastingexpeditioner för Agenda 2030. *Report to the Swedish Association of Local Authorities and Regions (Sveriges Kommuner och Regioner)*

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[4] Pre-marriage.

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Preface

What you have in your hand or see on your screen, or interact with in some other way in these strange times is a Thesis by Publication. This format implies that I, as a doctoral candidate, have been occupied with publishing my research throughout my PhD, and my final research papers are compiled in a book format including an overarching 'Kappa'. The Kappa positions my papers in their broader context. For better or worse, there are no universal standards for how such a Kappa is to be structured or dimensioned (Mason & Merga, 2018). I have followed a conventional format that should be recognisable to the reader with some experience in engaging with academic texts and reports.

The Kappa has several functions. First, it provides an opportunity for me to position my papers within their broader field of research and argue for them as a collective contribution, where the whole may be understood as being more than its separate parts. Second, it provides me an opportunity to deliberate upon meta-theory and methodology in ways that journal articles seldom have space for or at times do not even value. Third, it provides me an opportunity to invite you to my conceptual world, present my story in doing this research and share thoughts and assumptions that have followed and guided me throughout the PhD process. In other words, the Kappa exposes a bit more of the kind of reasoning and thinking that has guided much work in the individual papers of this thesis. Hopefully, it helps you to better understand the overall contributions and implications of this thesis, opening up for further dialogue related to my work.

The thesis has allowed me to take a stance in working towards the betterment of the world in 'which we have been thrown', to cite philosopher Roy Bhaskar (1944-2014). My primary interests have been to be relevant to society and those struggling with sustainability challenges on a daily basis, which has led me into research processes with close connection to and relation with practice. This has been possible thanks to the privileged position as a researcher in Sweden in combination with a supportive research group and institutional setting, where I have had the freedom to pursue a PhD in line with my own interests. These interests have happened to coincide with a defining challenge of our time: realising a sustainable future for all, knowing that we in the present are far from there and in many ways seem to move further away from such ambition for every day that passes. However, we may remind ourselves that a good thing about the future is that it has not yet happened.

<div align="right">Johan Holmén, Gothenburg 2020-11-20</div>

NAVIGATING
SUSTAINABILITY
TRANSFORMATIONS

– The planet and the future, according to Greta Adamsson, 4 years

1 Introduction

We live in times of transformation. On top of, and partly resulting from, social, technological, cultural, political and economic developments, we face a series of interconnected challenges including climate change, resource depletion, political polarisation, social injustices, and biodiversity loss. These issues provide a context of persistent and complex sustainability challenges that require deliberate and purposeful transformations to be handled in time. Or, we will have to live and cope with transformations resulting from insufficiently addressing the same. In other words, transformation is no longer an option, and the challenge of sustainability is less an issue of creating change, and more about navigating already ongoing change processes into sustainable and desirable pathways (Burch et al., 2014; Fazey et al., 2018; Grin et al., 2010; O'Brien, 2013; Riahi et al., 2017).

While many of our pressing sustainability challenges manifest in nature (UN Environment, 2019), their resolution requires transformations and transitions[5] on a level of the societal structures, systems and practices generating the same (Grin et al., 2010; Loorbach et al., 2017; Scoones et al., 2020). Díaz et al. (2019):

> Reversal of recent declines—and a sustainable global future—are only possible with urgent transformative change that tackles the root causes: the interconnected economic, sociocultural, demographic, political, institutional, and technological indirect drivers behind the direct drivers. As well as a pan-sectoral approach to conserving and restoring the nature that underpins many goals, this transformation will need innovative governance approaches that are adaptive; inclusive; informed by existing and new evidence; and integrative across systems, jurisdictions, and tools. Although the challenge is formidable, every delay will make the task even harder (p. 1).

Transformations necessitate explorations into futures that cannot be known in advance and are yet to be given shape, guided by purpose and ethics in light of historical developments. We tend to be good at outlining disastrous futures with ever increasing rigour, detail and accuracy, describing what will happen when the challenges we face increasingly get out of hand under assumptions of inaction. While important, such reports must not distract us from also generating knowledge on how to meaningfully address the challenges whose consequences we are occupied with describing. Futures are not pre-determined or solely questions of probability and likelihood, but also about feasibility, choice and creation – futures

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[5] I understand transformations as wider societal change processes on a level of structure and encompassing human-environment relationships, that may also include transitions as change processes on a level of delineated socio-technical -institutional and -ecological configurations (Feola, 2015; Hölscher et al., 2018).

cannot only be forecasted, but also 'backcasted' (Robinson, 1988; cf. Meadows, 1999).

A new form of 'solutions-oriented' research and practice is emerging that seeks to not only describe and explain past and previous developments but also generate knowledge into how sustainability challenges can be addressed, transformations navigated, and sustainable futures given shape (Bai et al., 2016; Köhler et al., 2019; Loorbach et al., 2017; Miller et al., 2014). As no single actor has full control, knowledge or mandate over how systems develop or should develop, transformations require interaction and collaboration among actors across sectors, perspectives and disciplines to comprehensively grasp the complexity of systems and associated challenges. This issue is further reinforced by sustainability challenges typically being ill-structured and not following disciplinary boundaries, hence not in sync with how knowledge and expertise have been developed and society structured since the enlightenment and the rise of the modern university (Brewer, 1999; Messner, 2015). Rather, the open-ended complexity associated with sustainability challenges spanning over the social and the natural require systemic inter- and transdisciplinary approaches that cross-cut and horizontally integrate traditional and vertical silos (Bhaskar, 2010; Cutter et al., 2015; Hirsch Hadorn et al., 2008; Olsson & Jerneck, 2018).

To navigate sustainability transformations in practice, attention is increasingly put on reflexive and learning-oriented modes of governance as a complement to traditional planning-oriented forms of government. Reflexive modes of governance acknowledge the complexity, uncertainty and ambiguity associated with transformations, let go of control and emphasise collective exploration, experimentation and learning (Folke et al., 2005; Muiderman et al., 2020; Rotmans & Loorbach, 2008; Smith et al., 2005; Voß et al., 2006). In practice, such governance initiatives seek to understand and link up with past and previous (unsustainable) development dynamics and mobilise efforts into strategic 'acupuncture' interventions that purposefully induce, guide and accelerate transformations and transitions into sustainable and desirable pathways (Loorbach et al., 2017; Voß & Bornemann, 2011). Due to their place-based and contextual nature, these processes tend to unfold in local communities, at urban and regional levels, in policy networks and in various cross-cutting organisational initiatives that address domain-specific challenges on a systems level by combining the top-down with the bottom-up (Loorbach et al., 2017; McCrory et al., 2020; Scoones et al., 2020).

To date, general challenges remain, including how such processes and associated learning processes unfold and may be facilitated in practice, how to capture eventual effects and systemic impacts (as is often promised) and handle the influence of and contingency on context (Köhler et al., 2019; Loorbach et al., 2017; Luederitz et al., 2017; van Mierlo & Beers, 2018). This call for practically oriented research seeking to learn from and further cumulate knowledge on how to navigate sustainability transformations in practice, preferably drawing from and building upon experience from various cases and contexts.

These research interests may be approached from a perspective of transdisciplinary research and practice with key attention to processes of social (transformative) learning. Transdisciplinary processes are essentially about bringing together actors and perspectives across disciplines around a shared issue or question of concern, and in so doing produce knowledge oriented towards understanding complex sustainability challenges in context as well as working towards their resolution (Hirsch Hadorn et al., 2008; Klein et al., 2001; Lang et al., 2012; Max-Neef, 2005). Attention to such processes as processes of social learning moves attention beyond cognitive domains into collective capabilities of wider communities and brings issues of purposeful social action, agency and collective transformation of human activity to the forefront (Lotz-Sisitka, 2012; Lotz-Sisitka et al., 2015; Macintyre et al., 2018; Wals, 2009).

In addition, the necessity of transdisciplinary knowledge production points towards the key role of educational institutions in sustainability transformations. Many argue for a re-orientation of educational institutions to properly build the capacity, capability, competence and commitment to adequately address our common sustainability challenges and so realise sustainable and desirable futures in time (Barth et al., 2016; Cortese, 2003; Lozano, 2006; Orr, 1994; Sterling, 2010).

In this thesis, I particularly explore backcasting as a key methodology to guide such processes in practice. Backcasting is commonly part of various reflexive governance frameworks and is gaining increased traction for its potential in guiding sustainability transition initiatives in practice (Vergragt & Quist, 2011), along with acknowledgment for its potential to complement mainstream planning processes (Giddens, 2009b), as well as further progress on Agenda 2030 and the 17 Sustainable Development Goals (SDSN, 2015).

1.1   Problem and purpose statement

This thesis aims to further knowledge on how sustainability transformations can be navigated in practice. This research purpose builds on a series of problems and

issues as well as interests and curiosities related to recent developments within research and practice that seek to generate knowledge on, and engage with, complex sustainability challenges in society and navigate transformations into sustainable and desirable pathways.

First, a plurality of approaches, frameworks, methods, tools and techniques are suggested and used to guide and support the navigation of sustainability transformations in practice. Empirical investigation into how they play out in practice is generally lacking, including understanding of their underlying assumptions, qualities and features (Halbe et al., 2020; Loorbach et al., 2017; Vergragt & Quist, 2011). In this thesis, I explore a particular backcasting-from-principles methodology with its associated set of tools and techniques. I advance it theoretically and practically while evaluating its application in transdisciplinary and reflexive governance settings, with attention to experiences from participating actors and the surrounding context. I put primary emphasis on how guiding principles for sustainability may be negotiated in such processes, especially as the procedural aspects of sustainability (Robinson, 2004), including how and what voices are brought into the conversation, are key in deliberate efforts to navigate transformations with an explicit normative orientation (Blythe et al., 2018; Schäpke, 2018; Scoones et al., 2020).

Second, there is increasing interest in approaching sustainability transformations as processes of transformative social learning. Less is known on how such learning processes unfold and may be facilitated in practice (Macintyre et al., 2018; van Mierlo & Beers, 2018; Van Poeck et al., 2018). In this thesis, I study transdisciplinary backcasting processes in formal (educational) as well as informal learning settings that seek to navigate sustainability transformations in associated contexts. In Education for Sustainable Development (ESD) there is a general interest in transforming higher education for sustainability as well as in furthering knowledge on pedagogies and curriculum models in practice, where students engage and learn by engaging with complex sustainability challenges and transformations in society (Barth et al., 2016; Macintyre et al., 2018; Rodríguez Aboytes & Barth, 2020; Tilbury, 2011). Related to this, there are research interests in better understanding what students learn in such processes and why, as well as how knowledge and experience from such curriculum models can be transferred, scaled and mainstreamed across institutions and contexts (Agbedahin & Lotz-Sisitka, 2019; Mickelsson et al., 2019; O'Donoghue et al., 2019; Tilbury, 2016). In this thesis, I draw from a particular curriculum innovation initiative with a transformational sustainability orientation sharing most ESD ambitions: Challenge Lab (C-Lab) at Chalmers University of Technology (Holmberg, 2014). I also hold a

general emphasis on social learning processes in the framing of the appended papers and thus of this Kappa, further highlighted in the discussion chapter.

Third, while the navigation of sustainability transformations in practice is contingent on context, there is a need to cumulate and transfer practically relevant knowledge and experience across cases and contexts (Bai et al., 2016; Köhler et al., 2019; Luederitz et al., 2017). Deliberate sustainability transformation initiatives tend to promise systemic impacts, but contributions to the same are seldomly empirically assessed or evaluated in practice. The difficulty of such evaluation generally relates to attribution and time. Attribution is problematic since reflexive and transdisciplinary initiatives operate in open-ended and complex systems, where boundaries between deliberate process and surrounding context are blurry. As sustainability transformations are long-term processes, evaluating whether a particular initiative produced systemic impacts influencing the same is difficult to do in the short term. Yet, knowledge on the efficiency and effectiveness of such initiatives is important both to transfer knowledge and experience across cases on what actually works and for their accountability e.g. towards funding bodies. A general research interest lies in evaluating deliberate sustainability transformation initiatives by identifying significant features and attributing factors across, e.g., their inputs, processes, outcomes, effects and impacts (Luederitz et al., 2017; Patton, 2010; Walter et al., 2007; Wiek et al., 2014; Williams & Robinson, 2020). In this thesis, I explicitly engage with evaluation frameworks that seek to capture process-related factors of importance as well as associated effects and impacts. I further draw from a critical realist underlaboring (Bhaskar, 2008a, 2016) and explore realist evaluation (Pawson & Tilley, 1997) to cumulate knowledge on a level of underlying and generative mechanisms that produce outcomes of interest in context. Mechanisms are understood as holding a certain generality allowing for transfer across cases and contexts (Danermark et al., 2002; Sayer, 2002).

1.2   Research questions

This thesis engages with the general issue of navigating sustainability transformations in practice. It recognises the transdisciplinary condition of reflexive governance and the contextual contingency of such practice. I put primary emphasis on backcasting from principles as a methodology for guiding engagement with complex sustainability challenges and transformations in practice. I further view such engagement processes as processes of transformative social learning, with particular interest in issues of education and underlabour with critical realism and a systems-based approach (Figure 1).

I ask the following research questions, the particular positioning of which can be found in the papers in which they were posed, and recap the general aim of this thesis in furthering knowledge on how transformations and transitions can be navigated in sustainable and desirable pathways:

RQ1: How might ESD pedagogies and associated learning environments contribute to sustainability transitions within and outside higher education institutions? What do such learning environments mean for the students and stakeholders involved? (Paper I)

RQ2: What are key features of guiding principles for sustainability in supporting the navigation of sustainability transformations, especially when embedded in a backcasting approach? (Paper II)

RQ3: How can conversations on sustainable and desirable futures be supported in transdisciplinary processes in general and backcasting in particular? (Paper III)

RQ4: What learning mechanisms are at play in Challenge Lab? How can these be conceptualised as context-mechanism-outcome configurations to allow for meaningful transfer and comparison across cases and contexts, in research and practice? (Paper IV)

RQ5: How can sustainability transition/transformation initiatives (labs and arenas) be compared and analysed 'cross-case'? What features may be important to compare? What is some added value in conducting cross-case comparison and analysis? (Paper V)

For reasons of style and consistency with the language used and framing of this Kappa, the questions above are slightly modified from they are phrased in the individual papers, but their essence remains the same.

Complex sustainability challenges and the issue of

Navigating sustainability transformations in practice

necessitate reflexive modes of governing drawing from…

Transdisciplinary research
and practice

may be approached as
processes of…

guided and
supported by…

Transformative social
learning

Backcasting as practical
methodology

of particular interest and importance for…

Education for sustainable
development

Figure 1 – Main concepts of this thesis and their assumed relations. Note that the research questions in this thesis primarily relate to the lower three boxes, whereas its positioning relates to all. In this thesis, I underpin and underlabour these concepts with a systems-based approach and critical realism. These concepts are further introduced in the Chapter Background and conceptual framing.

1.3   Outline

The following chapters of this Kappa are dedicated towards outlining a background on theories and concepts informing and inspiring this research with emphasis on backcasting, transdisciplinarity and social learning (Chapter 2), followed by the methodological orientation of the thesis work (Chapter 3). I then briefly summarise the appended research papers (Chapter 4), followed by a discussion and synthesis that connects and situates the individual papers in light of the broader framing of this Kappa, considers limitations and outlines areas for further research (Chapter 5). I then draw some general conclusions (Chapter 6) and share personal experiences and reflections emerging from engaging as a researcher and teacher concerned with sustainability and societal transformations (Chapter 7). After the reference list, the research papers that form part of this thesis are appended in full.

2 Background and conceptual framing

This chapter provides a background and conceptual framing based on theories, concepts and assumptions that have guided my dissertation work. The chapter starts with a general introduction on *Complex sustainability challenges and systems change*, followed by a section on *Sustainability transformations in practice* with a focus on transdisciplinarity, social learning and backcasting. The chapter then ends with a section on *Education for sustainable development* dedicated to sustainability in higher education on a level of institution, pedagogy and curriculum.

2.1 Complex sustainability challenges and systems change

Sustainability can broadly be approached as the quest to give shape to a world where human life and societies can continue without deteriorating their own conditions for doing so (Daly, 1990; Kates et al., 2005; Sneddon et al., 2006; Waas et al., 2011). For example, when socio-economic development is dependent on processes of continuous environmental destruction, the planet's carrying capacity upon which life ultimately depends may eventually be exceeded, today evidenced in terms of, e.g., accelerating climate change and biodiversity loss. At the heart of sustainability lie notions of justice (WCED, 1987), within and between generations, as well as between humans, societies, nature and other species (Holmberg et al., 1996; Sen, 2013; Swilling & Annecke, 2012). Sustainability necessarily reflects what is considered important in a particular time and place by the voices that are heard and is often a matter of perspective, which has made it a well-debated concept that has been subjected to and has withstood much criticism. One may best approach sustainability as an essentially contested and moving object whose particular meaning evolves over time, deserving procedural negotiation in time, place and related to its particular context of application (Jacobs, 1999; Leach et al., 2010; Robinson, 2004).

Historically, mobilisation efforts on sustainability and sustainable development have often been facilitated by the United Nations (UN) and related bodies (e.g. UNCED, 1992; UNEP, 1972; United Nations, 2002, 2012; WCED, 1987). Further, in the most recent decades, a range of concepts (see Faran, 2010; Hopwood et al., 2005; Lozano, 2008) have been developed that highlight and bring sustainability-related concerns to the agenda, including *Spaceship Earth* (Boulding, 1966), *Limits to Growth* (Meadows et al., 1972), *Ecological Footprint* (Wackernagel & Rees, 1998), *Planetary Boundaries* (Rockström et al., 2009) and *Doughnut Economics* (Raworth, 2017).

The UN recently launched Agenda 2030 with its 17 Sustainable Development Goals, with the main message of *Transforming our world* (United Nations, 2015). The agenda refers to the integrated and indivisible nature of the social, economic and environmental dimensions of sustainability, and pledges that no one will be left behind in the transformation process. Despite much criticism of the anthropocentric and modernist views propelled by the United Nations and Agenda 2030 (de Vries, 2019) as well as in mainstream sustainability discourse (Hopwood et al., 2005), the Agenda may, due to its wide adoption, serve as a legitimate starting point for bringing issues of our collective futures to the fore. Yet, the particular understanding and meaning of sustainability still require negotiation in time and place, which may be referred to as *procedural sustainability*:

> Sustainability can usefully be thought of as the emergent property of a conversation about desired futures that is informed by some understanding of the ecological, social and economic consequences of different courses of action.

> This view acknowledges the inherently normative and political nature of sustainability, the need for integration of different perspectives, and the recognition that sustainability is a process, not an end-state. It must be constructed through an essentially social process whereby scientific and other 'expert' information is combined with the values, preferences and beliefs of affected communities, to give rise to an emergent, 'co-produced' understanding of possibilities and preferred outcomes (Robinson, 2004, p. 381).

