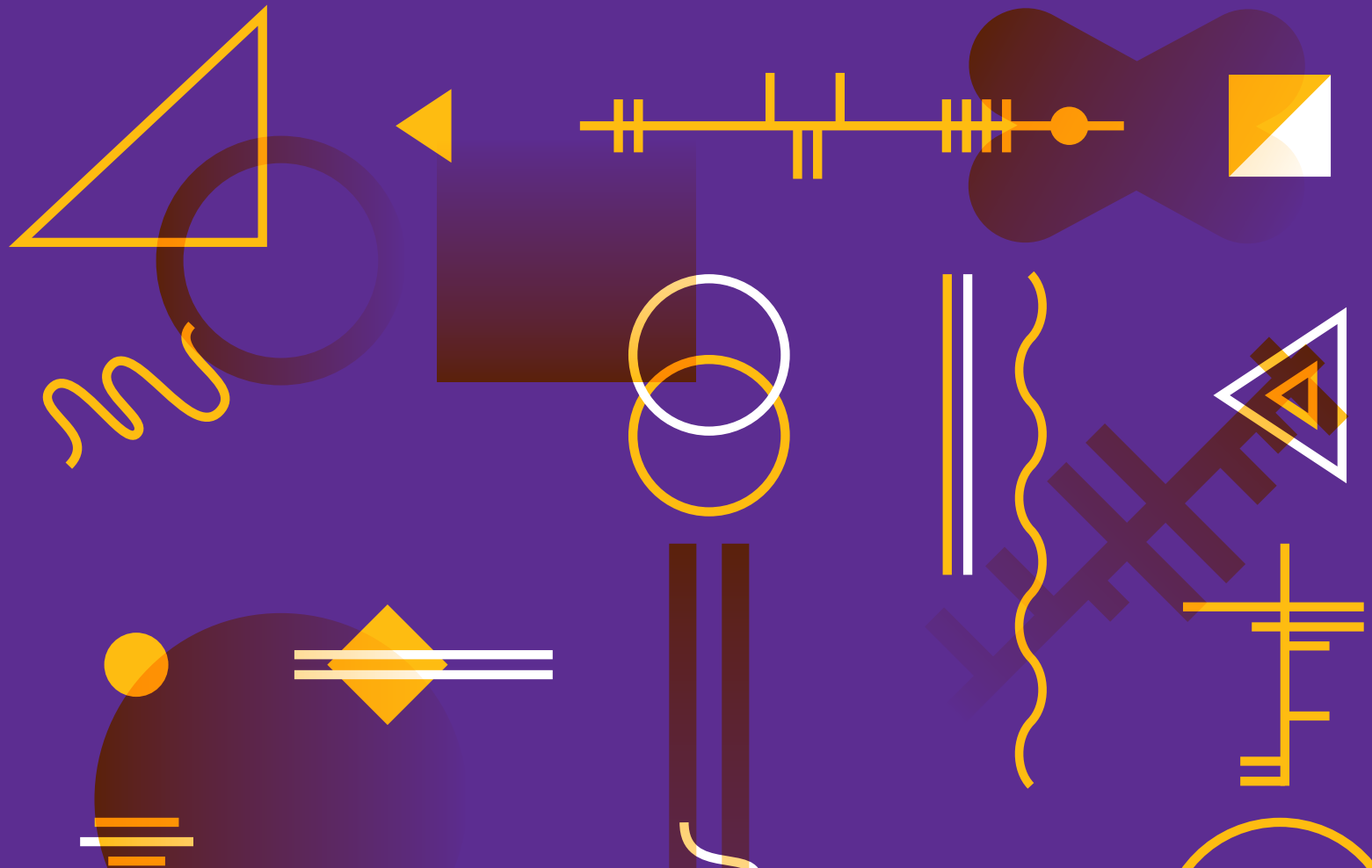
PLATFORMS OF CO-CREATION

Learning Interprofessional Design Practice in Creative Sustainability

Tatu Marttila

A? Aalto University



PLATFORMS OF CO-CREATION:

Learning Interprofessional Design Practice in Creative Sustainability

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Aalto University publication series
DOCTORAL DISSERTATIONS 154/2018

Aalto University School of Arts, Design and Architecture
Department of Design

Aalto ARTS Books
Espoo, Finland
shop.aalto.fi

Cover design: Safa Hovinen

Paper: Scandia 2000 Natural 115g and Scandia 2000 White 300g
Typeface: News Gothic MT

ISBN 978-952-60-8135-9 (printed)
ISBN 978-952-60-8136-6 (pdf)
ISSN 1799-4934
ISSN 1799-4942 (electronic)

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Unigrafia
Helsinki
2018

Abstract

Contemporary design and planning activities often involve complex and multifaceted problems that call for collaborative assessment between several actors, concepts, and interests. The overarching discourse on sustainability is a clear example, connecting together not only scientific research and politics, but also the perceptions and actions of professionals and laypeople.

Recently, academic education has become increasingly structured around overarching thematic content, involving problem- and project-based learning in real-world contexts and in interprofessional constellations. Design, as a professional practice of collaborative problem-solving and communication, can offer several insights into the management of such interaction; and yet, in the context of sustainability, design becomes challenged as a discipline, constrained by the professional, institutional, and cultural structures and roles in contemporary meaning-making.

This research studies the context of interprofessional design education for sustainability — more specifically, the development and implementation of an international and interprofessional Master's degree study program in Creative Sustainability (CS), initiated in 2010 at Aalto University, Finland. The case assessment on which the analysis is based consists of three sets of interviews with supportive data, collected from the initiators, teachers, and students of the CS program between the years 2010 and 2015. Overall, the findings contribute to an understanding of how (design) professionalism contributes to sustainability, what type of support is needed in learning for interprofessional design for sustainability, and how such learning develops the (design) academia itself.

In analyzing the case, the analytical framework builds on cultural-historical activity theory, with supporting insights that are drawn from practice theory (with a notion of communities of practice) and actor-network theory. In line with these theoretical perspectives, and to emphasize organizational learning and developmental perspectives, interprofessional interaction in the academic context is constructed to involve three phases — priming, implementing, and experiencing — that also act as analytic components in assessing data.

In this research, those aspects that are identified as important in implementing interprofessional learning for sustainability are ensuring that sufficient resources and competences exist to initiate practical inquiries and real-world interaction, and determining that the learning connects back to the initial objective of developing practice. Through such a process, a new kind of professionalism emerges, also renewing the academia as a platform for transdisciplinary action.

For Aalto University, the CS interaction created new openings for outreach and for the development of teaching. At the same time, however, this new interaction became conflicted with existing interests and conventions, introduced by the various actors and interacting agendas, and the roles and structures in the current academia.

Keywords: *sustainability; sustainable design; interdisciplinarity; transdisciplinarity; design education; activity theory;*

Tiivistelmä

(Abstract in Finnish)

Tämän päivän muotoilu ja suunnittelu käsittelee usein kompleksisia ja monitahoisia ongelmia, jotka vaativat useiden toimijoiden, konseptien ja kiinnostusten yhteistä arviointia. Selkeä esimerkki tästä on kestävä kehitys, joka yhdistää tieteen ja politiikan, mutta myös ammattilaisten ja kansalaisten näkemykset ja toiminnan.

Akateeminen koulutus on järjestynyt nykyisin yhä selkeämmin temaattisiin kokonaisuuksiin, jotka sisältävät ongelmalähtöistä ja projektipohjaista oppimista. Muotoilu ammatillisena taitona yhteissuunnittelun toteuttamiseen voi tarjota useita menetelmiä tällaiseen oppimiseen. Kestävä kehitys kontekstina haastaa kuitenkin muotoilun ammattina, sekä ne roolit ja rakenteet joille se perustuu.