By viewing sustainability as an emergent property of a conversation and inherently a social process, we move away from accepting it as a solely scientifically pre-defined bio-physical property (Ison et al., 2007). Such framing opens up for conversation and negotiation not only towards establishing (un)desired states and effects in nature, but also into the social domains via socio-ecological relationships and societal structures, systems and practices that eventually give rise to that which we refer and react to as 'unsustainable' in society and nature (cf. Price, 2019)

In the following sections, I seek to further articulate how we may approach complex sustainability problems[6] and challenges. I introduce a systems-based approach of

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[6] In this thesis, I've chosen to refer to sustainability challenges as *challenges* rather than *problems*. Problems tend to be part of problem-solution dichotomies, where solutions are assumed possible in eventually making problems go away. Several 'problems' of sustainability, such as climate change, depletion of scarce resources and social injustice, will likely be ongoing struggles for long periods of time and thus ever-present concerns. Such issues may not or cannot ultimately be solved. Rather, they have to be lived with, engaged with, addressed and handled over time. Further, there is a different logic between solving problems, by making something we do not like go away, and creating futures, by making something we truly care about come into existence (Senge, 2003).

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importance to both understanding and addressing such challenges and outline a view of systemic change processes as transformations and transitions.

2.1.1 Complex problems, challenges and systems

Persistent sustainability challenges are commonly understood complex or even wicked. Rittel and Webber's (1973) seminal work on wicked problems may be used as an entry point for this section, as the characteristics identified there fit most contemporary complex and persistent societal sustainability challenges (Lönngren, 2017; Loorbach, 2007; Miller et al., 2014), which therefore call for complementary and alternative approaches to traditional linear problem-solving procedures:

1. There is no definitive formulation of a wicked problem
2. Wicked problems have no stopping rule (no ultimate criteria for when the problem is solved)
3. Solutions to wicked problems are not true-or-false, but good-or-bad
4. There is no immediate and no ultimate test of a solution to a wicked problem
5. Every solution to a wicked problem is a 'one-shot operation' […] (no opportunity to learn by trial-and-error)
6. Wicked problems do not have an enumerable set of potential solutions […]
7. Every wicked problem is essentially unique
8. Every wicked problem can be considered a symptom of another problem
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways […]
10. The planner has no right to be wrong (planners are liable for the consequences of the actions they generate) (Rittel & Webber, 1973, pp. 161–167)

However, it is equally important to understand when the problem or challenge at hand is not wicked, which may be difficult to know beforehand due to the complex nature of society and associated systems in which problems emerge. Glouberman and Zimmerman (2002) produced a taxonomy that distinguishes key characteristics of simple, complicated and complex problems, where a simple problems is something that can be solved by following a recipe, where no expertise is required (although it may help), and good results are highly assured given that one has followed the recipe. Complicated problems have the properties of simple ones but additionally require specialised expertise and coordination, often due to their tendency to be large and of technical character. Complicated problems tend to be solvable by means of prediction and control measures in relation to externally set

goals, facilitated by Cartesian reductionism (where wholes are broken down into parts and solved individually) and so a functional division of labour. Success at one stage towards solving the problem increases the assurance for success in the next step, and knowledge cumulation tends to reduce uncertainty over time. This procedure may metaphorically be referred to as an issue of sending a rocket to the moon, which sure is technically complicated but not socially complex.

Before moving into how complex and even wicked problems may be understood and approached, some additional comments need to be made. First, while complicated problems may contain (but not be reducible to) simple problems, complex problems come with their unique and distinctive features. As such, the way we approach complex problems does not require a positioning that adds to the complicated, but rather distinguishes from. These advances are relatively recent in the complexity sciences, and there is to date still much confusion and conflation in how the complicated, complex and even the wicked are understood. In this thesis, I move forward with the view that we may understand the wicked as emergent from the complex *and* the complicated (Andersson et al., 2014). Further, the qualities and properties of a particular problem are deeply connected to the properties of the system within which it manifests, but the nature of this connection remains to be worked out (ibid.). This also means that even seemingly simple problems emerging in society may produce unforeseen and cascading consequences in complex ways (Lane, 2016).

Complex and wicked problems, then, cannot be separated from the systems of which they are part. Complexity may be understood as the dynamic properties arising from bottom-up self-organisation, often present in social, biological and other living systems. This can be contrasted with the complicated, understood as the structural properties arising from top-down organisation. When combining the complex and the complicated, what we have is essentially a wicked system or problem, wherein society and most contemporary sustainability challenges fit (Andersson et al., 2014).

In getting back to the work by Glouberman and Zimmerman (2002), who do not include wicked problems in their taxonomy but their description of complexity moves in that direction, stating that in addressing socially complex problems strict formulations have a limited application, successes at one step do not assure success for the next, expertise can contribute but is neither necessary nor sufficient as relations are also important, every problem is unique and must be understood as such, and uncertainty over outcomes remains. This understanding of complex problems is not too far away from how Rittel and Webber (1973) outline properties of wickedness.

I chose to describe sustainability challenges as challenges (rather than problems) in this thesis and use the term complexity due to its recognition in the field. While I recognise recent developments that seek to further distinguish the complex from the wicked, I do not pursue that distinction here and may use these terms interchangeably and in combination at times.

The complexity or even wickedness of sustainability challenges typically comes from their manifestation in social as well as natural domains. This makes sustainability issues operate in inherently complex and open-ended systems, significantly reducing the possibility of control (Leach et al., 2010; Loorbach, 2007; Olsson & Jerneck, 2018). Further, their causes tend to be contested due to their tendencies of being rooted in societal structures, systems and socio-ecological relationships (Holmberg et al., 1996; Price, 2019; Wynne, 1992), the causes of which may require ideological explanation (de Vries, 2019; Feola, 2019; Scoones et al., 2020). Further, sustainability challenges tend to be interconnected (e.g. across food, energy and water, or across economic growth, depletion of natural resources and well-being). Sustainability challenges also operate on multiple levels and are dispersed across time and space, making them generally assigned high degrees of complexity, uncertainty and ambiguity (Kates et al., 2005; Leach et al., 2010; Stirling, 2010).

Complex sustainability challenges require an approach adequately fit to its characteristics. For example, to deal with their complicatedness we must be systematic, and to deal with complexity towards the wicked we must be systemic (Ison, 2017). Otherwise, attempts to make progress on complex challenges may fall short, or even make issues worse in the longer run (Meadows, 2008; Ross & Mitchell, 2018). The following section looks farther into how systems-based approaches and critical realism may underpin and underlabour efforts of understanding and addressing complex sustainability challenges.

2.1.2 Systems-based approaches and critical realism

In approaching sustainability challenges meaningfully, this thesis takes a systems-based approach with a critical realist underlaboring (cf. Mingers, 2014). This approach to sustainability challenges seeks to direct attention towards such (underlying) structures, properties, systems and mechanisms in society and human-environment relationships that eventually give rise to unsustainable patterns, events and effects. Systemic challenge framings may thus move away from end-of-pipe measures and reactive/symptomatic problem solving that, for sure, may make certain undesired effects go away in the short run but also further entrench

unsustainable properties and systems dynamics that risk making situations even worse in the long run (Meadows, 2008).

Systems-thinking ontology is often illustrated in reference to iceberg models (Figure 2), seeking to illustrate how the events we observe and commonly react to (above the surface) emerge from certain patterns of behaviour conditioned by systemic structures (below the surface) (Meadows, 2008; Ramage & Shipp, 2009; Senge, 1990). From such conceptualisation we may, for example, better understand why individual behavioural change for sustainability efforts tend to fall short or remain marginal in contexts where underlying structures, norms and systems (that give rise to or even reward certain forms of practices and behaviour) remain intact (cf. Nyborg et al., 2016; Shove & Walker, 2010).
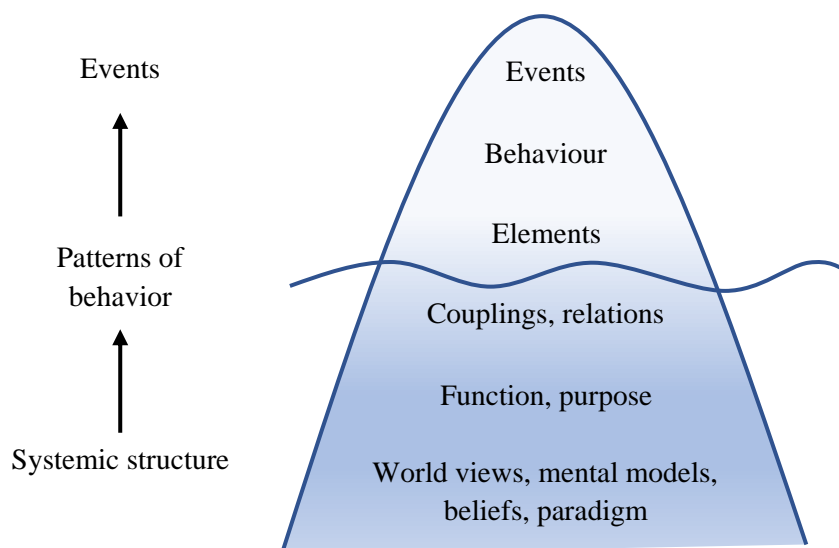
Figure 2 – An iceberg model representing systems as a set of coupled elements organised in such way that they fulfil a certain function or purpose within a current paradigm, eventually giving rise to certain behaviours and events. Hierarchy and description adapted from Senge (1990) (left) and Meadows (2008) (right).

Critical realists adopt a similar ontology to many systems thinkers (Mingers, 2014). In critical realism, the world is understood as stratified and differentiated across the three primary domains of *the real*, *the actual* and *the empirical*, where each is a subset of the former (Figure 3). The real refers to objects, their structures and properties with their causal powers and potentials. The actual refers to resulting happenings when powers and potentials are activated and generate change via mechanisms, and the empirical understood as the subset of the real and the actual as experienced by actors (Bhaskar, 2008a).
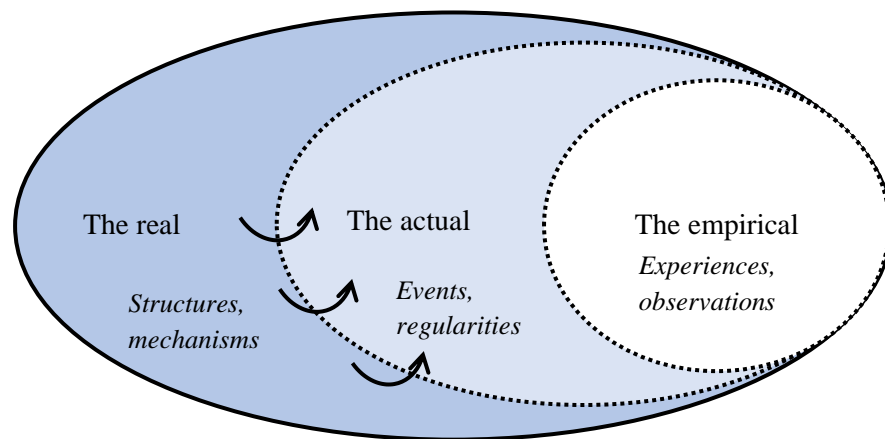
Figure 3 – Overview of the three domains of the real, the actual,
and the empirical in critical realist ontology.

The reduction of the real to the actual and empirical is referred to as the epistemic fallacy, i.e. where the world (ontology) is reduced to what can be known about the world (epistemology). Yet, to properly understand and even causally explain that which happens in the world, we must acknowledge not only the transitive domain (the actual and empirical) but also the intransitive domain (the real)[7]. Modes of inference that seek to construct knowledge of structures and mechanisms follow a retroductive logic, asking questions of the form what qualities must exist for something to be possible[8] (Bhaskar, 2008a; Danermark et al., 2002; Sayer, 2002). It is important at this stage to note that even knowledge of the intransitive domain will essentially be constructed in social processes by us humans who in turn are limited by our senses, where theory will always be concept-dependent and fallible (Bhaskar, 2008; Danermark et al., 2002; Sayer, 2002; cf. Mendelsohn, 1977).

Central to systems views and therefore critical realism are concepts of levels and emergence (Mingers, 2014). We may refer to the world as consisting of a series of distinct levels that are irreducible to one another yet related and interdependent and hence 'laminated' (Bhaskar, 2008a). These levels range from the (sub-)individual, psychological and biological levels to groups and societies, all the way to global and planetary wholes. Properties at one level may emerge from processes going on at other levels, either from 'below' or 'above' referred to as upwards and downwards emergence. For example, to explain the functioning and properties of water, we cannot solely rely on an explanation of its individual atoms as separate entities; we also need to look into properties of water molecules as emerging from it parts and

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[7] For an example of how this logic may shine new light on how we approach issues of climate change, see Price (2019).

[8] N.b. that critical realism is founded on the very question of what society must be like for science to be possible.

as emerging from relations between molecules (in this case caused by the hydrogen bond). The same goes for the way we approach and explain most complex and social phenomena (Danermark et al., 2002). In this sense, critical realism is anti-reductionist[9] and inclusive, acknowledging the importance of paying attention to wholes and parts across multiple levels and scales to properly grasp phenomena in the world. Further, Bhaskar (2008) considers any social event to simultaneously occur along the four planes of *material transactions with nature*, *social interactions between people*, *social structures*, and *the stratification of the embodied personality*.

In approaching social systems additional complexities arise compared to when approaching the natural, which partly relates to their properties of being open or closed (Bhaskar, 2008a; Danermark et al., 2002; Sayer, 2002) and to systems combining social and natural elements (e.g. socio-ecological systems). When understanding natural, physical and essentially non-human phenomena, we can assume an ontological distance to that which we observe. We may 'close' natural systems by constructing experimental settings that isolate single factors, introduce hypotheses and produce evidence giving us reason to either verify or falsify our hypotheses in deductive manners, where we assume that certain observed outcomes are governed by (natural) laws. From a critical realist understanding, we may understand such inquiry as attempts to generate knowledge into structures and mechanisms based on an initial set of guesses. The possibility of closing natural systems and uncovering their fundamental 'laws' (properties and mechanisms) may provide a main explanation for the success and cumulation of knowledge in the natural sciences. Similar procedures have proven difficult when studying the social. First, there is no ontological distance, as we are essentially part of the systems we seek to understand and observe (Bohm, 2002, 2013; Checkland, 2000). Social systems are inherently open systems contingent to context, different human beings may interpret similar phenomena in different ways and not only respond in different ways but also adapt and learn new ways of responding (Sayer, 2002). These conditions give rise to essentially unpredictable outcomes. And as social systems cannot be closed, it is not possible to study their underlying structures and mechanisms with the same degree of accuracy and precision as when studying the natural. In short, structures and social mechanisms are created by humans, may change over time and the way they operate and manifest is dependent upon, and may

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[9] N.b. that 'holism' as often proposed in sustainability-related contexts is also a form of reductionism. Yet, acknowledging the world as laminated and levelled implies that there is no contradiction in acknowledging that processes at various levels and scales indeed may co-exist and occur simultaneously (Cash et al., 2006; Sayer, 2002).

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differ across, contexts. On top of this, we have the ethical contestation of certain experiments, particularly those involving humans and animals (Giddens, 2009a).

Systems thinkers may not only be interested in understanding and explaining systems, but also changing them (where understanding and explanation play an important part). While the very act of observing systems may indeed produce change, I am here particularly interested in deliberate attempts to produce purposeful change (cf. Ison, 2017). In recalling the laminated view of reality, one may for example start asking questions about forms of possibility and limits across levels, including what limits sustainability challenges put on societies, systems and therefore individuals, and what possibilities there might be for individuals to influence systems and societies, all the way to how we live on this planet. In the transformational model of social action (TMSA), societal development trajectories are not understood as pre-determined by their structural properties and historicity, but rather understood as unfolding in a temporal interplay between structure and agency. Structure is understood as always pre-existing and necessary for agency by either limiting or enabling, but agency in turn may reproduce or even at times transform structure. TMSA further acknowledges that agency may also come from within, understanding human beings as possessing the power to act upon intentions, where reasons are understood as *causally efficacious in producing action* (Archer, 1995, 2003; Bhaskar, 2008a, 2016). We may further refer to the importance of power-to relationships in this context, where power-1 is essentially that which is referred to as agency above, and power-2 the specific kinds of power that (significantly) limit people's opportunity to act (Bhaskar, 2016).

The approach to systems as briefly outlined above may support overcoming the overly structural and functionalist turn in cybernetics and other forms of 1st generation systems thinking (Ison, 2017; Mingers, 2014). When approaching the world as an ontological rather than epistemic construct, we may overcome the issues of ending up in a situation where there is no external referent, with everything becoming relative and a matter of perspective. Rather, we may acknowledge that complex and essentially problematic situations may hold multiple (often conflicting) views and perspectives, which together may provide clues into what actually is or has been the case. We would still, however, acknowledge that even seemingly 'false' views are real and indeed analysed as real, in the sense that these views may still guide action and so have real consequences (cf. Sayer, 2002).

2.1.2.1 Levers for change and possibility

A key concept in systems thinking that brings together issues of structure, agency and change as briefly outlined in the previous section is the leverage point. The idea of the lever as a means of changing and essentially moving big things with little external force can be traced back to Archimedes (c. 287–212 BC) who, when explaining the principles of the lever, is supposed to have said something like *"give me a lever long enough and a fulcrum on which to place it, and I shall move the world"* (Figure 4).
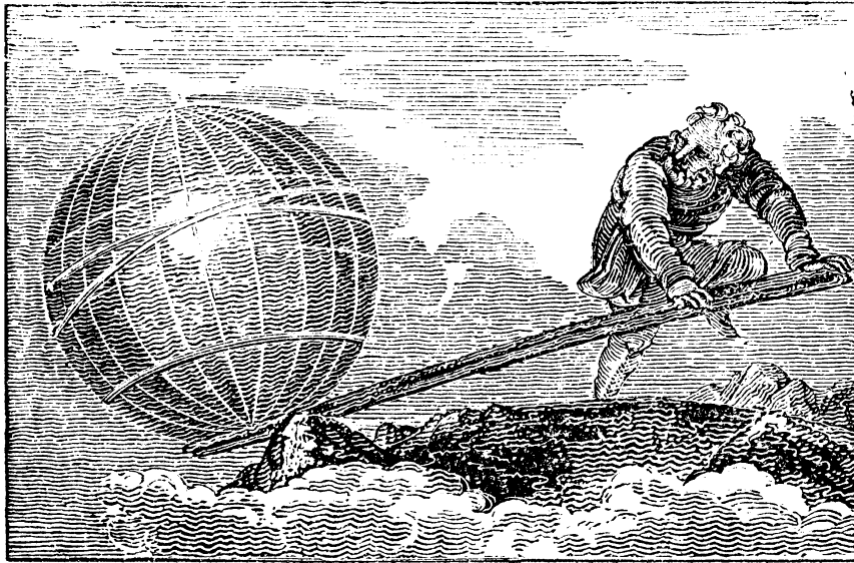
Figure 4 – The leverage point concept is commonly used to illustrate the possibility of small interventions having large effects on systems. Illustration from Wikimedia Commons.

The concept of the lever has been furthered in systems communities, where Donella Meadows popularised earlier work by Jay W. Forrester and referred to leverage points as *"places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift in one thing can produce big changes in everything"* (Meadows, 1997, p. 1). Meadows suggested a series of possible leverage points for intervening in systems across nine to twelve different levels, with a similar ordering as the levels of the iceberg in Figure 2. Deeper forms of leverage (bottom of the iceberg) are ascribed higher transformative potential, whereas shallower forms of leverage (top of the iceberg) are ascribed lower transformative potential and thus considered incremental. Abson et al. (2017) furthered the work by Meadows and suggested a conceptual ordering ranging from shallow, (1) adjusting parameters and (2) addressing interactions between elements and feedback mechanisms, to deep, (3) re-designing into social structures and institutions and (4) influencing values, goals and world-views giving shape to the emergent direction in which systems develop.

Rather than relying on an overly technicist view of leverage point as a well-planned intervention with tendencies towards social engineering, the leverage point concept may come in handy to support reasoning into the possibility and feasibility of desired change processes, as well as providing a general opportunity to further learn how systems work and should work by means of intervening (cf. Midgley, 2000). Kurt Lewin, who is one of the founders of action research, said that *"if you want truly to understand something, try to change it"*; a systems thinker would also stress the reverse, i.e. if you truly want to change something, try to understand it.

In further approaching change, the process of change and issues of deliberately and purposefully changing, we must acknowledge that facts alone are insufficient in changing the world (Caniglia et al., 2020; Kläy et al., 2015; O'Brien, 2013; Potthast, 2015). Rather, change processes imply dialectical moves from ontology (being) to axiology (value, ethics). In understanding dialectic as the general flow of argument, change or augmentation of freedom, critical realist dialectics view such movement as occurring along an onto-axiological chain linked in a MELD scheme (Bhaskar, 2008, 2016; cf. Schudel, 2017):

> 1M: First movement – non-identity, what is and is not (absence) of the depth strata of the real, i.e. not only what is empirically observed but also the actual and the real with its generative structures and mechanisms with power to make things happen in the world
> 2E: 2nd edge – negativity, of absence and process including the possibility to 'absent absences' by bringing forth novelty as alternative ways of being and transformation of structure
> 3L: third level – totality, bringing in morality, ethics and affective domains including choice among possible options of absenting, by discerning situations and relationships across, e.g., social, cultural and ecological factors and implications
> 4D: fourth dimension – transformative praxis as reflexive engagement with the world in context, performing intentional action that yet may hold unintentional consequences.

In the following section, I move from emphasis on systems and structures as *objects of change* into transformation and transition as *processes of change* in light of complex and persistent sustainability challenges.

2.1.3 Transformations and transitions

The width and depth of the sustainability challenges of our times, in combination with the desire for making rapid progress on addressing the same, increasingly make challenging navigating transformations on a level of systems, structures and practices in society, as also acknowledged in Agenda 2030 (United Nations, 2015). In ensuring sustainability and desirability of associated and already ongoing transformation processes (Burch et al., 2014; O'Brien, 2013; Riahi et al., 2017), deliberate and purposeful 'reflexive' modes of governance are needed that acknowledge conditions of uncertainty, complexity and ambiguity (Ison, 2018; Rotmans & Loorbach, 2008; Voß et al., 2006).

Various conceptualisations of transformation exist. Hölscher et al. (2018) note that transformation and transition are two common buzzwords signalling the need for deep and radical changes to achieve sustainable futures. These concepts are further understood as providing *"nuanced perspectives on how to describe, interpret and support desirable radical and non-linear societal change"* (p. 1). Transformation is often used in reference to encompassing and fundamental societal change processes, including changes in human-environment relationships with attention to sustainability, resilience and adaptive capacity. Transitions tend to denote more delineated shifts from one stable equilibrium to another, e.g. in socio-technical, -economic or -institutional domains (Feola, 2015; Hölscher et al., 2018; Patterson et al., 2017). A series of domain-specific transitions may thus be understood as contributing to wider processes of societal transformation (Loorbach, 2014).

In paying key attention to discourse and roles of agency, Scoones et al. (2020) outline three complementary conceptualisations of approaches to transformation as either structural, systemic or enabling. Structural approaches *"focus on changes in perceived underlying foundations of politics, economics and society, and the need for a complete overhaul of the ideological underpinnings of social systems writ large"*. Systemic approaches *"follow the resurgence of growth in systems thinking in the 1980s to identify particular features of systems as targets for focused change"*. Enabling approaches *"draw on both these traditions to highlight the agency and uncertainties inherent in choosing aims and directions for transformative change"* (pp. 2-3).

Transition (and to some extent also transformation approaches) to sustainability may thus be understood as situated at an analytical 'meso-level', in between the macro-level seeking to understand and change the nature of, e.g., capitalism and modernity, and the 'micro-level', seeking to understand and change, e.g., human behaviour and lifestyles (Köhler et al., 2019).

Regardless of conceptualisation, most important to this thesis is that these approaches have in common an understanding of complex and persistent sustainability challenges as partly resulting from and relating to established structures, systems and practices in society. While producing unsustainable results that are generally undesired by many, they may also fulfil functions, purposes, needs and wants that are generally desired. This double-edged nature of most societal structures and systems makes it generally difficult to figure out ways forward, especially in cases where sustainable alternatives do not have immediate user-benefits (Geels et al., 2008) and when there is a tension and clash of interests and benefits in the short and long term (Sen, 2013).

Generally, sustainability transformations (and transitions) may be viewed as essentially disruptive, uncertain, complex, ambiguous and open-ended change processes: where something old and established is being phased out, and something new is provided space and conditions to grow and eventually become established. Resulting futures from such change processes cannot be known in advance, but emerge from the process (Dreborg, 1996). In launching the idea of 'transitions management', Rotmans et al. (2001) argued that transitions cannot be planned and controlled in a traditional top-down sense, but may be induced, guided and accelerated by means of systemic interventions developed in processes of experimentation and learning-by-doing. Transitional processes were conceptualised as occurring in four distinct phases forming an 'S-curve', including phases of pre-development, take-off, breakthrough and stabilisation. More recent conceptualisations (e.g. Loorbach et al., 2017) of transitions and transformations view them as 'X-shaped' processes, where dominant, established and unsustainable structures, systems and practices are being phased out while sustainable and alternatives emerge (Figure 5).
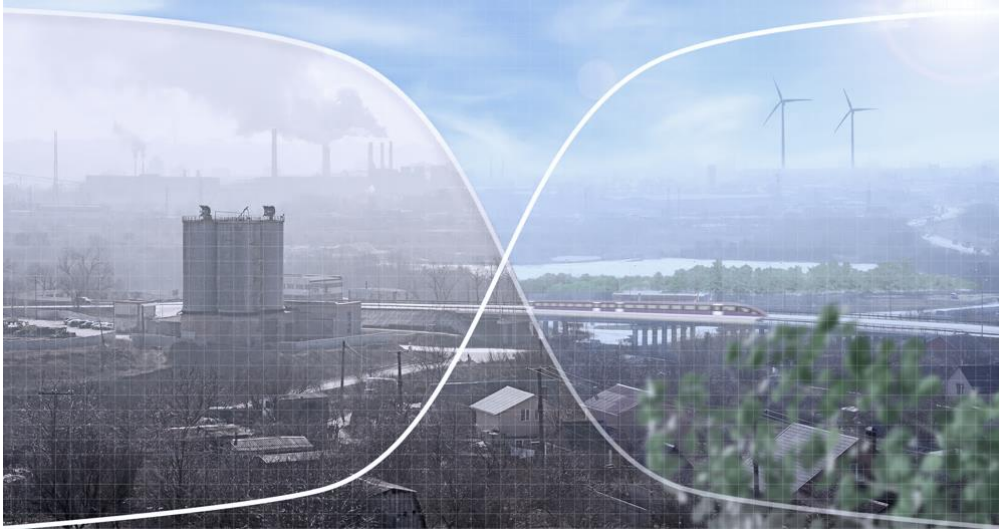
Figure 5 – In sustainability transitions and transformations, dominant and unsustainable systems and structures are phased out while sustainable alternatives are provided the conditions and space to become established. Image from Chalmers Initiative for Innovation and Sustainability Transitions (CIIST).

In the research papers included in this thesis, I have primarily related to socio-technical system conceptions, which I further present below. However, the contributions have implications for those with a general interest in deliberately navigating complex systems and change processes in sustainability-related contexts. Thus, I adhere to the concept of transformation as broad framing of this thesis, as transformations may include a series of transitions but not necessarily the other way around. I also relate to socio-institutional change processes from a perspective of cultural-historical activity theory (Engeström & Sannino, 2010), due to its emphasis on open-ended learning processes, transformative agency and transformation of activity systems.

2.1.3.1 Socio-technical transitions

Socio-technical systems and transition approaches put key attention on dynamics of stability and change in dominant configurations, with special attention to lock-in mechanisms that generate resistance, inertia and path-dependency, which make systems only develop incrementally and become generally difficult to change (Geels, 2002; Geels et al., 2016; Unruh, 2000). Socio-technical systems bring together processes of consumption and production oriented around important societal functions or services including, e.g., mobility, food, energy and health care. Systems configurations oriented towards fulfilling such functions have normally developed over long periods of time and essentially become entrenched. And, while they, to varying extent, tend to deliver on their main function, they may also produce negative side effects and rely on processes that make them essentially unsustainable over time. For example, consider a fossil-based transportation system that is

essentially dependent on depleting the very resource base it needs to function and that, in the process of doing so, produces negative effects such as climate change and local air pollution.

The functioning of socio-technical systems tends to be conditioned on its key technologies, but equally important are elements of and interactions across infrastructure, policy, markets, legislation, culture, norms and behaviour. These interactions are what provide the system with its properties in terms of a stable, dominant and 'mainstream' configuration in its particular context (Elzen et al., 2004; Geels, 2002, 2011; Grin et al., 2010). This system configuration may also be referred to as the 'regime', which puts primary emphasis on the social norms, rules and relations that seek to explain why certain forms of regime and so systems behaviour come about. However, from a critical realist perspective as taken in this thesis, I maintain an understanding of the dominant configuration as a 'system', which brings forward the general issues, including the social domains, of structures and properties of socio-technical systems (cf. Sorrell, 2018). The socio-technical system is further understood as positioned on a level in-between 'niches', where radical innovation and developments occur that may challenge the dominant system, and the 'landscape', representing long-term developments exogenous to the system given its boundaries.

This 'multi-level perspective' model of transitions (popularised in Geels (2002)) is often used as a heuristic to describe dynamics of systems change, often via historical analysis and case studies into, e.g., the shifts from horse-based to car-based transportation systems, the introduction of low-carbon district heating and moves from centralised coal and nuclear into decentralised solar and wind energy systems (Di Lucia & Ericsson, 2014; Geels, 2011; Smith et al., 2010). In such analysis, we may look into underlying dynamics of patterns and interactions across niche, system and landscape to understand how transitions come about and unfold (Geels & Schot, 2007). Transitional change processes may also be termed 'system innovation', denoting the replacement of one entire configuration with a different one, in contrast to product and service innovation that may still disrupt systems but keep its overall logic intact (Elzen et al., 2004). In short: transitions not only disrupt systems but also the very criteria on which their performance is evaluated:

> The more disruptive a socio-technical change, the more uncertain and uncommon it will be. This is because of the greater scope and depth of the changes required, because of the more complex set of countervailing factors, and because of new problems that emerge in the complex process of systems change. A related consideration is the ability to capture fundamental system re-

configurations that challenge the very performance criteria by which existing systems are analysed (Turnheim et al., 2015, p. 241)

In addition to the interest in understanding, analysing and explaining past and ongoing transitional change processes, there is an interest in sustainability transition and transformation research to understand how sustainability transitions and transformations can be induced, guided and accelerated into sustainable and desirable pathways (Köhler et al., 2019; Loorbach et al., 2017; Smith et al., 2005). In the following sections, I introduce some key aspects of importance in the context of this thesis for navigating sustainability transformations in practice.

2.2   Sustainability transformations in practice

The previous sections have established the view that sustainability challenges and associated transformation processes are more than merely simple and complicated problems to be solved; they are complex and even wicked challenges to engage with following a systems-based approach.

Reflexive approaches for governing transformations seek to acknowledge and incorporate the open-ended complexity, uncertainty and ambiguity associated with sustainability challenges and transformations. These conditions require us not only to be systematic but also systemic (Ison, 2018). Rather than relying on rational governmental logics of setting goals, predicting and controlling, reflexive modes of governing put increasing emphasis on processes of envisioning, collective experimentation and learning-by-doing, while broadening the views of participation and incorporation of top-down and bottom-up agency as all actors may influence but no single one dictate the change processes (Loorbach, 2010; Rotmans & Loorbach, 2008; Voß et al., 2006). Simply put, modes of reflexive governance let go of the assumption that society and systems can be steered from a control room, and instead

> take account of the complexity of interlinked social, technological and ecological development, fundamental uncertainty with respect to system dynamics, ambiguity of sustainability criteria and assessment and contingency of the effect of human action in the context of long-term system change. Reflexive governance modes are therefore geared towards continued learning in course of modulating ongoing developments, rather than towards complete knowledge and maximization of control (Voß & Kemp, 2005, p. 12)

Of particular relevance in the context of this thesis is the view of reflexive governance modes in the context of the 'cruise' and the 'expedition' (Holmberg, 2019; Holmberg & Larsson, 2018), distinguishing two complementary governance logics. The cruise is oriented towards what March (1991) in reference to Schumpeter

(1934) would refer to as processes of *exploitation of old certainties* (optimisation) and the expedition as *exploration of new possibilities* (transformation). These two logics are considered equally important. Rather than replacing one with the other, mutual learning across the logics is key:

> Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation. Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, execution. Adaptive systems that engage in exploration to the exclusion of exploitation are likely to find that they suffer the costs of experimentation without gaining many of its benefits. They exhibit too many undeveloped new ideas and too little distinctive competence. Conversely, systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibria. As a result, maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival and prosperity (March, 1991, p. 71).

A range of models and frameworks exist that seek to operationalise reflexive governance logics as complement to traditional (governmental) planning. Two well-known models are transition management and adaptive management (Armitage et al., 2008; Folke et al., 2005; Voß & Bornemann, 2011), which both emphasise collective experimentation and learning to handle the inherent complexity and uncertainty associated with transitions. In practice, transition management builds upon a cyclical process encompassing: (i) structuring the problem in question and establishing/organising a transition arena; (ii) developing a transition agenda, and images of sustainability and deriving the necessary transition paths; (iii) establishing and carrying out transition experiments and mobilising the resulting transition networks; (iv) monitoring, evaluating and learning lessons from the transition experiments and, based on these, making adjustments in the vision, agenda and coalitions (Loorbach & Rotmans, 2010). Adaptive management builds upon an iterative cycle encompassing (0) problem definition: defining the problem from different perspectives; (1) policy formulation: scenario analysis and strategies for navigating possible but initially uncertain future developments; (2) management actions: policy experimentation and implementation; (3) monitoring and evaluation: continuously following ongoing developments pinpointing undesired outcomes at an early stage; (4) assessment and feedback: assessing performance of management strategies used as input for the next cycle (Pahl-Wostl et al., 2007). A plurality of related and alternative models exist that fit within reflexive governance models, including sustainability-oriented labs such as urban living labs, social innovation labs, and real-world laboratories (Bulkeley et al., 2016; McCrory et al., 2020; Schäpke et al., 2018).

Reflexive modes of governing are essentially 'transdisciplinary' and place-based initiatives engaging with complex challenges in context, where the participating actors hold knowledge on and are in position to influence (or seek such position) how systems develop and should develop. We may understand such processes as essentially transdisciplinary, in the sense that actors are brought together across sectors and perspectives to integrate and co-produce knowledge oriented towards resolving problematic situations by means of engaging with complex questions and challenges of concern (Hirsch Hadorn et al., 2008; Klein et al., 2001; Lang et al., 2012; Max-Neef, 2005). Such processes are the focus of the following section.

2.2.1 Transdisciplinarity

Funtowicz and Ravetz (1993) referred to the need of a 'post-normal' approach to knowledge production and science-society relationships to properly handle contemporary challenges of risk and the environment. Such challenges, they meant, differed from traditional problems in the sense that they generate situations where "*facts are uncertain, values in dispute, stakes high and decisions urgent*" (p. 744). To properly address such issues, expert investigation is not considered enough, and the assurance of progress relies on the involvement of an extended peer community outside traditional scientific domains:

> Only a dialogue between all sides, in which scientific expertise takes its place at the table with local and environmental concerns, can achieve creative solutions to such problems, which can then be implemented and enforced. Otherwise, either crude commercial pressures, inept bureaucratic regulations, or counterproductive protests will dominate, to the eventual detriment of all concerned (Funtowicz & Ravetz, 1993, p. 751).

Around the same time, Gibbons et al. (1994) referred to an emerging form of socially robust 'mode-2' knowledge production in complement to traditional disciplinary academic 'mode-1' knowledge production. They referred to mode-2 knowledge as transdisciplinary, heterogenous, socially accountable and reflexive forms of research carried out in the context of application.

Since sustainability challenges do not come as disciplinarily structured, they necessitate integration of knowledge across disciplines (e.g. interdisciplinary research) to be properly understood and eventually addressed (Brewer, 1999; Klein, 1990). As argued in the sections above, sustainability challenges may also require us to move beyond ideas of disciplinarity altogether (transdisciplinarity) to co-produce knowledge together with those affected and with the possibility to affect complex sustainability challenges in their particular contexts. In such work, knowledge and experience are drawn from wherever necessary and further produced

to meaningfully address complex challenges and questions of concern in context (Hirsch Hadorn et al., 2008; Klein, 2004; Klein et al., 2001; Lang et al., 2012). The necessity of transdisciplinary (post-normal, mode-2) research and practice come, especially, from the realisation that facts and values cannot easily be separated when coping with complex societal challenges and sustainability, in particular as their eventual resolution relies upon context-relevant explanation with normative grounding and mere observation of society implies influencing it (cf. Sayer, 2011). Research and practice operating in complex sustainability contexts rather benefit from evaluative and judgemental reflexivity to cope with epistemic-moral issues that may arise (Fritz, 2020; Kläy et al., 2015; Potthast, 2015), including reflexivity in how values are brought in and boundary choices made (Midgley, 2000). Transdisciplinary research and practice may be understood as oriented towards generating three primary forms of knowledge, (A) systems knowledge: of present systems and their historical developments; (B) goal/target knowledge: of future targets, goals and visions; and (C) transformation knowledge: of processes that shift present systems into desired future states (Hirsch Hadorn et al., 2008). To better grasp the extent to which transdisciplinary processes manage to produce such knowledge and eventually produce systemic effects and impacts, a range of evaluation frameworks have been suggested (Luederitz et al., 2017; Wiek et al., 2014; Williams & Robinson, 2020). Evaluation of transdisciplinary processes is important for further developing such collaboration processes as well as for accountability reasons.