Tämä tutkimus keskittyy moniammatilliseen muotoilukoulutukseen kestävän kehityksen kontekstissa. Tapaustutkimukseni kohteena on Creative Sustainability (CS), Aalto-yliopistossa vuonna 2010 alkanut korkeakoulujen välinen maisteriohjelma. Tutkimusmateriaalina ovat haastattelusarjat ohjelman aloittajista, opettajista ja opiskelijoista vuosilta 2010–2015 sekä muu kerätty kirjallinen materiaali ohjelman alkuvuosilta. Tutkimuksen tulokset lisäävät ymmärrystä siitä, mikä muotoilun suhde on kestävyyteen, minkälaista tukea tarvitaan moniammatillisen muotoilun oppimiseen kestävän kehityksen kontekstissa, ja miten tällainen oppiminen muuttaa itse koulutusta.

Analyysin viitekehys perustuu toiminnan teoriaan (cultural-historical activity theory) ja huomioihin sekä käytäntöteoriasta (practice theory) että toimijaverkkoteoriasta (actor-network theory). Työssä tarkastellaan moniammatillisen oppimisen toteutumista kolmivaiheisen rakenteen kautta (priming, implementing, experiencing), jonka osien välisen dynamiikan ja mahdollisten ristiriitojen pohjalta syntyy syvempi ymmärrys vuorovaikutuksesta.

Työ nostaa esiin viisi pääteemaa, joiden ympärille analyysi rakentuu. Tarvitaan riittävä resursointi ja tarvittavien kompetenssien tunnistaminen, jotta käytännön vuorovaikutus voi alkaa ja jotta vuorovaikutuksen tulokset linkittyvät takaisin toimintaan. Tällöin syntyy uudenlaista ammatillisuutta, joka mahdollistaa oppimisympäristön kehittämisen edelleen.

CS toi Aalto-yliopistoon uudenlaista yhteiskunnallista vuorovaikutusta ja opetuksen kehittymistä. Samaan aikaan nämä avaukset synnyttivät kuitenkin myös jännitteitä suhteessa nykyisiin opetuksen ja ohjelmakehityksen käytäntöihin ja rakenteisiin.

Avainsanat: *kestävä kehitys; kestävä muotoilu; moniammatillisuus; tieteidenvälisyys; muotoiluopetus; toiminnan teoria*

Acknowledgements

This research has been made possible with the support of several people who deserve a mention at the beginning.

Firstly, I would like to thank the supervisor of this work, Professor Turkka Keinonen, who has been fundamental in creating the setting for research that exists today in the Department of Design in the School of ARTS at Aalto University. I also thank my advisor Professor Mikko Jalas (now acting as director of the Creative Sustainability program), who willingly contributed his time and energy to this research throughout its making. My gratitude goes, too, to Professor Sampsa Hyysalo, who, as the current leader of the doctoral program in the School of ARTS, offered the final push in completing this work. Furthermore, I express my gratitude to the pre-examiners of this work, Professors Janne Hukkinen and Martina Keitsch, for their extensive comments to help make this work more coherent. Lastly, I would like to thank several other academics who have commented on the work in its various stages, such as Professors Kirsi Niinimäki, Jack Whalen, Alastair Fuad-Luke, and Ramia Mazé, and researcher Tiina Härkäsalmi.

Secondly, this work would not have been possible without Aalto University and its CS study program with its staff and students, and so I express my gratitude to the various people interacting in these communities. Overall, Aalto University and its School of ARTS has acted as an encouraging environment for such research. Furthermore, the directorship and staff involved in CS, including its community of students and other interested collaborators, have remained open and patient with my efforts from their initiation. Hence, I would like to thank Eija Nieminen as the head of CS preparations, Tiina Laurila as the CS program director between 2010 and 2015, and Naoko Nakagawa as the amanuensis of the program, for allowing me access to all the necessary information and activities during the years of this study.

I would not have survived in this effort without my fellow researchers and colleagues. As a result, my sincere gratitude goes to the people who acted in the Design Connections doctoral program (2005–2010), in the NODUS Sustainable Design Research group since 2011, and more recently, also to the people in the INUSE research group. I would like specially to thank Cindy Kohtala, Michael Lettenmeier, Pekka Murto and Karthikeya Acharya for offering the necessary peer support in finalizing the doctorate (they completed theirs quicker than me).