In this thesis, I refer to transdisciplinary research and practice as the general engagement and attempt to facilitate social collaboration among actors across sectors, perspectives and disciplines, whether or not these include a formal research component[10]. Complex and systemic sustainability challenges and questions particularly suited for transdisciplinary approaches tend to fall 'in-between' the mandate and resources of affected actors and organisations yet be in their interest to understand and address. Transdisciplinary research and practice thus require deliberate creation and holding of safe spaces for social collaboration and learning to happen (Vilsmaier & Lang, 2015). Depending on situation and context, such processes may require collaboration among actors that not necessarily know, understand, like, or even trust each other (Kahane, 2017). Collaboration and progress on complex issues do not have to imply agreement and consensus but do necessitate openness and trust (Wendelheim, 1997). It is about convening around a shared intent, agreeing to disagree by committing to understanding each other's perspectives by listening, and seeking to co-create ways forward out of problematic

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[10]Various approaches to transdisciplinary knowledge co-production view the role and involvement of research and researchers differently (Schäpke, 2018; Scholz, 2017).

situations (Checkland & Poulter, 2010; Isaacs, 1993; Lewis, 2008; Sandow & Allen, 2005). In the words of Engeström and Sannino (2010), we may understand such processes as inherently multi-voiced processes of debate, negotiation and orchestration, which they (in reference to Bakhtin (1981)) view as open-ended social learning processes dealing with tension and contradiction, where:

> all the conflicting and complementary voices of the various groups and strata in the activity system under scrutiny shall be involved and utilized. As Bakhtin shows, this definitely includes the voices and non-academic genres of the common people. Thus, instead of the classical argumentation within the single academic speech type, we get clashing fireworks of different speech types and languages (Engeström & Sannino, 2010, p. 5 [references have been omitted from this quote]).

In approaching sustainability-oriented transdisciplinary processes from a view of social (transformative) learning, we bring issues of participation, purposeful social action, agency and collective transformation as human activity to the forefront (Barth & Michelsen, 2013; Engeström, 2016; Lotz-Sisitka et al., 2015; Macintyre et al., 2018; Wals, 2009). This is the focus of the coming section.

2.2.2 Social (transformative) learning

Many place, and argue for the importance of, social learning in sustainability-related contexts (see Lotz-Sisitka (2012) and Wals (2009)). And while learning is a complex and multi-faceted phenomenon, two main metaphors may prove helpful in approaching the concept: acquisition and participation (Sfard, 1998). Learning as acquisition refers to the cognitive dimensions of learning, where the human mind is viewed *"as a container to be filled with certain materials and about the learner as becoming an owner of these materials"* (ibid., p. 5). Learning as participation refers to the relational dimensions of learning and its situated nature in relation to the community in which learning occurs, where learning is understood as *"a process of becoming a member of a certain community [of practice]"* (ibid., p. 6). The word 'social' in social learning points towards its relational characteristics as highlighted in the participation metaphor above, which can be traced back to the work by Vygotsky (1978).

A popular view on social learning considers such learning as essentially situated and occurring in relation to communities of practice (Lave, 1991; Wenger, 1998). Here, the main emphasis is put on processes of participation and reification, where participation refers to engaging in activities, conversations and reflections, while reification refers to the production of artefacts such as tools, concepts and stories around which participation is organised (Wenger, 2010). Over time, participation

and reification processes that occur in a particular community generate a certain history – forming a community with a set of established meanings, practices and identities, where what is considered 'legitimate' competence and expertise is negotiated in relation to the community. From such a view, social learning processes imply the moves of becoming a member of a certain community of practice, understood as a form of situated and socio-cultural process of learning a communities' associated language, norms, concepts and practices, etc. (Lave, 1991; Wenger, 1998, 2010).

In sustainability-oriented contexts, Wals (2009) refers to social learning as:

> learning that takes place when divergent interests, norms, values and constructions of reality meet in an environment that is conducive to learning. This learning can take place at multiple levels i.e. at the level of the individual, at the level of a group or organisation or at the level of networks of actors and stakeholders (p. 18).

> From a social learning perspective, the emergence of sustainability in the context of education can be viewed both as an evolving product and as an engaging process […]. Through facilitated social learning, knowledge, values and action competence can develop in harmony to increase an individual's or a group's possibilities to participate more fully and effectively in the resolution of emerging personal, organisational and/or societal issues. In social learning, the learning goals are, at least in part, internally determined by the community of learners itself (p. 19).

However, the concept of social learning is, perhaps especially in sustainability-related contexts, used in reference to different kinds of learning processes generating different kinds of outcomes, which has led to much confusion about the concept (Barth & Michelsen, 2013; Lotz-Sisitka, 2012; Reed et al., 2010). In asking the seemingly simple question, *what is social learning?* Reed et al. (2010) conclude that to be considered social learning, a process must

> (1) Demonstrate that a change in understanding has taken place in the individuals involved. This may be at a surface level, e.g., via recall of new information, or deeper levels, e.g., demonstrated by change in attitudes, world views or epistemological beliefs;

> (2) Go beyond the individual and become situated within wider social units or communities of practice within society; and

> (3) Occur through social interactions and processes between actors within a social network (p. 5).

Without going further in unpacking the term 'social' in social learning, we may view social learning largely as a process of (transformative) change towards sustainability, or equally sustainability as a (transformative) learning process (Lotz-Sisitka, 2012; Macintyre et al., 2018).

A third metaphor of learning may be added to the acquisition and participation (social learning) metaphor [11], referring to learning as not only acquiring pre-defined knowledge or as becoming a member of a certain established community of practice, but as engaging in a process of creation (Engeström, 1987, 2016; Nonaka, 1994; Senge, 2003). Wenger (2010) refers to such learning processes as 'navigating landscapes of practice' and Engeström (2016) as expansive learning as forms of 'learning what is not yet there'. In such learning processes, the knowledge to be learnt, embedded in practice, and/or reified in physical and conceptual artefacts is not there beforehand, but generated and given shape throughout the learning process. Often, such learning processes operate around some complex question, task or issue of concern in the absence of prior expertise or community that can be learnt from. Such learning processes are inherently open-ended, experimental and exploratory processes, ascending from the abstract to the concrete (ibid.). Such an approach to learning may be positioned as apt to adequately grasp the complexities of addressing sustainability challenges and navigating transformations, broadly referred to as transformative social learning (Lindley, 2015; Lotz-Sisitka et al., 2015; Macintyre et al., 2018).

Much work on transformative notions of learning can be traced back to Bateson's (1972) levels of learning denoting qualitatively different change processes:

> Learning I denotes processes of conformative and transmissive learning, which is about *doing things better*

> Learning II denotes processes of reformative and transactional learning, which is about *doing better things*

> Learning III denotes processes of transformative learning, which is about *seeing the world anew*

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[11] Note that while Engeström suggests such a metaphor as helpful in approaching learning, he also opposes the view of establishing a distinct set of 'metaphors' of learning, stating that learning is too complex and important a phenomenon, one where metaphors risk being more misleading than useful, that calls for a more multi-dimensional treatment. Aware of critique of these metaphors, I still relate to them for the sake of the flow of the text in this thesis. Further, as I am not primarily trained in the learning sciences, I do not primarily aim towards furthering learning theory; instead, I apply existing theory from the learning sciences to shine light on particular phenomena of interest and importance for this thesis.

(descriptions adopted from Sterling (2011) and Winter et al. (2015) in reference to Bateson (1972)).

Based on these conceptions, common terms include the notion of transformative learning as developed by Mezirow (1997), single- and double-loop learning by Argyris (1976) as well as triple-loop learning (Tosey et al., 2012). Learning I seldomly makes a systemic difference (Blackmore, 2010), as put by Ackoff (1995) in the following words: *"it is better to do the right thing wrong than the wrong thing right; the former leads to learning; the latter to reinforcement of error"* (p. 43).

The notion of Learning III and associated transformative notions of learning operating on a level of world views is often highlighted by systems thinkers as a deep form of leverage (Göpel, 2016; Meadows, 1997). We may as well understand such learning as an important mechanism in overcoming problematic situations, tension or contradiction by generating transformative forms of agency or even material objects, practices and patterns of activity (Engeström, 2016; Greeno & Engeström, 2014). In contexts of sustainability, such processes would preferably include (or even necessitate) deliberation upon normative orientation, identification of means for transforming underpinned by a systemic understanding in context, and purposeful reflexive action and practice (Blackmore, 2010; Ison, 2010, 2018).

However, it is not enough to bring people together and expect such learning to happen:

> It might be thought that one simply needs to bring together individuals who care deeply about authentic and unscripted problems and based on that colocation, learning will happen. It turns out there is little support for such a claim by learning scientists (Budwig, 2015, p. 102).

Rather, various forms of support are required for people and collectives to make progress on complex challenges. In the learning sciences, such support is commonly referred to as 'scaffolding', as something that enables people and collectives to do something they would not have been able to do in the absence of such support (van de Pol et al., 2010; Vygotsky, 1978). In acknowledging the open-ended nature of most social learning processes, Budwig (2015) suggest a form of scaffolding and facilitation technique called 'guided emergence', oriented towards creating conditions that allow for key features associated with the desired learning to emerge without strictly determining the nature of the same.

In the following section, I look further into backcasting as an approach and methodology that may be used to guide, support and scaffold

transdisciplinary/learning processes that seek to engage with complex sustainability challenges in contexts of transformation.

2.2.3 Backcasting and futures

Backcasting is commonly suggested, used and referred to as approach, framework, methodology, method or tool to guide sustainability- and transformation-related processes in various contexts and settings (Dreborg, 1996; Loorbach et al., 2017; Vergragt & Quist, 2011). Backcasting was originally developed by Robinson (1982) as an alternative to conventional energy planning that predominantly relied upon forecasting methods. It took inspiration from Lovin's (1977) work that sought to describe alternative energy futures relying on a diversity of renewable energy sources in combination with energy conservation and efficiency as forms of 'soft energy paths', put in contrast to mainstream developments that extrapolated past and previous trends into the future by further entrenching energy systems' reliance on fossil fuels and nuclear power in the U.S. A related early exploration[12] into alternative energy futures was made by Lönnroth et al. (1980) who outlined and discussed an emergent possibility of making a deliberate choice between a solar and a nuclear energy future in Sweden.

A key feature of backcasting is its acknowledgement of futures as not only a matter of prediction and likelihood based on developments of the present and the past, but also a matter of feasibility and choice (Robinson, 1988, 1990; cf. Meadows (1999). Such a view acknowledges that futures unfold through an interplay of causal and teleological factors[13], as human beings may act upon intentions and so take deliberate and purposeful action towards desired ends (Dreborg, 1996), knowing that such actions and agency even when emerging from backcasting are enabled or constrained by structure (Wangel, 2011). In other words, backcasting acknowledges that *the future has not yet happened but remains to be created*[14] (Robinson, 1988, 1990).

From a methodological point of view, backcasting seeks to first articulate sustainable and desirable futures, followed by analysis into the feasibility of achieving the same that may guide various measures and actions for facilitating progress towards desired futures (Robinson et al., 2011). Backcasting logics are

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[12] For a more comprehensive overview of the historical developments of backcasting, I refer to Quist (2007) and Vergragt and Quist (2011).

[13] N.b. that (human) reasons indeed may be understood as causes when analysing human actions and agency

[14] Such a view sees backcasting as closely resembling anticipation studies (Fuller, 2018; Fuller & Loogma, 2009) and anticipatory governance (Muiderman et al., 2020).

often part of various reflexive governance frameworks (implicitly or explicitly), including transitions management (Quist et al., 2013). By being explicitly normative, backcasting processes tend to start by asking questions of the form 'what should happen' in terms of what is desirable and deemed important. As such, it may complement other futures-oriented approaches such as forecasting – asking questions of the form 'what will happen' by means of trend extrapolation – and scenarios – asking questions of the form 'what could happen' by means of trend extrapolation under various and distinct sets of assumptions. A main reason to complement forecasting approaches with backcasting as suggested by Robinson (1982) came from the realisation that forecasts (especially in complex social systems) tended to rely upon a range of (often implicit) assumptions, choices and values made by those doing the forecasts, whereas backcasting sought to make such values and norms explicit at the start and include a broader audience in negotiating the same.

Based on similar reasoning about backcasting as that briefly outlined above, Dreborg (1996) considered backcasting as especially useful when:

- the problem to be studied is complex, affecting many sectors and levels of society;
- there is a need for major change, i.e. when marginal changes within the prevailing order will not be sufficient;
- dominant trends are part of the problem–these trends are often the cornerstones of forecasts;
- the problem to a great extent is a matter of externalities, which the market cannot treat satisfactorily;
- the time horizon is long enough to allow considerable scope for deliberate choice (p. 816).

These characteristics fit most contemporary challenges of sustainability well.

Polak (1973) outlined how societal change can be viewed as a push-pull process, where society is *"pulled forward by its magnetized views of an idealized future and pushed from behind by its realized past"* (p. 1). And the views of the future held in societies, in turn, were argued essential for the survival of culture:

> The rise and fall of images of the future precedes or accompanies the rise and fall of cultures. As long as a society's image is positive and flourishing, the flower of culture is in full bloom. Once the image begins to decay and lose its vitality, however, the culture does not long survive. (p. 19)

In close resemblance with the transformative model of social activity (TMSA) as outlined in section 2.1.2., Polak further outlined that we may at any point in time find ourselves in a position where we not only have to construct futures based on our actions guided by an implicit or pre-determined ethics, but have to reason about and generate the values determining the same.

This leads us into the next sub-section that looks into a backcasting from principles methodology. It starts from principles and values for a sustainable and desirable future as an explicit normative and ethical frame on an abstract level. The frame is then used to eventually construct concrete futures via interventions and actions in the present.

2.2.3.1 Backcasting from principles

Backcasting from principles is a particular approach to backcasting that plays a key role in this thesis. It was originally developed by Holmberg (1998) and Holmberg and Robèrt (2000), and is evaluated in practice and further developed in this thesis. Please note that while this thesis adheres to the general backcasting steps as outlined in Holmberg (1998), this thesis has explored the possibility of moving from sustainability principles (as scientifically pre-determined) into guiding principles for sustainability (as procedurally negotiated in context), and studied applications of backcasting from principles in transdisciplinary settings that engage with complex systemic challenges, rather than in particular organisations (see Broman & Robèrt, 2017; Nattrass & Altomare, 2002; Vergragt & Quist, 2011).

While also presented in the various papers of this thesis, a brief summary of the backcasting methodology as engaged with in this thesis is presented below (Figure 6), and further elaborated in the discussion section. The methodology encompasses the following steps (as generally outlined by Holmberg (1998; 2014) and Holmberg and Larsson (2018)):

1. Formulate guiding principles for a sustainable and desirable future
2. Analyse some present situation or system in relation to the principles to illuminate gaps and challenges
3. Identify leverage point interventions with the potential to bridge the gaps
4. Strategically experiment with leverage point interventions

By starting from guiding principles for sustainability, the approach seeks to outline a normative and generally abstract frame outlining what is considered of key importance for a sustainable and desirable future, rather than outlining a particular

future in detail from the start (cf. Holmberg & Robèrt, 2000). These guiding principles may come predefined yet be further adapted to the particular context in the form of *sustainability principles* and procedurally negotiated as part of the process in a more balanced way and become *guiding principles for sustainability* (Holmberg & Larsson, 2018). In contexts of reflexive governance and transdisciplinary research and practice, these steps are preceded by preparatory work including, e.g., the identification of a generally problematic situation, challenge, question or issue of concern in context, establishment of some safe space and initial invitation of actors (cf. Loorbach & Rotmans, 2010).

1. Formulate guiding principles for a sustainable and desirable future

4. Experiment strategically with leverage point interventions

3. Identify leverage point interventions with potential to bridge gaps

2. Analyse some present situation or system in relation to the principles to illuminate gaps and challenges
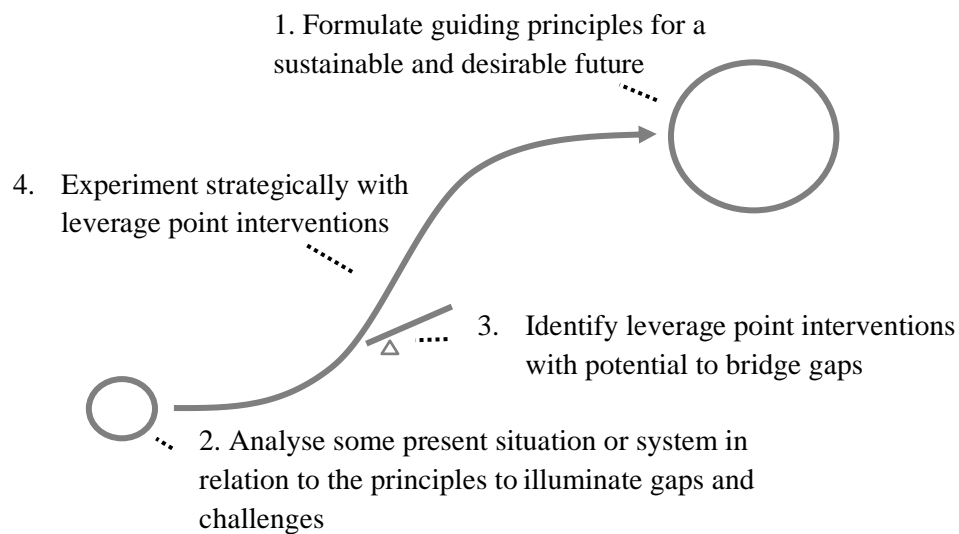
Figure 6 – Primary steps in a backcasting from principles methodology (adapted from Holmberg (1998) and Holmberg and Larson (2018)).

Once a set of guiding principles (or values) for sustainability have been formulated, the second step is to bring those principles into the present by analysing some present situation or system in its context, to eventually illuminate gaps and challenges. This is done via an analysis into underlying causes and factors that eventually give rise to the challenges identified.

Based on the results from the second step, a move is made into a third step oriented towards identifying leverage points, which tends to start from an identification of areas within a system where a potential for change might lie, in terms of shallower or deeper forms of leverage with attention to possibility and agential disposition. Following this third step, a fourth step seeks to incorporate that which has been generated throughout steps 1-3 in forms of strategic experimentation in/with leverage point interventions. The various forms these experiments may take largely depends on the challenge at hand and context of application, and may also lead to

the initiation of an additional backcasting cycle related to a particular area of intervention or leverage point.

Note the close resemblance of these steps with the 'four tasks of changing the world' as outlined by Wright (2010): (i) elaborating the normative foundations; (ii) diagnosing and critiquing the world as it is (on the basis of the normative foundation); (iii) elaborating an account of alternatives that would better realise the normative foundations given the critique of the world as it is; and (iv) constructing a theory of transformation, a how to get from 'here' to 'there'. I will return to this in the discussion section, also in relation to the MELD scheme (Bhaskar, 2008b; Schudel, 2017).

In the last section of this background and conceptual framing chapter, I briefly introduce education for sustainable development, as this thesis engages with and makes particular contributions in that context.

2.3   Education for sustainable development

Education and educational institutions are understood as playing a special role in sustainability transformations (UNESCO, 2014). The complex nature of sustainability challenges, the transdisciplinary condition and the importance of social learning processes as outlined in the sections above only represent some reasons for why many ascribe education a key role in navigating sustainability transformations. David Orr (1994) put it as follows:

> Education is not widely regarded as a problem, although the lack of it is. The conventional wisdom holds that all education is good, and the more of it one has, the better […] The truth is that without significant precautions, education can equip people merely to be more effective vandals of the Earth.

> The kind of education we need begins with the recognition that the crisis of global ecology is first and foremost a crisis of values, ideas, perspectives, and knowledge, which makes it a crisis *of* education, not one *in* education (p. 5).

Higher education institutions may be of special importance. Such institutions commonly represent a stable institution in society developing knowledge for the common good, in a position to orient around (long-term) questions of societal importance and concern and to use its internal operations as role model and campuses as test-beds, and with a tradition of hosting processes of community engagement and outreach (Barth et al., 2016; Cortese, 2003; Etzkowitz & Leydesdorff, 2000; Sterling, 2010). Recent developments that seek to further the relevance of higher education institutions for society's complex sustainability challenges explore the possibility of moving sustainability from a 'third mission'

issue into being part of the institution's core identity (Barth et al., 2014; Munro et al., 2016; Sterling, 2010; Wals, 2014). Trencher et al. (2014):

> in many institutions, local manifestations of the global sustainability crisis are prompting a deviation from the pursuit of income generation and economic development alone. A broader and more ambitious function has emerged: that of a societal transformer and co-creator. Boundaries between 'town and gown' are dissolving as university actors collaborate with local government, industry and civil society to drive the physical and sustainable transformation of a specific locality, region or societal sub-sector, often with ambitions to influence a much broader geographical area. Admittedly, many of the methods and approaches adopted in such partnerships appear little more than an accentuation of more established paradigms such as agricultural extension, action and participatory research, transdisciplinarity, technology transfer, urban reform, regional development etc. Yet what appears novel in the emerging co-creative function is the combining of these various modes of societal engagement into a systematic response to localised sustainability challenges, and most importantly, the integration of values of sustainable development (p. 1 [references have been omitted from this quote]).

However, the realisation of such a complementary 'function' of higher education institutions is not without its problems, often facing internal as well as external resistance and ending up compartmentalised as well as marginal (Conceicao et al., 2006; Ferrer-Balas et al., 2010; Holmberg & Samuelsson, 2006; Lozano, 2006; Lozano et al., 2015). These concerns are commonly part of developments within Education for Sustainable Development (ESD) and related concepts including Environmental Education (EE), Sustainability Education (SE) and Environmental and Sustainability Education (ESE) (Barth et al., 2016; Palmer, 2002; Sterling, 2010). UNESCO plays an important role in globally mobilising efforts in reshaping education and educational institutions to become increasingly relevant for the challenges of our times; perhaps especially apparent during the United Nations Decade on Education for Sustainable Development (UNESCO, 2014) from 2005-2014.

ESD refers to more than learning about sustainable development (which may be difficult enough at times), by also referring to processes of learning to take action for the same, including learning to: *(1) ask critical questions, (2) clarify one's own values, (3) envision more positive and sustainable futures, (4) think systematically, (5) respond through applied learning, and (6) explore the dialectic between tradition and innovation* (Tilbury, 2011, p. 8).

In connection to ambitions of ESD and sustainability-oriented education in general, competence frameworks have been developed to support curriculum design and assessment. A popular conceptualisation is the work by Wiek et al. (2011) building upon the work by Barth et al. (2007), which is now moving towards becoming a reference framework of key competences in sustainability (Brundiers et al., 2020). The competences include futures-thinking, values-thinking, systems-thinking, strategic-thinking, interpersonal and integrated problem-solving competency. They point towards the necessity of learning to create future sustainability visions and scenarios, broadly negotiate sustainability values, analyse complex problems in the current state and its history, develop transition strategies, and collaborate at each step of the problem-solving process in an integrated manner (ibid.)

In better grasping what kinds of learning approaches, processes and curriculum models that may facilitate such competence development or more generally support its participants in (learning to) address complex sustainability challenges and navigate sustainability transformations in practice, we may adapt a popular frame developed by Wals and Jickling (2002). It positions sustainability in higher education as tending towards learning processes tending towards being either: closed, predetermined and prescribed; or open, self-determined and co-created, and teaching processes towards being either: hierarchical, authoritative and technocratic; or integrated, participatory and democratic. Figure 7 presents an adapted version of this conceptualisation.
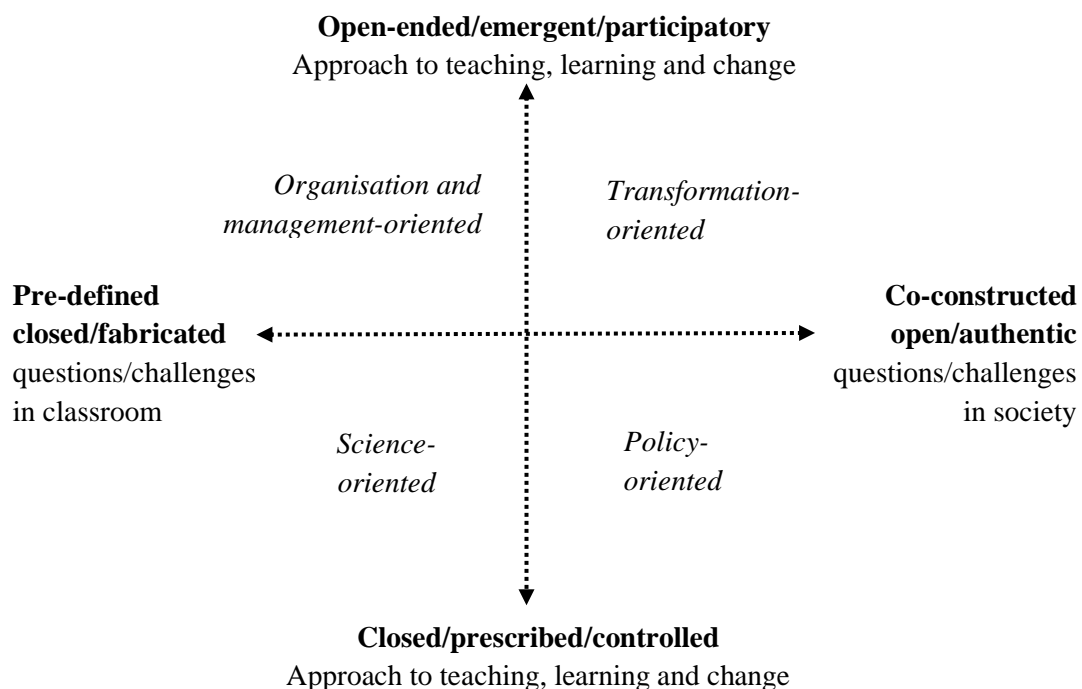

Figure 7 – Teaching and learning orientations in (Higher) Education for Sustainable Development. Adapted from Macintyre et al. (2018) and Wals & Jickling (2002).

2.3.1 Backcasting and ESD

Chikamori et al. (2019) developed a tense-based conceptualisation of ESD learning building on a backcasting logic. The conceptualisation builds on TMSA (transformational model of social activity) emphasising learning processes of connecting the past, present and future. Such an approach recognises that activity in the present is dependent on activity in the past, and that activities in the present not only reproduce/transform current society but also set conditions for future generations. In enacting thinking and action across these three different tenses related to sustainability challenges in context, the emergent learning processes become socialisation and development of capability by "*engaging intentional praxis to bring about the changes required of existing society to become a sustainable one a daily basis*" (p. 427).

This conceptualisation of ESD may directly guide student-teacher interactions towards exploring and engaging with ongoing societal developments in connection to its historicity and future possibilities. To do so, they suggest a learning model oriented around (i) knowing the present situation of society, community and human activities, (ii) examining the past and present on a level of structures, mechanisms and events that have generated current and anticipated problems, and (iii) imagining a utopian future where the current situation is ameliorated combined with an outlining of how present actions might impact the utopian future. They note that these three sub-processes together can be termed backcasting, as "*knowing what causes a problem is not the same thing as knowing how to resolve that problem*" (p. 429). In this process, they stress that the imagined future is not only idealist and visionary since it gets explicitly connected to the present and the past with grounding in an understanding of structural conditions that may enable and limit agency in taking action in realising desired futures. I will return to this ESD model in the discussion section of this thesis.

Based on this background overview of concepts and theories of relevance and use in this thesis, the following chapters move towards outlining the contributions of this thesis, starting with the methodology chapter and a brief summary of the appended papers. The following chapters make a case for how most of the concepts introduced in this chapter become part of the seemingly messy efforts of navigating sustainability transformations in practice.

3 Research methodology and methods

My research journey and dissertation work started from a general interest and curiosity in the practices of sustainability-oriented systems change, backcasting and education that have lasted throughout the doctoral work. My ambitions have been formalised in various ways as also illustrated in the appended papers of this thesis, which relate to and draw from concrete engagement, research and reflection with and on concrete cases that seek to navigate sustainability transformations in practice. Methodologically, the thesis can be understood as encompassing three primary and interrelated moves:

- o Move 1 represents an *initial engagement with cases* that sought to navigate sustainability transformations in practice via backcasting in educational as well as informal learning settings, where I primarily focused on gathering experiences from participating actors and resulting effects from the process (RQ1 and RQ2).
- o Move 2 represents *conceptual development* to enhance such and similar backcasting processes as studied in the first move, with an emphasis on the negotiation of sustainability principles and embedding the same in process (RQ3 and parts of RQ2).
- o Move 3 represents a form of *analytical deepening,* seeking to better understand and explain how and why experiences and effects are generated with attention to the surrounding contexts (RQ4 and RQ5). This research built on results and reflections from the first move as well as related cases and processes.

These moves did not follow one another in a linear and temporal sequence throughout my dissertation work. Rather, they represent a series of explorations into a wider methodological landscape with its associated theories, concepts and practices, which put emphasis on various forms of questions and issues that I have engaged with in parallel throughout the dissertation work.

Choices of methodology and particular methods were made in relation to the object of study and research purposes and questions, in line with critical realist methodology (Danermark et al., 2002). By primarily drawing from a qualitative research tradition (Bryman, 2012), the following quality criteria (adapted from Frambach et al. (2013)) have guided the research presented in this thesis:

- o Credibility – making the research trustworthy by drawing from multiple data sources, often longitudinally, and asking interview subjects (often towards the end of the interview or in follow-up conversation) to reflect on my theories and assumptions including inviting them to support in interpreting my observations and results.

- o Transferability – seeking to make the research applicable in different settings, which was primarily part of the third move that explicitly takes into consideration contextual contingency and underlying mechanisms, features and qualities of the concrete processes as observed. Alongside this, all papers have been discussed in relation to related research in their respective fields.

- o Dependability – making results consistent with the larger processes and contexts from which they have been derived. Here, I have sought to collect data until the case can be properly established and in thematic analysis sought to reach saturation of themes, continuously engage in data analysis to gather further data and be open towards alternative interpretations and insights emerging throughout the process of analysis.

- o Confirmability – seeking to establish results based on the study participants rather than my own biases. Here, I have sought to position the theories, assumptions and questions asked in the research in the context of the work by others, sought alternative explanations and continuously reflected upon my own role and influence on that which I participate in as facilitator (Paper I and IV) and as participant observer (Paper II and V). This has also meant the neeed to take a critical role to challenge underlying assumptions and enhance my own practices.

Below, I present the methodological aspects of the three moves introduced above, in a way that complements how methods and associated procedures have been presented in the appended papers.

3.1   Move 1: Initial engagement with cases

This first move includes research building on concrete engagement in and with cases (RQ1 and RQ2). These two cases are (1) an educational case study (Bassey, 1999) of Challenge Lab at Chalmers University of Technology in Gothenburg, Sweden, and (2) an evaluative and theoretically oriented case study into an arena-based transdisciplinary process related to regional climate policy and sustainability transitions in West Sweden.

The studies of these two cases have predominantly adhered to qualitative research designs. Qualitative research is oriented towards understanding and explaining how people interact, view, interpret and ascribe meaning to phenomena in the world with a focus on their experiences (Merriam, 1998).

Case studies deal with one or a limited set of empirical settings in their natural contexts, providing a possibility to follow and explore how particular phenomena manifest and how processes unfold and are experienced by people (Yin, 1994). The complexity and open-ended nature of social settings make it difficult, or even impossible, to take into consideration everything that is going on and therefore all variables of interest. This is made further difficult as the boundaries between the object of study and its surrounding contexts tend to be blurry. Based on this, case studies benefit from some initial theoretical/conceptual orientation providing signifiers as to where to focus attention and typically rely on multiple data sources and triangulation efforts to properly establish the case (Bassey, 1999; Stake, 2010; Yin, 1994).

In line with an ethnographic tradition, in this thesis data on cases were collected through observations and interactions in the natural settings in which the studied processes unfold (Bryman, 2012). As ethnographic research arguably is more than mere 'participant observation', data were also gathered through semi-structured interviews and focus groups, surveys and document analyses (ibid.). The reliance on multiple data sources has been important to create an as comprehensive view as possible on what has actually happened by drawing from multiple perspectives and experiences. I have primarily emphasised the role of semi-structured interviews and free text answers in surveys to establish an understanding of the cases from the experiences of the participating actors related to the research questions posed, although I stress the importance of complementing such with additional data sources and triangulation and continuous analysis throughout the data gathering process to reach analytical saturation. Hopefully, cases are presented in such a way to also open up for alternative interpretations and explanations (Adelman et al., 1980).

Analysis of participant experiences has always started from an inductive procedure by means of thematic mapping (Braun & Clarke, 2006) and then sought further understanding by means of relating to pre-established theories and frameworks (see Paper I) and by means of theorising findings based on theoretical reasoning and in relation to theories and concepts by others (see Paper II). Such an approach to case study may be understood as complementing an inductive procedure with an abductive logic (Dubois & Gadde, 2002).

3.2   Move 2: Conceptual development

This move includes the attempt to develop a conceptual framework (Paper III) to further support backcasting processes, particularly in transdisciplinary settings, seeking to support conversations on sustainable and desirable futures at the level of principles (RQ3). In this move, we conducted a brief review, resembling a scoping procedure (cf. Pham et al., 2014), of the broad and heterogenous literature basis of established sustainability frameworks. The methods adopted in this paper followed a sequence: an initial scoping of the literature basis, selection of frameworks based on a set of criteria adopted for the purpose of the study, inductive thematic mapping and a re-contextualisation of themes for the resulting conceptual framework to fit within a backcasting from principles logic.

As sustainability is a far from straightforward concept, the development of a framework to guide conversations on sustainability is far from straightforward. A series of choices had to be made by relying on a series of assumptions, which are further elaborated upon in the paper. For examples, what dimensions of sustainability to include? Why dimensions? How to relate to the Brundtland definition? What alternative conceptualisations would surface more marginalised views or perspectives? What can, could or should research say about sustainability? How much can and needs to be left open for negotiation in context, knowing that conversations on sustainability, dominated or shut down by those whose framings or voices are the strongest (Leach et al., 2010; Stirling, 2007).

In developing this conceptual framework, it was important to transparently share the reasoning leading up to it, including on the methods and procedures applied. Apart from relying on the primary data sources upon which the framework eventually rests, it is also a result of the assumptions and choices made throughout its development.

3.3   Move 3: Analytical deepening

This third and final move represents two related attempts to analytically deepen the understanding of the processes also studied via RQ1 and RQ2. We sought to better understand students' learning experiences at Challenge Lab by seeking explanations, with attention to context, for how and why these were generated (RQ4) and, by paying attention to process, effects and sustainability transition impacts, how similar backcasting methodologies in their wider governance settings played out in different contexts (RQ5). This resulted in two papers providing an in-depth qualitative inquiry of Challenge Lab by means of realist evaluation (Pawson & Tilley, 1997), and a study of the arenas for a fossil-independent West Sweden (also

studied in Paper II) and Energy Futures Lab in Alberta, Canada, by means of cross-case comparison and analysis (Khan & VanWynsberghe, 2008).

The study of Challenge Lab built on a realist evaluation approach, which is a form of theory-driven evaluation gaining increased traction for advancing educational theory and practice (Stöhr & Adawi, 2018; Wong et al., 2012). Realist evaluation is oriented around the three constructs of context, mechanism and outcome, acknowledging that the way programmes or interventions work is contingent on the particular resources they provide, the participating actors and the surrounding context. Due to these contingencies, it is less a question of whether a programme universally works or not, but rather a question of what works, for whom and why (Pawson & Tilley, 1997). Explanation is sought on a level of (underlying) mechanisms (generated or not by the programme) with the power to produce certain outcomes in context. In other words, mechanisms are understood to result from a complex interplay between on the one hand the resources provided by the programme and on the other hand the resulting responses (experiences) from its participating actors, operating in a certain context. Identification of mechanisms requires retroductive modes of inference (Danermark et al., 2002), and while the arguments for realist evaluation are persuasive, conducting such research is far from straightforward (Alvarado et al., 2017; Dalkin et al., 2015; Jolly & Jolly, 2014). For example, it may be beneficial to invite interview subjects not only to deliberate on their experiences with a certain programme or intervention, but also to dialogue on potential mechanisms and contextual factors that may have been at play (Manzano, 2016).

The comparative study into the arenas for a fossil-independent West Sweden and Energy Futures Lab in Alberta, Canada, built on the possibility of comparing similar backcasting processes in their wider governance settings occurring in different contexts. We adopted a multiple-case research design and performed a cross-case comparison and analysis (Bryman, 2012; Khan & VanWynsberghe, 2008) with a focus on empirical observations. The study was guided by an evaluation framework to guide data collection and analysis, where a few categories of interest were selected as recommended in comparative research designs where emphasis lie on generating comparative insights, often at the expense of creating rich and in-depth accounts of a particular case (Stake, 2010). The initially identified similarities and differences of interest were subject to further reasoning and analysis to understand possible reasons underlying them as well as the potential implications.

Cross-case research designs may be not only an opportunity to advance knowledge by means of analytical research drawing on multiple cases, but also an opportunity

for researchers with knowledge from their respective cases to share their experiences, in dialogue. This may add to the way tacit and practical knowledge tends to be developed, where we in the face of new situations draw from earlier experiences as a form of 'case-based reasoning' (Flyvbjerg, 2006). In this paper, we sought to share our experiences and insights as emerging from doing the actual comparison, similar to the popular study by Loorbach and Rotmans (2010) where they deliberate upon and share examples and lessons learnt from their work on four cases of transition management in practice.

4 Brief summary of appended papers

This chapter provides brief summaries of the research papers of this thesis. The summaries are organised according to the three emergent moves of this thesis process as outlined in the methodology section. For the full papers, please see the appendix.

4.1 Move 1 – Initial engagement with cases

4.1.1 Paper I – Learning while creating value for sustainability transitions

The aim of the first paper of this thesis (Larsson & Holmberg, 2018) was to position Challenge Lab (C-Lab) in an Education for Sustainable Development (ESD) discourse and to conduct an initial investigation into the experiences of students and stakeholders participating in the Lab.

ESD seeks to institutionalise and integrate sustainable development into teaching and learning at various levels and to empower learners to take action for a sustainable future (UNESCO, 2014). ESD integration in higher education tends to challenge the way educational institutions are structured and organised (Barth et al., 2016; Cortese, 2003; Lozano, 2006). Apart from the various institutional challenges that emerge in making Higher Education Institutions relevant for sustainable development, there is an interest within research as well as practice in understanding how initiatives that take ESD ambitions seriously 'work' once in place on the ground. This interest relates to most research on innovative and experimental pedagogies in line with ESD ambitions being of a conceptual character, with the few empirical studies that exist relying on measuring student satisfaction levels, rather than understanding students' learning experiences and associated processes (Tilbury, 2016).