Finally, a special thanks with enormous gratitude goes to my family, to my wonderful (and wonderfully patient) partner Liina Sillanpää, and my two sons, Juksu and Timi, along with my mother and (unfortunately deceased) father, who started this all for me in the first place.

Besides various Aalto University funding, this work has been supported with a grant from the Alfred Kordelin foundation.

TABLE OF CONTENTS

(Photo spread on pages 144–145)

FOREWORD

This work looks into current understanding of sustainability and design, studying their connections in the context of contemporary higher education. Furthermore, it describes a five-year research project (2010–2015) into Creative Sustainability (CS) — an international Master's degree program at Aalto University, Helsinki, Finland, combining students from several disciplines in shared studies and collaborative project-based design and planning activities in the context of sustainability. Over the period, I was active in both the development and teaching of the program, as well as researching it, its courses, and the student and staff interactions and experiences.

The research analyzes interprofessional design education and its organization and management with an activity theory lens, and from a theory perspective built on components of several contemporary theories on practice, communities, and interdisciplinarity. In general, this work emerges from the notion that development in education and sustainable development are often very tightly linked to other historical developments in the society, and are based on interactions that take place in the networks of people and institutions. In summary, this work seeks to understand how contemporary design education should respond to the call for interprofessional sustainability, and how this progress impacts academic learning itself.

This book is structured around areas of contribution and overlapping reflection. Its contents describe a historical journey, a theoretical journey, a methodological journey, and finally an empirical journey into the complex phenomenon of interprofessional design education in the context of sustainability. Together, they create the context for the general inquiry and the findings that emerge from it.

Furthermore, it is hoped that this research also works as a historical record of the first years of the CS study program. As an example of interprofessional design education for sustainability, its story gives a clear oversight of how new ideas travel to university education, how they are implemented, and how they become expressed in the developing professionalism. Through the interview and observation data and the elaborated theoretical approach, this work can lead to improvements in how we approach sustainability in an interprofessional design education context.

I hope that this work acts not only as my personal contribution to academic research in sustainable design and its education, but also as a step in the expanding body of research around contemporary challenges of transforming design, education, and professional collaboration, aiming toward more sustainable practices.

1. INTRODUCTION

Contemporary challenges of design and planning often involve complex and multifaceted problems that call for collaborative assessment between several actors, perceptions, and interests. The current overarching discourse on sustainable development is a fine example of such a challenge, not only connecting scientific facts and research with politics, but also public media and shared perceptions on what is considered valuable in life. Together with the emerging concept of sustainability, the world has grown to become more populated, more consumptive, and more competitive. At the same time, sustainability as a term has become an important catchword in contemporary business and design.

The design of infrastructures, urban developments, and everyday products and services affects us all. For some time, the discourses around contemporary design have been increasingly promoting collaborative models of work to further understanding of a given problem in the early phases of a design process with co-design activities, to prototype solutions with potential users as developers, or to test different product- or service-related hypotheses in various contexts of use. In sustainable design, the need for such a collaborative approach grows more comprehensive, and the roles of actors transform as the necessary expertise and problem ownership expand. Contemporary design activities are demanding of an increased ability to pursue interprofessional collaboration between various experts, but sustainable design also requires the ability to bridge the gaps between experts and laypeople in various different problem contexts.

Before the start of the millennium, the university as an institution was already facing an increasing pace of change. New approaches to pedagogy and organizational management, as well as to societal interaction, were being introduced into academic discourses. Recently, this pace has only been increasing and the academic environment has become more competitive; however, collaboration between various actors inside and outside the academic context has also increased. Academic education has become increasingly structured around overarching thematic content that involves problem- and project-based learning in real-world contexts in an interprofessional constellation.

This research studies interprofessional design education for sustainability and, more specifically, the development and implementation of an interprofessional Master's degree study program in Creative Sustainability (CS), initiated in 2010 at Aalto University, Finland. The first area of inquiry is how the introduction of new interprofessional contents affect teaching and learning in a contemporary academic context. The second question is what aspects are introduced with sustainability as a context and focus of the learning action. Thirdly, this work is interested in how design as a discipline, as a method for management, and as a subject of learning can contribute to this interaction, and how it is affected by it. Fourthly, this work is interested in how such an interaction challenges and changes learning and meaning-making in higher education.

1.1. Overview

This work has been written with a specific audience in mind — scholars, managers, and teachers involved in interprofessional education, specifically with a design focus, and design practitioners who are interested in incorporating sustainability aspects in their work. In summary, it is an effort to ascertain how sustainability can be fostered within collaborative design processes and actions, how can this be supported in the setting-up and management of education, and what kinds of processes and tools should be used to develop interprofessional design education further. As a focal case, this work describes a five-year long research into CS: a cross-school Master's degree program in Aalto University, Finland.

1.1.1. Contextual background: learning sustainability and design

The discourse on sustainability can be perceived to continue from discussions in the 1960s on pollution and on the oil crisis in the 1970s. In 1972, the United Nations (UN) initiated broad international dialogues, through which the concept of sustainable development (SD) was gradually formed. During the 1980s and '90s these initiatives were gradually taken to the societal and industrial domain; after the change of the millennium, they reached laypeople's discussions and activities across all sectors of our society.

During this period, another development was also emerging: the incipient academic understanding around design processes in decision-making and planning in industrial production that met the sustainability agenda. Sustainable design as a concept was developed and refined in both in corporate and academic settings, connecting to the discourse around more sustainable societies, to act as an answer to the growing impacts of industrial manufacturing on our ecological and societal systems.

Today, besides their traditional role in implementing education and research, universities have adopted a new, emerging third role through which they seek to establish their position in the political and economic structures of an increasingly knowledge-driven society. This new role emphasizes knowledge production for society and for societal benefit, calling for stronger connections between research, education, and everyday practices, expanding participation to the outside world.

What is sustainable development…?

Today's most agreed-upon definition of SD was coined by the Brundtland Commission, formally known as the World Commission on Environment and Development (WCED), in a UN commissioned report "Our Common Future" (1987), also known as the Brundtland Report:

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* (WCED, 1987, §1)

The concept of sustainability in its contemporary use was coined in the UN Conferences in 1972,[1] and by the United Nations Environment Programme (UNEP) that was initiated the same year. The Brundtland Commission, which was commissioned to work on the concept in 1983, defined SD as seeking to transform processes and activities of our society to be "in harmony and enhance both current and future potential to meet human needs and aspirations" (WCED, 1987, §15). This not only connects environmental considerations with societal and economic aspects, but also the processes of planning, making, and decision-making with what is perceived as valuable in life in general.

Sustainable development, however, also resonates with the progress of modernity in general. Alongside the emergence of contemporary mass consumption and the global community, SD connects ideas of progress into discussions on global human rights, equality, and individual empowerment and freedom to contest the fixed truths on cultural and technological development.

Then, what is design…?

In English, the word "design" has been around since the 1540s, derived from the Latin "designare," meaning to mark out, devise, choose, designate, appoint.[2] In this sense, design is about making educated choices alone or with a larger group of people. This careful approach to selecting between choices, conceptual and real-life testing of results of possible actions, and informing decision-making by research is one of the things that makes us human (cf. Fry, 2012).

Design as a word can refer to a process, a discipline, a plan or a model, or a quality or style. The activities in design can be understood to focus on aesthetics, functions, and meanings in materials and activities, elaborated together and for fellow people. Trendy design thinking (see, for example, Cross, 2011) can take place at both process and management level, through a reflective and holistic approach with "integrative reasoning" (Hassi & Laakso, 2011, p. 6), in this sense existing not only as a instrument but also as an agenda (see Keinonen, 2009). As a method for collaborative meaning-making, design activity involves an interplay of ideas and concepts, often represented in objects and artifacts.[3]

Design as a profession has matured and specialized (like all contemporary disciplines) along with the development of modern society: today it covers several specific fields ranging from traditional crafts to graphic design, industrial design, communications design, interface design, system design (see, for example, Buchanan, 2001), organizational design, various collaborative design activities (see Sanders & Stappers, 2008, 2014), and even design activism (Fuad-Luke, 2009; Thorpe, 2008).