C-Lab, an institutional innovation and curriculum methodology with transformational sustainability ambitions located at Chalmers University of Technology in Gothenburg, Sweden, seeks to embody ambitions of ESD. C-Lab creates space and support for students to develop capabilities for leading sustainability transitions via transdisciplinary engagement with complex and systemic sustainability challenges in local and regional contexts. The space for learning becomes the 'in-between' space situated around a complex challenge or question of concern on a systems level in a local/regional context. The challenge identification and framing process is pursued by students, with stakeholders invited to take part and exchange perspectives in dialogue, guided by a backcasting methodology where students move through a series of steps and actions from inside-out and outside-in perspectives (Holmberg, 2014).

Using a case study approach (Bassey, 1999) in combination with ethnographic methods, this study primarily built upon an in-depth analysis of three selected student theses conducted in the Lab during 2015 and 2016. Data were collected through process-related documents, published master's theses, participant observation, semi-structured interviews and focus groups. A questionnaire was also administrated to the main stakeholders involved related to the three cases. The analysis was guided by an analytical framework seeking to capture indications of transformative and integrative value creation underpinned by cultural-historical activity theory and expansive learning, as well as a broad collection of student learning experiences.

The main results indicated that students involved in C-Lab experienced their engagement as meaningful. In particular, they referred to how the lab exposed them to uncertainty and taught them to cope with it. Additionally, they emphasised how C-Lab had supported them in fostering empowerment, self-awareness and openness towards others. Further, the study indicated that stakeholders experienced their interactions with students as impactful, in how students could take a special role in facilitating mutual understanding on complex and shared 'in-between' challenges across stakeholder groups and perspectives and support in resolving the same by, for example, organising stakeholder dialogues and challenging underlying assumptions.

This contribution was a first attempt to better understand how C-Lab students and involved stakeholders experience the Lab related to its internal aims and ambitions. The indicative results from this study spurred further interest in understanding C-Lab with a more rigorous conceptualisation of learning and analytical frame to better understand students' learning processes (Paper IV)

4.1.2 Paper II – Features (capacities) of guiding principles for sustainability

The aim of the second paper in this thesis was to gather general experiences and effects from participants working through a backcasting from principles process in a transdisciplinary reflexive governance setting, navigating sustainability transformations in a regional context. In particular, we sought to further theorise on potential features (capacities) of guiding principles for sustainability in supporting such undertakings, embedded in a backcasting methodology.

The paper built on the observation that future visions are commonly positioned as central to support transitions governance, where sustainability principles may be understood as a particular form of vision or complement to vision. Yet empirical

inquiry into what the principles actually are and may contribute in such processes remain scarce.

The study built upon a mixed data set combining participant experiences gathered in a pre and post evaluation survey, interviews and field notes from participant observations, as well as semi-structured interviews with the project group members and scanning of meeting protocols throughout the design, conduction and evaluation of the process.

The results of the paper are divided into two main blocks, (1) being an overview of the backcasting process in context and broadly gathered experiences and effects from the same, followed by (2) a further theorising into potential features (capacities) of guiding principles for sustainability that combined claims from previous research, theories and concepts of relevance and built upon participant experiences as concrete empirical manifestations of these features.

The survey indicated a build-up of transformations, systems and target knowledge among the participants providing an overall indication that the process supported participants in generating knowledge of importance in navigating sustainability transitions. However, these indications lack triangulation and are better understood as a further development of tendencies to only evaluate effects from transdisciplinary processes post (Walter et al., 2007; Wiek et al., 2014), where this paper showed that participants scored high on several indicators already at the start of the process.

The theoretical/conceptual part that of the paper sought to further understand what the joint formulation and use of a sustainability framework on the level of principles did for the process. This resulted in a conceptualisation of three suggested features (capacities) of guiding principles when embedded in a backcasting process: supporting thinking beyond what currently is, thinking broadly by handling multiple aspects of concern, and thinking together by creating a shared view of a multi-faceted phenomenon. These features are tentative concepts and benefit from further conceptualisation and empirical testing, yet (theoretically) indicate that principles possess the potential to surface general, meaningful reflections on the normative underpinnings of the futures we seek to give shape to in sustainability transformations.

4.2   Move 2 – Conceptual development

4.2.1 Paper III – A sustainability lighthouse

The aim of the third paper in this thesis (Holmberg & Larsson, 2018) was to create a conceptual framework that can support and inspire conversations on sustainability procedurally.

The paper builds on the realisation that leadership for sustainability transitions (in the broad sense) requires an explicit normative direction (where to?) and purpose (why?) that can motivate and guide the change processes into desirable pathways. In transdisciplinary research and practice, and backcasting in particular, negotiation of sustainability in context is typically part of the process. However, such negotiation is far from straightforward due to the complexities and ambiguities attached to the concept, requiring some level of support.

In the paper, we sought to create a conceptual framework that provides support to structure and guide conversations on sustainability towards aspects of key importance within social, economic, ecological and human needs and well-being domains, without strictly defining. In this way, the framework was sought in order to approach sustainability in a *balanced way*, by acknowledging scientific yet fallible legitimacy on the concept, while acknowledging its moral, ethical and political implications that require negotiation in the particular time and place where all relevant actors take part in the conversation.

The conceptual framework built on data from a qualitative literature review that collected a set of established sustainability frameworks with suggested categorisations. Based on the frameworks collected, we performed a thematic analysis and further mapping in relation to three criteria, searching for a categorisation that would be basic (seeking upstreams 'first-order' properties and mechanisms that are key for the dimension), sufficient (seeking to cover all major aspects of the dimension) and non-overlapping (seeking internal homogeneity and external heterogeneity). Finally, a re-contextualisation was made with attention to the intents of this particular framework as functioning within a backcasting logic and transdisciplinary research and practice. The results were visualised in the form of a lighthouse (Figure 8) to illustrate its conceptual basis and make assumptions explicit in a pedagogical way, illuminating relations between the dimensions (ecological as basis, social and economic sustainability as building blocks and

human needs/well-being as ends in line with the Daly triangle (Daly, 1973) and the Brundtland definition (WCED, 1987)).

Figure 8 – The conceptual framework visualised in a 'lighthouse' model aims to inspire and support conversations on sustainable futures. At the top of the lighthouse, we have the human needs and well-being dimension. Depending on how these needs are met, this dimension influences the other dimensions and provides direction and purpose. The lighthouse rests on the ecological dimension. The social and economic dimensions are understood as structures combining the other two dimensions and are also in themselves critical for sustainability.

This paper showcases one of several ways to approach and conceptualise sustainability based on the assumptions brought in and the pre-existing frameworks used as a basis for the review. In line with contemporary sustainability discourse and indeed the United Nations framing (de Vries, 2019), a strength of the framework may be that its dimensions and categories are recognisable and may serve as a sufficiently legitimate starting point in supporting further conversations to handle its multiple aspects and complexities in a comprehensive way, and also open up for critique. However, evaluation of its eventual usefulness and how it may be engaged with in practice was beyond the scope of this particular paper. The procedural idea for engaging with the lighthouse implies that one preferably starts with the lighthouse empty and participants start a conversation on dimensions and categories of relevance. Aspects from the lighthouse may be sequenced in to inspire and support such emergent conversations that essentially negotiate the meaning of sustainability in context.

4.3 Move 3 – Analytical deepening

4.3.1 Paper IV – Opening the black box of learning in Challenge Lab

This contribution (Holmén et al., 2021) builds on experience from earlier research and practice in Challenge Lab (C-Lab). It aims to further understand students' learning experiences by explaining why and how these are generated in the process, as well as reasoning about potential learning outcomes emerging from the experiences. Further, the paper aims to generate knowledge in such a way that it would be of value in comparing and giving shape to initiatives with similar ambitions in other contexts.

Based on a realist evaluation framework, a socio-cultural approach to learning and ethnographic methods including interviews and participant observation, we sought to identify and conceptualise important learning mechanisms at play in C-Lab with a set of associated context-mechanism-outcome (CMO) configurations.

Three CMO configurations of importance for students in developing capabilities for leading sustainability transformations were conceptualised: (1) *learning space*, referring to the importance of engaging with complex 'in-between' sustainability challenges in society with stakeholders across sectors and perspectives; (2) *learning methodology*, referring to the importance of navigating purposeful and transformative change via backcasting; and (3) *learning within*, referring to whole-person learning from the inside-out as an identity-shaping process, guided by personal values. These CMO configurations tie together seven interrelated learning mechanisms that together seek to explain what works, for whom, why, and in what circumstances in a C-Lab curriculum in context (Table 1).

Table 1 – A summary of the seven learning mechanisms (M1-M7) at play in C-Lab, grouped into three CMO configurations. CMO1 presupposes M_1, M_2, with an emphasis on M_6 and M_7. CMO2 sequences the learning process particularly emphasising M_4, M_5 and M_6. CMO3 emphasises whole-person learning dimensions of M_1, M_2 and M_3.

C-Lab supports students in meaningfully leading on sustainability transformations through…

CMO1 Learning space			CMO2 Learning methodology		CMO3 Learning within	

Encompassing the following learning mechanisms:

M_1	M_2	M_3	M_4	M_5	M_6	M_7
Students in the centre	Sense of togetherness	Values	Sustainability orienting	Multi-perspectivity	Leverage point attraction	Holding an exploratory in-between space
						… in context

These learning mechanisms and their associated CMO configurations should be possible to adapt in giving shape to educational initiatives with transformative ESD ambitions, where space is created for students to develop leadership capabilities for engaging with complex sustainability challenges in society.

4.3.2 Paper V – Comparing sustainability transition labs in practice

The fifth contribution of this thesis aims to illuminate similarities of and differences between two similar backcasting-oriented transition processes taking place in different contexts: the arenas for a fossil independent West Sweden leading up to a regional climate strategy (Climate 2030) and the Energy Futures Lab in Alberta, Canada. The paper takes an exploratory approach in addressing the three questions of 'why, what and how' to compare sustainability transition initiatives.

Starting with a general motivation that cross-case research is called for within sustainability transition and transformation research communities (Köhler et al., 2019), we position and adapt an analytical framework building on Williams and Robinson (2020) that may support such efforts. The framework focusses on the three overarching categories of process, effects, and sustainability transition impacts, with an associated set of sub-categories to guide data collection, structuring, comparison and further analysis of observed similarities and differences of interest across cases.

The paper primarily builds on pre-existing datasets and single case evaluation, why this paper is dedicated towards sharing findings and insights emerging from the comparison rather than providing in-depth accounts from each case. The analysis procedure sought to provide analytical width across a selected set of categories, while also providing depth into each category to understand underlying reasons for the observed similarities and differences, including analysis into the eventual implications with attention to context.

The comparative findings illuminated how contextual differences in terms of urgency and turbulence impregnate lab activities, and how ownership and governance conditions influence the various directions that outputs, effects and wider impacts may take, including their political feasibility. Further, we found how backcasting and the multi-level perspective for transitions may serve as complementary frameworks, methods and tools in transition processes.

The paper ends with a reflexive account, sharing knowledge and experience from doing the actual comparison. This account shares concrete examples of why and how the cross-case comparison was of value for us researchers where we share

insights and a series of questions for further cross-case attempts in this research context. Importantly, we saw reason to question some general orientations in transitions-oriented research agendas that seek to derive 'success' and 'failure' factors from transition experiments and facilitate large-scale comparisons to derive best practice, which risk overlooking important contextual considerations that make deliberate transition initiatives different in their own right.

5 Discussion

This thesis aims to contribute knowledge on how sustainability transformations can be navigated in practice. In the introductory and background/conceptual framing chapters, I outlined and motivated a systems transformation approach to persistent and complex sustainability challenges. I further positioned the central role of transdisciplinary research and practice (in the broad sense) as a form of reflexive governance and proposed that such essentially social collaboration processes can be understood as processes of transformative social learning. Based on these considerations, I outlined a backcasting from principles methodology that may guide, support and scaffold such processes. I also introduced the special role of education and educational institutions in sustainability transformations. Below, I discuss contributions from this thesis in light of this broader framing by means of combining and synthesising contributions from individual papers.

This wider discussion attempt is emphasised as the specific contributions from the individual papers have already been discussed in their respective studies (see Table 2 for an overview of the individual research papers and their full form in the appendix). The following discussion is thus oriented towards contributing knowledge to the general issue at the heart of the individual papers and this thesis as a whole, namely contributing knowledge into the general issue of navigating sustainability transformations in practice. I start by discussing the main contributions and their implications, including attempts to synthesise, followed by deliberation and discussion of the main limitations before outlining some promising areas for further research.

Table 2 – Overview of the research papers of this thesis

		Type	Field	Object	Analytical or theoretical frame	Methods	Form of result
Move 1	Paper I	Empirical	Sustainability transitions ESD	ESD curriculum guided by backcasting	Learning as value creation Expansive learning	Case study, mixed data set	Student learning experiences Transformative/integrative value creation
	Paper II	Empirical Conceptual	Sustainability transitions	Arena-based climate policy process guided by backcasting	Process and effect evaluation. Emphasis on sustainability principles and backcasting	Case and process-evaluation, mixed data set	Indication of process-related effects Features (capacities) of guiding principles for sustainability
Move 2	Paper III	Conceptual	Sustainability transitions	Sustainability frameworks	Principles as basic, sufficient, non-overlapping	Qualitative literature review Thematic analysis	Conceptual framework
Move 3	Paper IV	Empirical Conceptual	ESD	ESD curriculum guided by backcasting	Learning mechanisms Situated learning	Realist evaluation, case study, mixed data set,	Mechanisms of learning Context-Mechanism-Outcome configurations
	Paper V	Empirical	Sustainability transitions	Two transition labs/arenas guided by backcasting	Process, effect and sustainability transition impact framework	Cross-case comparison and analysis, mixed data set.	Comparative results across process, effects, impacts Reflective insights

5.1 Contributions and implications

Below, I discuss overall contributions and implications stemming from this thesis organised into the three main themes of (1) principles-based transformative praxis followed by a synthesised backcasting methodology, (2) transformative education for sustainable development followed by a synthesis into emerging approaches of ESD, and (3) comparing process, effects and impacts in context for methodological development and beyond.

5.1.1 RQ2 & RQ3: Principles-based transformative praxis

The primary step, first move and action in backcasting in practice is engagement with sustainability principles providing a normative foundation and outlining an orientation providing purpose (why) as well as direction (where to) for navigating transformations into sustainable and desirable pathways. In a transdisciplinary setting, this step presupposes process codesign that, e.g., establishes the space and scope for engagement, setting a thematic orientation, including some overarching complex challenge or question of concern, and gathers actors across sectors and perspectives with knowledge on, and/or possibility to influence how, systems develop and should develop (Hirsch Hadorn et al., 2008; Lang et al., 2012; Wanner et al., 2018).

In their early development, sustainability principles that sought to guide transitional processes were assumed possible to predefine and scientifically construct (Daly, 1990; Holmberg et al., 1996; Upham, 2000). Contributions of this thesis point toward the possibility of incorporating the procedural condition (cf. Robinson, 2004) in principles-oriented practice, where the particular meaning of sustainability is negotiated in an essentially social process in context that may be informed but not controlled by research. Here, we sought to maintain what works well in principles-oriented practice (Broman & Robèrt, 2017; Holmberg, 1998; Holmberg & Robèrt, 2000; Nattrass & Altomare, 2002), while suggesting a move from *sustainability principles* (scientifically pre-determined) into *guiding principles for sustainability* (procedurally negotiated in context, e.g. with support from the lighthouse in Paper III). This shift was considered especially important to handle values, ethics and framing choices that become particularly apparent when moving from the natural into the social and so the societal aspects of sustainability and related implications. Further, to systemically address sustainability challenges, it is important to understand not only undesired states, effects and thresholds in nature (e.g. Rockström et al., 2009), but also associated socio-ecological relationships and underlying social/societal systems, structures and mechanisms deemed unsustainable in various dimensions. In addition, by partaking in constructing the

meaning of the concepts engaged with, one may further enhance ownership and intrinsic motivation and thus agency 'from within'.

As theorised in Paper II and further built upon in Paper III, guiding principles for sustainability may, due to their abstract form and explicit ethics, support *thinking beyond what currently is* toward what is considered important and desirable for sustainability. Such a normative stretch into the future may allow for an expansion of the possibility space in which interventions and options that challenge and depart from patterns of the present and the past are sought, rather than extending the same. This feature is commonly recognised as a key motivator for engaging with backcasting in general (Dreborg, 1996; Robinson, 1988; Vergragt & Quist, 2011), motivated by Stewart (1993) in his work on future state visioning in the following way:

> *What is* can be a great barrier to *what could be*. Those who want to move forward through bold and effective change, should begin at the end–with where they want to be. (p. 98)

We further theorised that guiding principles for sustainability support *thinking broadly* about sustainability, where a set of succinct formulations may cover essential aspects along ecological, social, economic domains, balancing the tendency to reduce sustainability into only an environmental concern or a question of climate change – which of course are broad issues in their own right, but sustainability is even broader. Sustainability framings that build on a narrow comprehension of its complexities tend to lead to paralysis, polarisation and trade-offs, where any (suggested) forward movement essentially become contested (Leach et al., 2010; Meadowcroft et al., 2019). An at least initially broad comprehension of sustainability and associated challenges from multiple perspectives may surface complexities and an interconnected nature, opening up for the possibility of exploring and learning from various framings and associated implications, in overcoming duality and either/or thinking. For example, climate planning and policy at various levels show increasing interest towards exploring co- and ancillary benefits where the same intervention may simultaneously address multiple issues and needs.

Further, we theorised that guiding principles for sustainability may support *thinking together*, assuming collective and personal ownership. Such integration with personal and collective values may educe an inner sense of meaning and motivation (I want to) or even congruence (I am) (Ryan & Deci, 2000; cf. Hock, 2008) in taking action in line with principles. This can be exemplified in the principles-based

practice of Gandhi (1983) as a constant experimentation in the present with one's inner (desired) truth.

To ensure that principles-based approaches to sustainability do not only become idealist thinking outlining what is important and desirable in terms of direction and purpose (where to, why), principles also necessitate juxtaposition with some present situation to illuminate creative tension and contradiction (cf. Senge, 1990). Such analysis may depart from using the principles as a lens to identify unsustainabilities in some present situation or system. As motivated in the background chapter of this thesis, such analyses benefit from not only recognising the empirical layer of observed experiences and events, but also searching for underlying factors and causes in the actual and the real (what is, why?). We may thus sketch on a fourth feature (capacity) of importance when navigating transformations in practice (apart from the features of principles of thinking beyond, broadly and together), namely the importance of *thinking below and behind* observable phenomena, patterns and events. Such an approach necessitates a systemic and systematic approach in moving attention *below the tip of the iceberg* and/or *behind the direct observable* domains into the underlying domains of e.g. world-views, structures and mechanisms (cf. Mingers, 2014).

And, while wishful thinking about futures and critique of the present are necessary for transformative change, these will not suffice (Westley et al., 2006). There is a necessity to *think forward.* Here, questions on agency and processes of change become important, building on prior knowledge about systems and structures in context that enable and constrain possibility of taking purposeful action in line with a normative orientation.

Principles-based work may along these lines be understood as a form of praxis (theory-informed action or critical reflection translated into action), where an explicit ethics on the level of guiding principles seeks to illuminate unsustainability in the current reality so as to motivate and guide action addressing the same. Such (critical) action demands introspection (Checkland, 2000; Ellsworth, 1989; Scharmer, 2009), as it is the integration of the inner and the outer that provides conditions for meaningful learning and change processes (cf. Kahane, 2012). In Challenge Lab, for example, Holmberg (2014) reminds us that such integration may be achieved by approaching the world from an 'outside-in' (sustainability objectives, systems analysis, leverage points, etc.) and 'inside-out' (values, dialogue, co-creation, etc.) perspective.

Below, I outline how these five modes of thinking may be woven together in a backcasting from principles methodology as a main contribution stemming from this thesis. I also remind the reader that we in paper III present a conceptual framework that may inspire and support processes of negotiating sustainability on the level of principles in context.

5.1.2 Synthesis: Backcasting from principles as methodology in practice

The backcasting methodology that has been furthered in this thesis seeks to support the navigation of sustainability transformations in practice by taking an explicit starting point in sustainable and desirable futures on the level of principles. Building on the (desired) sequence of such principles-based transformative praxis as outlined in the section above, the backcasting methodology furthered in this thesis includes formulating guiding principles for sustainability (step 1), followed by an analysis of present systems on a basis of principles to illuminate gaps (step 2), leverage point interventions for bridging the gaps (step 3) and strategic experimentation in leverage points (step 4). This methodology may be particularly important in supporting progress on complex sustainability challenges and transformations on the level of groups and collectives in diverse settings.

Table 3 provides an overview of this backcasting methodology, including an overview of its primary steps and actions, guiding questions, desired qualities and features and examples of tools and methods that may be used. The explanatory phrasing in the table should be familiar to the reader acquainted with the concepts put forward in this thesis.

This backcasting methodology is not to be understood as a strict prescribed procedure at a level of tool and method, but rather a guiding methodological frame that may sequence conversations and actions by providing scaffolding support towards desired qualities, features and mechanisms, where various methods, tools and techniques may be used. However, it is important that the methodology is specific enough to provide practical guidance, while being adaptable to its particular context of application and participating actors, similar to the transition management cycle (Loorbach, 2010).

Table 3 – Summary of backcasting methodology including steps, actions, guiding questions, desired qualities and features and an example of tools and methods. The methodology builds upon sequencing of steps as suggested by Holmberg (1998), with tools and methods partly from Holmberg (2014). Adapted versions of this methodology are applied in the cases presented in Papers I, II IV and V, and further motivated in Paper III. Conceptualisation and phrasing take inspiration from Robinson (1988), Schudel (2017) and Wright (2010).

Step	Action	Guiding question(s)	Desired qualities and features	Example of tools and methods
1 **Desirability** *Where to, why?*	Formulate guiding principles for sustainability	What is important? What should be?	Connecting the inner with the outer Setting purpose and direction Thinking beyond and broadly, together	Sustainability frameworks (e.g. the lighthouse) Values clarification
2 **Reality** *What is, why?*	Analyse a present situation or system in relation to the principles: illuminating gaps, challenges and absences	What is in relation to what should be, and why? Moving into underlying factors and causes, illuminating difference and possibility	Being systematic and systemic Incorporating multiple perspectives Thinking below/behind and broadly, together	Systems mapping Dialoguing
3 **Achievability** *What could be different, where?*	Identify leverage point interventions for bridging gaps, addressing challenges, absenting absences	Where lie potential to shift what is into what could be in direction towards what should be?	Encouraging creativity and iteration Finding place of transformation Thinking below/behind and forward, together	Leverage points Synthesis, reflection and re-framing
4 **Viability** *What can be, how?*	Experiment strategically with leverage point interventions	Given who and where you are, what and whom you know: what can be done, how?	Mobilising transformative agency and praxis in context. Thinking forward with 1-3 in mind, together	Co-creation Effectuation Experimentation

From this view, we may view backcasting from principles methodology as a supporting framework for a form of purposeful (step 1), systemic (step 2), transformative (step 3) and reflexive (step 4) praxis. Purposeful, by taking an explicit starting point and stance in ethics and normative orientation; systemic, by approaching systems and challenges with attention to underlying factors and causes in a non-reductionist way; transformative, by seeking potential for impactful achievable change; and reflexive, by incorporating theory and reflection in practical action in context, adapting to dynamic circumstances (cf. Ison, 2017). The methodology may further outline a form of dialectic exploration and movement along a sequence of desirability, reality, achievability and viability in context (cf. Wright, 2010), where reality-achievability-viability together may encompass that which Robinson (1988) refers to as feasibility in backcasting.

Please note that when such methodology is employed in practice related to some complex challenge, question or issue of concern around which multiple actors collaborate in a transdisciplinary setting, multiple factors come into play simultaneously. The role of methodology may here be viewed as a supporting scaffold oriented towards removing unnecessary uncertainty while maintaining desirable difficulties (Bjork & Bjork, 2011), by means of sequencing conversations, focussing attention and providing movement in a way that seeks to maintain and contain complexity without reducing it. Analytically, we must be wary of assuming a causal connection between intended methodology in theory and the actual process as unfolding in practice, without a priori assuming a connection between the two (cf. Pawson & Tilley, 1997).

There are several methodologies of interest worthwhile comparing and contrasting (in their broader transdisciplinary/reflexive governance setting) to the particular backcasting methodology outlined in this thesis. Such methodologies include, but are not limited to, the transition management cycle and urban transition labs (Loorbach, 2010; Nevens et al., 2013), participatory backcasting (Quist & Vergragt, 2006), adaptive management (Pahl-Wostl et al., 2007; van der Voorn et al., 2012), transdisciplinary research in real-world laboratories (Lang et al., 2012; Schäpke et al., 2018; Wanner et al., 2018), transformative scenario planning (Kahane, 2012), Theory U (Scharmer, 2009), responsible innovation (Stilgoe et al., 2013), three horizons (Sharpe et al., 2016), and social innovation labs (Westley et al., 2012). I will return to this in the section on further research.

5.1.3 RQ1 & RQ4: Transformative Education for Sustainable Development

This thesis has engaged with Education for Sustainable Development (ESD) on a level of higher education institutions and curriculum models. Higher education

institutions play a special role in sustainability transformations, and much research and practice is oriented towards understanding how such institutions can be re-oriented to be even more relevant for societal challenges (Barth et al., 2016; Cortese, 2003; Lozano, 2006; Sterling, 2010). On the level of pedagogy and curriculum models, there is growing interest and demand for educational approaches with transformational sustainability ambitions. Such approaches tend to take the situated nature of learning seriously and acknowledge the importance of the democratic importance in educating and learning for sustainability (UNESCO, 2014). In such approaches, students engage with complex sustainability challenges in their authentic societal context in open-ended processes together with societal actors, and preferably with high levels of student engagement (Chikamori et al., 2019; Macintyre et al., 2018; Tilbury, 2016). Despite several examples of initiatives where sustainability challenges in their authentic context constitute the situated space for learning, and students work together with societal actors to learn from and resolve problematic situations (e.g. Barth et al., 2014; Biberhofer & Rammel, 2017; Blake et al., 2013; Bodorkós & Pataki, 2009; Macintyre et al., 2018; Munro et al., 2016; Scholz et al., 2006), little qualitative research has been conducted to better understand what, how and why students learn by being part of such processes. Rather, research has tended to focus on measuring student satisfaction levels and report what teachers rather than students do (Tilbury, 2016). And while important knowledge has been attained on conceptualising sustainability competence frameworks and desired learning outcomes (Brundiers et al., 2020; Svanström et al., 2008; Wiek et al., 2011), less is known about the (learning) processes and mechanisms by which such competences and outcomes are developed. This makes it generally difficult for teachers to give shape to sustainability-oriented curricula and support students' learning processes in practice (Chikamori et al., 2019).

The contribution to ESD in this thesis stems from studies of a Challenge Lab (C-Lab) curriculum with transformative sustainability ambitions, where students are provided space and support to take a lead in sustainability transitions together with societal actors. C-Lab emerged as part of a larger process at the university seeking to create institutional inter- and transdisciplinary space for engaging with complex sustainability challenges in society (Holmberg, 2014; Holmberg et al., 2012). On the level of its pedagogy and curriculum, the studies of C-Lab presented in this thesis have broadly gathered students' learning experiences from being part of such an initiative, indicating general experiences of meaning and hope, having coped with complex and uncertain situations, and learnt to lead themselves (e.g. values-based self-leadership), together with others (e.g. dialogue, co-creation) and for humanity (e.g. sustainability, systemic change). The contributions further highlight the seemingly unique role students can play in sustainability transformations by being

simultaneously challenging and unthreatening. Provided the right conditions, these contributions to Challenge Lab highlight that students possess an ability to facilitate, e.g., expansive learning processes and systems change by bringing stakeholders together across sectors around a complex systemic issue of concern, surfacing various perspectives, illuminating contradiction and tension, challenging underlying assumptions, building trust and facilitating forward movement.

Curriculum models that meaningfully engage with sustainability challenges in context have often been carefully developed and evaluated based on their often unique circumstances made up of institutional conditions, participating actors, local context, etc. This has made it generally difficult to transfer knowledge and experience on such curriculum models across cases and contexts. In studying C-Lab, we identified a set of underlying learning mechanisms conceptualised into an associated set of context-mechanism-outcome configurations that may inform comparative research, curriculum development and teaching practices across contexts; the learning mechanisms may be similar across contexts whereas the way they come about and manifest may differ. With an understanding of learning mechanisms, teachers and facilitators may scaffold towards desired situations and activities with knowledge about context and participating students to create conditions for such mechanisms to come alive. Such an approach acknowledges the open-ended nature of the learning processes by not steering towards a pre-defined set of outcomes, but rather guiding (see Budwig, 2015) students towards situations where desired mechanisms may come alive.

Finally, the contributions on C-Lab showcase that for students to take ownership of their learning processes and engage with complex and open-ended sustainability challenges in society requires support rather than leaving it all to them. Several studies point towards the importance of scaffolding to make progress on complex challenges and to create conditions for learning to become meaningful (Budwig, 2015; Jordan, 2016; Levy, 2011; Lönngren et al., 2019). The studies of C-Lab add an additional and concrete example showcasing how such scaffolding support may be provided, where the three context-mechanism-outcome configurations may provide a starting point, highlighting the importance of (1) creating a safe space of openness and trust, in combination with (2) methodologically supporting to contain complexity by means of sequencing, while (3) acknowledging the inner and affective dimensions of learning and change.

5.1.4 Synthesis: Education for, as and in sustainability

A risk associated with ESD is that it becomes instrumental, which has its tendencies since it is framed as education *for* something (Jickling, 1992; Kopnina, 2012).

However, moving environmental and sustainability-oriented education from traditionally instrumental into an intrinsic activity is a main ambition of ESD, calling for a series of educational shifts to enhance deliberation and participation (Tilbury, 2011): *From passing on knowledge – To understanding and getting to the root of issues. From teaching attitudes and values –To encouraging values clarification. From seeing people as the problem – To seeing people as facilitators of change. From sending messages – To dialogue, negotiation and action. From behaving as expert: formal and authoritarian – To acting as a partner: informal and egalitarian. From raising awareness – To changing the mental models which influence decisions and actions. From changing behaviour – To more focus on structural and institutional change"* (p. 25).

Similar shifts were proposed by Vare and Scott (2007), referring to ESD1 and ESD2, and Wals and Jickling (2002), arguing for how meaningful sustainability education indeed requires a participatory, democratic, pluralistic and emancipatory approach. Such education does not seek to impose but rather to open up for challenging and critiquing value and knowledge claims as well as inviting students to construct their own meanings. A move from instrumental to intrinsic may increasingly emphasise the role of education *as*, rather than *for*, sustainability. Such education may still occur in a classroom context in isolation from the outer world and become a critical conversation of mere academic interest.

In light of the contributions of this thesis and the interest in sustainability transformation learning orientations, we may assume a third branch of ESD as currently emerging. This is a form of education that is not primarily a form of education *for* or *as* sustainability, but *in*. As outlined in the previous section, such education and learning take an explicit starting point in sustainability challenges in their authentic context. Associated learning processes unfold in concrete situations and interactions emerging from the situated engagement with sustainability challenges together with societal actors, not controlled by but facilitated by the teacher where societal actors, students and a complex challenge are put in the centre (cf. Chikamori et al., 2019; Lotz-Sisitka et al., 2015; Macintyre et al., 2018). The contributions on Challenge Lab as part of this thesis show such characteristics (see the 'upper right' quadrant in Figure 7), shared with a series of related place-based, transdisciplinary and service-learning pedagogies and curriculum models that involve students in addressing complex sustainability challenges in their situated context.

5.1.5 RQ5: Comparing process, effects and impacts from initiatives across contexts

Transdisciplinary and reflexive governance initiatives often have as ambition to resolve complex sustainability challenges while contributing to systemic and transformative change. However, progress on the change front is seldom checked, and has proven generally difficult to evaluate, as transformations are long-term processes, and initiatives seeking to contribute to the same operate in open-ended complex systems (Williams & Robinson, 2020). Yet a general interest remains in understanding and explaining processes, effects and impacts associated with and generated by particular deliberate transformation-oriented initiatives. For example, it is often important for accountability reasons to report what has been achieved in relation to set goals and allocated resources. In terms of internal learning and enhancement of practice, it is often important to reflect on what has worked well and why, where ongoing monitoring and evaluation may be an integrated part of the initiative (Patton, 2010; Penfield et al., 2014; van Mierlo, 2010).

I have been particularly interested in and concerned about the possibility of making causal (e.g. mechanism-oriented) claims on how backcasting approaches play out in their wider transdisciplinary governance setting, and to what extents particular outcomes, effects and impacts not only can be attributed to the initiative at large but also to its particular methodological orientation. Here, main contributions come from Paper II adapting an evaluation framework by Wiek et al. (2014) and Walter et al. (2007), where we highlighted an indication that the steps in the backcasting from principles approach in the process studied corresponded to how participants experienced a build-up of target (step 1), system (step 2) and transformation (step 3 and 4) knowledge. However, a main issue remained (and still remains) relating to the issue of (causal) attribution also in relation to context.

While Paper IV (discussed in the previous section) represents an attempt to better distinguish process from context by adopting realist evaluation (Pawson & Tilley, 1997), Paper V sought to distinguish process from context by means of cross-case comparison and analysis into two similar backcasting-oriented processes unfolding in different contexts. This paper broadly approached the initiatives by paying attention to key characteristics of their respective processes (including methodologies and methods deployed) as well as effects and impacts from the initiatives. Main contributions of Paper V in the context of this discussion may not be on a level with its empirical results (for which I refer to the appended paper in the appendix), but on a level with why cross-case comparison and analysis may be of value, what to compare and how such comparisons can be made.

A main motive in developing encompassing evaluation frameworks for sustainability transition initiatives has been to synchronise data collection to facilitate comparison (Luederitz et al., 2017), with little motivation for why such research may be worthwhile. Paper V represents an empirical contribution towards such ends, illustrating how the comparative design not only allowed generating comparative findings on e.g. similarity and difference, but also better understanding how and why the respective initiatives studied unfolded the way they did in relation to their surrounding context. From a methodological point of view, this contribution also noted a risk based on its empirical findings, related to calls for large-scale comparative efforts that seek to establish success factors, best practices and ideal-type processes as recently called for in transitions-research communities (Newig et al., 2019; Sengers et al., 2016; cf. Köhler et al., 2019). Such efforts may support a general understanding of what tends to work, but in overlooking contextual contingencies and case-specific considerations, such studies may fall short in guiding practice by being prescriptive/imposing rather than creating conditions for sustainability transformation initiatives to emerge (see Diercks et al., 2018; Schot & Steinmueller, 2018; Torrens et al., 2019), in response to their often unique challenges of concern in their respective contexts (Scoones et al., 2020).

5.1.6 Reflective synthesis: How to approach evaluation in complex settings?

I chose not to present a synthesis into this particular research question, as with the previous sections outlining contributions and implications. This is partly due to that RQ5 stands on its own in an individual paper that has already been discussed. Instead, I've chosen to share a general concern related to evaluation as emerging from the efforts of Paper V below.

In furthering knowledge into particular evaluative interests as furthered in this thesis, main challenges remain in distinguishing particular methodologies of engagement as planned and intended, vs. how they actually unfold in practice and are experienced by the participating actors in their wider governance setting (see the categories in the evaluation framework by Williams and Robinson (2020) for clues on what may be worthwhile to include and account for in such inquiry). With this thesis comes a general concern about the possibility of making causal (e.g. mechanism-oriented) claims on what backcasting from principles means (or not) for the wider transdisciplinary collaboration process in context, including associated effects and impacts from a perspective of social learning. Likely, such research efforts benefit from qualitative/intensive research efforts (Danermark et al., 2002), which I bring forward in the section on further research.

An alternative take comes in the form of a 'principles-based evaluation', as developed by Patton (2017), which may be apt in responding to the concerns raised above. The approach fits seemingly well with the idea of guiding principles for sustainability as a form of purposeful, systemic, transformative and reflexive praxis as furthered in this thesis.

In principles-based evaluation, the focus is on making explicit and evaluating towards guiding principles used to guide deliberate change processes, in contrast to evaluating towards goals fulfilment. Such an approach to evaluation, as argued by Patton (2017), is fit for navigating the turbulence and uncertainty of complex dynamic systems where one cannot assume control and steer towards pre-set goals by means of measuring and following up, but one may assume the possibility to influence dynamics in desired directions, which necessitates reflexive thinking and action guided by principles. Principles-based evaluation is oriented towards evaluating whether 1) principles are clear, meaningful and actionable, (2) whether they are being followed and/or lived, and 3) to what extent they lead to desired results (ibid.). And as eventual long-term impacts to complex systems change remain a mundane task to causally attribute single interventions in a meaningful way, the long-term accountability in evaluating progress on deliberately navigating complex systems change becomes an internalised conversation and concern, because:

> For vision-and-values-driven social innovators the highest form of accountability is internal. Are we walking the talk? Are we being true to our vision? Are we dealing with reality? Are we connecting the dots between here-and-now reality and our vision? And how do we know? What are we observing that's different, that's emerging? These become internalized questions, asked ferociously, continuously, because they want to know. Those funding innovations join in the questioning and need to understand that the seriousness of inquiry and resulting learning constitutes accountability (Patton, 2010, p. 13).

In other words, rather than evaluating towards pre-set indicators of sustainability (see Luederitz et al., 2017), this approach opens up for each initiative to procedurally negotiate its own principles for 'success' while encouraging systematic reflection upon the same throughout the process.

5.2 Limitations

Below, I discuss two main limitations of this thesis work, (i) how it relies upon cases from a limited set of contexts and (ii) how it relies on participant experiences.