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[1] To sustain can mean to maintain, support, or endure. In ecology, sustainability defines how biological systems endure over time and remain productive and diverse. For humans, according to an anthropocentric view, sustainability defines how human systems endure.

[2] From http://www.etymonline.com/index.php?term=design — for a more thorough explanation, see, e.g., Boradkar (2010).

[3] This work uses the word "artifact" to denote both physical things (tools) and conceptual objects (e.g., theories).

The concepts of sustainability, development, and design have emerged through and with modernity, and echo its cultural and material, and dialectical logic. The birth of modernity and its rational approach to the world, combined with its counterparts — the Industrial Revolution, the prevailing progress of science, and the gradual emergence of a mass consumption culture — have all played a part in the interplay between design and sustainability.

Learning interprofessional design for sustainability

In the European Union (EU), sustainable design has gradually become a highly promoted strategy connecting industrial developments, consumer domain actions and policy-making.[4] In sustainable design, as often in complex problem-solving processes, several different actors from different fields need to work toward a shared goal, and more detailed discussions of the pursued goals and processes are needed. As values and knowledge integrate further in a collaborative interprofessional process, a more traditional multidisciplinary approach evolves into interdisciplinarity, and eventually — after this collaboration is linked to existing societal cases and problems — into transdisciplinarity, pushing the boundaries of collaboration outwards from a group of experts and professionals towards a wider audience.

As universities seek their position in the political and economic structures of a modern information society, besides the highest levels of teaching and research, a new emerging third role comes into focus: creating practical knowledge for the use of our society (Nieminen, 2004). Accordingly, interdisciplinary education has been defined as one of the three preconditions for "achieving excellence" in twenty-first century university teaching (European Commission, 2003, p. 17). In this process, understanding interprofessional design collaboration, and education promoting its learning, helps to support various transactions between several different actors.

Design as a term connects to a vast range of strategies, philosophies, methods, and approaches. While SD is difficult to put in action, as it depends on the context and worldviews, in understanding design as activity there are similar difficulties. Who should be perceived as practicing design? Who sets the boundaries of the problem context? Do the designers have real decision power?

Whether the designer's responsibility is understood in a narrow or a wide sense, the contemporary design activities are nevertheless in an interplay with the excessive resource use of mass consumption, with communication and decision-making, and thus with sustainability. In this respect, sustainability as a context of design challenges not only the conventional practice, but also the learning for such activity.

[4] See, for example, the EU's Sustainable Consumption and Production (SCP) framework, as discussed in section 1.2.2.

The multi-, inter-, and transdisciplinary approaches to collaborative design are expanding the way experts and laypeople collaborate. Whereas multidisciplinarity invites different professionals to tackle a shared inquiry from their disciplinary perspectives, inter- and transdisciplinary approaches expand this collaboration further, to the development of a shared understanding, and toward mediation with other societal actors on a larger scale; and yet, these concepts remain still "ill-defined" (Bruun, Hukkinen, Huutoniemi, & Klein, 2005, p. 5).

In this research, the term "interprofessional" has been chosen to denote the collaboration of several different professions in the most neutral way as possible. The term "interprofessional collaboration" is used here simply to describe collaboration among different professionals from various disciplines.

1.1.2. Positioning the research effort

With an initial focus on how to set up interprofessional design collaboration for sustainability, the topic of this research was on a broad and general inquiry:

- *How should interprofessional design education and education for sustainability be approached and improved?*

The title of the research proposal in 2010 was "Tools for sustainable design and the stakeholder interactions." By Fall 2011, the title had evolved to "Mediating interprofessional collaboration within complex contexts." These early developments in the title of the work also underline the complex setting that was encountered at the beginning of the work. Firstly, different people perceive different things as tools. Aspects related to language, behavior, processes, or places for collaboration can also be perceived as constructs that guide interaction, and perceptions on collaboration vary from one participant to another.