5.2.1 Case-based research and context specificity

The number of processes and contexts studied to empirically inform the knowledge developed in this thesis are limited, where additional and further research is merited from multiple theoretical frames and perspectives, informed by multiple cases and contexts.

A common concern with case-based research is the issue of generalisation. Since case studies typically engage with one or a few entities, often with unique characteristics in a particular context, concerns are normally raised about the possibility to extend and transfer findings of such inquiry to other situations (Kennedy, 1979; Lund, 2014; Yin, 1994). For some, case studies are acknowledged unique and contextual in their own right, as case study research essentially is about telling the story of the case without an ambition to generalise (Stake, 1995).

To this, Flyvbjerg (2006) illuminated the contradictory critique on case study as meaningless because of context. Namely, if it were that no case-specific knowledge holds value beyond the particular contextual situation in which it has been developed, it would simultaneously mean that all knowledge of practical value is contextual. Then, we would only have use of case- and context-specific knowledge, so what point would there be in deriving general knowledge as it would necessarily be useless? (see Sfard (1998) for a similar argument related to the participation and acquisition metaphor of learning). Flyvbjerg further notes that most practical knowledge is indeed generated by experience and so is case-based, arguing for the key importance of generating knowledge and experience based on involvement in concrete cases and situations that may be transferred to new situations by means of case-based reasoning often drawing from examples.

Others argue for a more middle-ground take on case study research, noting that generally applicable insights have indeed been drawn by building on a few or selected number of cases, especially when the research design has been adequate[15] (Bryman, 2012; Danermark et al., 2002). Further, from a critical realist position (particularly explicit in Paper IV), it is acknowledged that generalisation is indeed possible even from single occurrences, but not primarily on a level of empirical observations but on a level of underlying generative mechanisms that make certain outcomes come about (or not). Yet the way such mechanisms come about and manifest may differ depending on context and so require testing across contexts to be further understood (Danermark et al., 2002; Pawson & Tilley, 1997; Sayer, 2002).

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[15] See Chambliss (1989) for a concrete example

In this thesis, I remain with the critical realist notion that the way of achieving rigorous understanding and explanation is not only by means of quantitative and extensive forms research but also by means of qualitative and intensive forms (Danermark et al., 2002; Sayer, 2002). In extensive research, we seek to understand regularities, patterns and distinguishing features among large populations and to what extents certain characteristics are distributed or represented. In intensive research, we seek to deeply understand how certain processes work in particular cases to eventually grasp the underlying structures and generative mechanisms that produce (or not) observed changes. Such an approach to research requires us to pay attention to the singular and particular.

5.2.2 Reliance on participant experiences

Important pieces of empirical material used in this thesis rely on self-reports and experience from people who have participated in the processes studied. Conventional episte-ontological views generally recommend not speculating about people's underlying reasons and possible motive for saying what they say or doing what they do and recommend remaining descriptive and openly reporting various perspectives and multiple interpretations without necessarily taking a stance for one or the other (Bryman, 2012; Gilje & Grimen, 1993).

Critical realist ambitions to understand and explain take this one step further by acknowledging that reasons can be approached and analysed as (real) causes. Here, it is acknowledged that some actual situation or process may indeed be experienced and so understood from multiple perspectives, but these different perspectives may be more or less accurate in representing what actually happened – as we all live in the same world, which is the world that exists (Bhaskar, 2016). However, all perspectives are acknowledged as real in the sense that they may have real consequences. This stance requires the research process to take into account all possible and alternative explanations to properly establish a particular situation, including explanations for what has been significant in generating that which is being observed.

Such an approach may at times be too resource demanding or even, in practice, impossible, which has required me to make decisions when to basically trust and when to be more critical of how participants portray things. For example, if there has not been an evident reason for why a person would seek to skew the way they have experienced or (really) think about some situation or process, I have found good reasons to trust and also on a basis of their expertise. In other instances, there have been good reasons to believe that people seek to provide a skewed account of

what has actually occurred. For example, process designers may have reasons to talk about their processes as particularly successful, and students their learning experiences as particularly significant. Depending on the aims of the research, it may be important to not only outline and describe possible reasons for why people do what they do or say what they say, but also seek to explain why that may be the case. And, if underlying reasons are seemingly false or build on dishonesty, there may be reason for critique. Related to this has been the importance of reducing bias to particular perspectives by (1) posing critical questions by asking for concrete examples and further explanation; (2) contrasting with additional data sources that might provide complementary or contradictory evidence, and (3) triangulating with other data sources such as formal and external evaluation, field notes and knowledge from related research.

5.3   Further research

Below, I outline two areas for further research: (1) backcasting conditioning transformative social learning and ESD and (2) comparative intensive research for methodological development and beyond (into space, process and leadership).

5.3.1 Backcasting conditioning transformative social learning and ESD

The following section takes much conceptual inspiration from the work by Lotz-Sisitka et al. (2015) and Macintyre et al. (2018), as outlined in the background section of this thesis. It further builds on the recognition by Robinson (2003) of backcasting as a form of social learning about desired futures and Quist (2007) of backcasting as having potential in generating higher-order learning.

The methodological positioning of backcasting in this thesis shows much similarity with concepts of process theory and in this case process theory of learning. Engeström (2016) views process theories of learning as inherently utopian and interventionist, by demonstrating that a comprehensive and productive learning process is possible in theory, which preferably has a *bold future-making orientation* (Greeno & Engeström, 2014). By building upon the work by Vayda et al. (1991), Engeström (2016) considered that for a theory of learning to be considered a process theory, it must contain (1) a sequence of actions or events that hold some degree of generality; (2) an explanation for why steps follow one another in a certain sequence; and (3) a rationale for how steps provide conditions for moving from one step to the next.

From such a view, process is considered an emergent and constitutive property of the various actions and events taken in context (Vayda et al., 1991). The backcasting methodology outlined in this thesis seeks to guide and support the emergence of

(learning) processes that navigate sustainability transformations in context. Such a methodology has been argued important to provide support, focus, movement and direction in the engagement process in relation to the everyday practices of muddling through (Lindblom, 1959; cf. Budwig, 2015). The backcasting methodology outlined in this thesis is constituted by a series of steps and desired actions following a certain sequence with a rationale, where each step seeks to condition activity in the following step. Together, these may make up a learning process when playing out in practice. This sequence may roughly be illustrated in a similar way as the expansive learning cycle (Engeström, 2001). At this stage, I refer to these as 'learning questions' (Figure 9) as the desired forms of reasoning, actions, events and experiences require further connection in learning theory. Such research would benefit from engaging with the general questions of who learns, what, why and how that take an explicit grounding in systems transformations and critical realism in transdisciplinary research and practice (cf. Lotz-Sisitka, 2012).
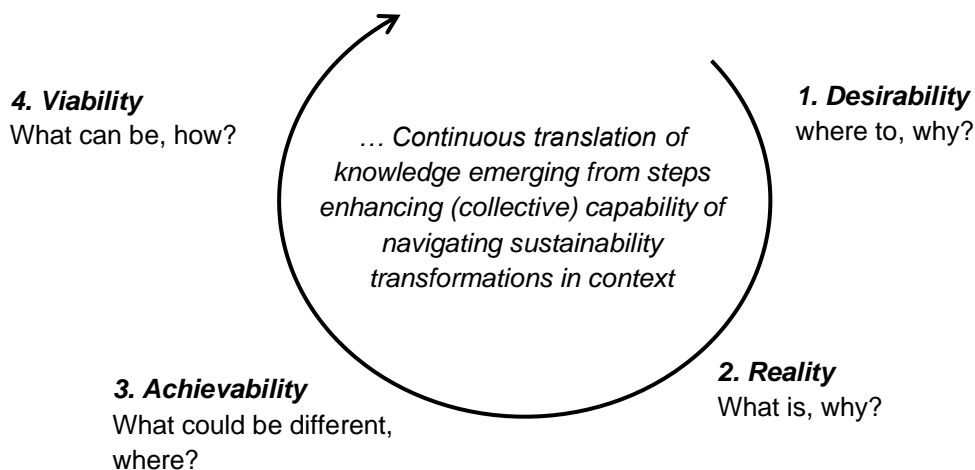
4. Viability
What can be, how?

… Continuous translation of knowledge emerging from steps enhancing (collective) capability of navigating sustainability transformations in context

1. Desirability
where to, why?

3. Achievability
What could be different, where?

2. Reality
What is, why?

Figure 9 – Sketch of cyclical backcasting-sequenced learning questions that may lead to processes of transformative social learning with its certain forms of reasoning, actions, events and experiences

Hence, further research could explore whether, how and to what extents social transformative learning processes may emerge from backcasting from principles in transdisciplinary research and practice without assuming correspondence between the methodology deployed and resulting learning process. In further exploring links across backcasting, social learning as well as ESD, there is the possibility of building on the learning mechanisms unpacked in Paper IV on Challenge Lab. Here, one may also build on the transformational model of ESD as outlined by Chikamori et al. (2019), who introduce a backcasting logic to guide concrete curriculum models and activity in line with ESD ambitions in a non-imposing way. Here, resulting open-ended learning processes are driven by efforts to understand and engage with

complex challenges in their situated context and the deliberate attempt to purposefully navigate transformations into sustainable and desirable pathways.

5.3.2 Comparative intensive research for methodological development and beyond

Transdisciplinary research and practice as a form of reflexive governance is often argued necessary and suitable to address persistent and complex sustainability challenges in the ways required by the challenges. Such initiatives, however, tend to be orthogonal to how societies and knowledge traditionally have been structured. This may be part of why there sustainability challenges in contemporary societies (Cutter et al., 2015; Hirsch Hadorn, 2008; Max-Neef, 2005; Ross & Mitchell, 2018), where we tend to emphasise the systematic (dealing with complicatedness) at the expense of the systemic (dealing with complexity towards the wicked) (Andersson et al., 2014; Ison, 2018). Further, dominant ways of social and economic organisation make actors and organisations generally occupied with optimising short term activity and benefits, rather than caring for the long-term health of the whole system upon which such activity is dependent and of which it is part (Feola, 2019; Ostrom, 2015; Senge et al., 2015).

This implies that there is of course more to transdisciplinary research and practice and reflexive governing than their methodology of engagement as particularly emphasised in this thesis. Drawing on a recent conceptualisation by McCrory et al. (2020), we may ask what kinds of spaces are needed for people to safely share perspectives and engage together across sectors and perspectives, and what ways of organising leadership and anchoring to established systems, structures and practices are needed for these initiatives to be meaningful beyond their inner spheres of engagement (Holmberg, 2019; Lam et al., 2020; Puerari et al., 2018).

To this, practical methodology and associated learning processes of course play an important role, given that certain conditions and incentives are in place. Further research may further compare and develop particular methodologies to guide and support transdisciplinary and reflexive processes on a surface level of method and tool (cf. Halbe et al., 2020) as well as on an underlying level into (desired) features, qualities and mechanisms at play when methodology with associated tools and techniques play out and are practically facilitated in context. Such research would benefit from intensive research designs (Danermark et al., 2002). Further, to better distinguish process from context and understand their interplay, we found in Paper V that comparative research designs may be worthwhile to complement rich studies of single processes. For example, we may be interested in further understanding significant qualities of particular methodologies by studying how they concretely

unfold in different contexts, as well as how different methodologies play out in similar contexts (see further Yin (1994) on literal replication and theoretical replication and von Wirth et al. (2019) for a concrete example in the context of this research).

Such research may be guided by analytical/evaluative frameworks to support data collection and comparison, for example further building on the work by Williams and Robinson (2020) to grasp characteristics of process, effects and sustainability transition impacts, and/or a related framework emphasising social learning and practice aspects of transdisciplinary processes (Slater & Robinson, 2020).

This area for further research thus briefly touches upon an interest in comparative intensive research that draws from in-depth knowledge and experience from multiple cases and processes that seek to navigate sustainability transformations in their respective contexts. Such research efforts may direct primary attention to space, methodology and organisational/leadership conditions and associated social learning processes as unfolding in practice with analytical interest in its underlying mechanisms. Such an approach may lead us even further in addressing questions on how to meaningfully and impactfully navigate sustainability transformations in practice.

By focusing on underlying generative mechanisms (Danermark et al., 2002; Pawson & Tilley, 1997; Sayer, 2002) and related qualities and features, we may provide practical support on how to address complex sustainability challenges in a way that is not imposing but is open to contextual negotiation; because mechanisms are understood as possessing power to generate certain events and regularities (outcomes), the way these mechanisms come about and manifest may differ depending on context. Mechanisms may thus inform the development of initiatives with similar ambitions across settings in a way that leaves room for situated expertise and contextual adjustment and negotiation. Hence, this represents a move away from prescribing ready-made models on the level of blueprint, best practice and toolbox, as such takes tend to overlook the situated and contextual nature of learning and practice.

From this view, the navigation of sustainability transformations in practice remains a question of practice but may be enhanced by knowledge into mechanisms that package knowledge and experience in the form of what works, for whom and why. Navigating sustainability transformations may thus be understood less as a question of 'what to do about it' and more as 'how to go about it'. Because, when seeking

out to do that which has not been, and is yet to be, done, learning comes before implementation (Engeström, 1987).

6 Conclusion

Complex and persistent sustainability challenges necessitate transformations into futures that are fundamentally different compared to what was before. Due to their open-ended complexity, such change processes cannot be planned in traditional ways, as resulting futures are not known in advance but emerge from the process (Grin et al., 2010).

Deliberate and purposeful navigation of transformations into sustainable and desirable pathways requires systemic modes of reflexive governance and transdisciplinary research and practice (Hirsch Hadorn, 2008; Ison, 2018; Voß et al., 2006), where we collectively learn how to navigate uncharted terrain throughout the process of doing so by means of exploring (Engeström, 2016; Holmberg & Larsson, 2018; March, 1991) – it is about navigating sustainability transformations.

Navigating sustainability transformations in practice is about bringing together actors across sectors, perspectives and disciplines around a complex and shared issue, question or challenge of concern in its authentic context. By drawing from experience and knowledge on how systems develop and the possibility to influence how they should develop, complex sustainability challenges are sought to be understood as well as addressed by means of resolving problematic situations and transforming (cf. Checkland, 2000; Lang et al., 2012; Scoones et al., 2020). Rather than seeking to create something out of nothing, they are essentially co-creative processes with attention to agency enabled and constrained by structure (Archer, 2003; Avelino, 2017; Chikamori et al., 2019). It is about linking up with and influencing ongoing developments, breaking with unsustainable trends and patterns, while creating conditions for sustainable and desirable alternatives to emerge (Rotmans & Loorbach, 2008). Such efforts may not succeed in generating the conditions or momentum for eventually generating systemic impacts as often desired (cf. Williams & Robinson, 2020). But one may at least learn more about how things work and should work by means of intervening (cf. Midgley, 2000).

This thesis has theoretically and practically furthered a backcasting from principles methodology seeking to make efforts at navigating sustainability transformations meaningful and impactful in context. The methodological development has been empirically informed by a limited number of learning settings and contexts, where it has been used in its authentic and wider transdisciplinary learning setting, educational as well as informal. Understanding methodological promises has been as important as understanding limitations, and critically evaluating as important as further developing.

So, in what way may the contributions of this thesis be of use?

The knowledge presented in this thesis may be of particular value in 'expeditions' (Holmberg, 2019; Holmberg & Larsson, 2018) where safe space is created separate from yet in connection to an established system or structure facing problematic situations and/or undergoing transformation. Here, a challenge, issue or question of concern is put in the centre, and actors invited to co-explore. Starting by creating a safe space for change, such exploration may be guided by the backcasting methodology as furthered in this thesis, seeking to condition a form of purposeful, systemic, transformative and reflexive praxis along the following steps:

1. Desirability: Formulate guiding principles for sustainability – where to, why?
2. Reality: Analyse some present situation or system in context in relation to the principles to illuminate gaps, challenges and absences – what is, why?
3. Achievability: Identify leverage point interventions with the potential to bridge gaps – what could be different, where?
4. Viability: Experiment strategically with leverage point interventions as transformative agency and praxis – what can be, how?

I have emphasised the special role of higher education institutions for sustainability transformations (Barth et al., 2016; Cortese, 2003; Sterling, 2010), particularly within a frame of Education for Sustainable Development (ESD) (UNESCO, 2014). By engaging with Challenge Lab (C-Lab) as a particular ESD curriculum, I hope to have concretely motivated why it may be a good idea to engage students as co-creators rather than consumers of knowledge in sustainability-oriented education (cf. Tilbury, 2016), and how teachers in such educational settings can move from experts to facilitators who create space for and support students in engaging with sustainability challenges of concern as part of their learning experience together with societal actors.

In addition to rich descriptions and references that seek to illustrate C-Lab in terms of what it is, how it seeks to function, why it was established and how it has been experienced by various actors who have taken part, knowledge has been packaged in a form of context-mechanism-outcome configurations, grounded in students' learning experiences: *learning space*; *learning methodology*, and; *learning within*. These tie together seven interrelated learning mechanisms with attention to context that may inform the design, development, evaluation and comparison of curriculum

initiatives with similar ambitions elsewhere, without imposing a particular design or learning outcome to steer towards, or prescribing how to practically 'do' the teaching, leaving that to the respective contexts to negotiate based on their often unique conditions and circumstances.

Transdisciplinary, systemic and systems-based approaches to complex and persistent sustainability challenges as outlined in this thesis seek to reflect the true nature of the challenges we face and so the complexity of the world in which we live (Cutter et al., 2015; Ison, 2017; Ross & Mitchell, 2018). The eventual resolution of such challenges relies upon our collective capability to deliberately and purposefully navigate transformations into sustainable and desirable pathways. This thesis sketched the possibility of viewing such change processes when guided by a backcasting methodology as conditioning and conditioned by processes of transformative social learning, calling for a form of learning oriented towards not only doing things better, but also doing better things and even seeing the world anew (Bateson, 1972). It is as much about stepping back to reflect by asking questions of why, as stepping forward to act by asking questions of how. Because, as André Gide (cited in Kahane (2012)) once said: *One doesn't discover new lands without consenting to lose sight of the shore for a very long time.*

7 Reflections

This thesis has allowed me to build an identity as an undisciplinary researcher and teacher seeking to make the world a better place to be. This identity-building has emerged from doing the research presented in this thesis, via experience from participating in several transdisciplinary research settings (not all of which are presented in this thesis), by exchanging knowledge, experience and perspectives with researchers and practitioners around the world, and through my role as developer and facilitator at Challenge Lab. Together, these experiences have given shape to my transdisciplinary but also essentially undisciplinary journey (Cockburn et al., 2018; Haider et al., 2018; Robinson, 2008), a journey guided by ethics and the ambition to generate knowledge that not only seeks to generate knowledge on challenges in the present, but also knowledge on how they can be addressed.

In particular, my involvement in C-Lab has provided an opportunity to test concepts and ideas in practice and critically reflect upon these together with students. This possibility has made me appreciate educational research as a way of enhancing my own educational practice, while also sharing experiences and grounded knowledge with a larger community (cf. Adams et al., 2007). These possibilities have largely been enabled by the privileged conditions of pursuing a PhD project in a conducive research environment in an enabling institutional setting. So, thanks to all of you for making this possible!

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