To approach these questions, this work introduces several theoretical takes on the above topics. In addition to the main theoretical framework, the cultural-historical activity theory (CHAT), this work utilizes understanding emerging from practice theory (with a notion of communities of practice) and actor-network theory (ANT), and the discourses around sustainability, interprofessional design, and education. These contextual ingredients are discussed further in section 1.2 as well as in Chapter 2; the theoretic and methodological choices are described in section 1.3 and in Chapter 3.

From Chapter 3 onward, the focus moves to analyzing a case in higher education in Finland — the CS Master's degree study program — that acts as a test site to test the emerging understanding on the topic and assess the change in design education that the challenge of interprofessional sustainability introduces.

This work as design research

This work arises from the discipline of design, in the sense that it has been done by a researcher with graduate studies in industrial and strategic design, with a focus in design education, in a design research community.[5] In this sense, this work can be perceived as design research. According to Christopher Frayling's (1993) typology, research on art and design can be categorized into three general types: 1) research into art and design; 2) research through art and design; and 3) research for art and design. This work has several of these elements. As a study of a degree program in design, this work has a historical focus, looking into the processes of design. The work aims to assess a "variety of [design-related] theoretical perspectives" (Frayling, 1993, p. 5) that connect to the topic. The work also aims to have a "developmental" orientation, representing research through art and design. Finally, the work contributes to the last category and to future practice.

In developing education, the design-based research method can be perceived as "a cyclic process in which successive phases can be separated" (Karppinen, Kallunki, Kairavuori, Komulainen, & Sintonen, 2013, p. 151). In this work, this is visible in how the assessment and the analysis are structured in consecutive phases in which the assessment iteratively evolves. Overall, "there is no standard procedure for doing design-based research" as the phases "depend on the goals and topic areas in the process" (Karppinen et al., 2013, p. 151). However, to acknowledge the overall context that this work emerges from, sustainability and sustainable transformation can be identified as the main ingredients that orient the assessment and its findings.

This work as organizational practice research

Organizational studies focus on "the examination of how individuals construct organizational structures, processes, and practices and how these, in turn, shape social relations and create institutions that ultimately influence people" (Clegg & Bailey, 2008, p. xliii). As a result, organizational research requires a framework "that can elucidate the technological, economic, political and symbolic forces that are at work in and on organizations" (Adler & Borys, 1993, p. 657). As interprofessional sustainability is bringing learning activities closer to real-world practice, such a framework can help to structure the assessment of interaction along real-world dynamics and connect it to a transformation in everyday practice.

In many cases in contemporary communities of practice (CoP; see section 1.3), there is a "level of routine" that is "taken for granted," laying "a solid foundation for professional practices" (Nummenmaa, Karila, Virtanen, & Kaksonen, 2005, p. 51). According to Nummenmaa et al. (2005), university departments are "often

[5] Aalto University School of Arts, Design and Architecture and its predecessor, the University of Art and Design, Helsinki, offer the highest levels of learning in design in Finland. In its Department of Design, there is a relatively strong research emphasis, also evident in the number of doctoral graduates, which is constantly increasing.

quite typical examples" of such "static" organizations, built on "established routines and work culture" (p. 51). As a result, in perceiving the learning environment comprehensively as a domain of professional work (whether studying, teaching, or becoming a professional expert in a given discipline), its development can be perceived as organizational practice research, not only aiming to develop activities of teaching and learning, but having an impact on future professional action.

This work as a case study with personal involvement

Lastly, this work includes personal involvement not only as researcher: I have been active in the CS community from its very beginning, initially as a student on a course preceding the CS (2007), then as a project coordinator (during its launch in 2009–2010), and then as a teacher and faculty member (2010 onward). This personal involvement links with both design studies (as a new graduate) and management of the university (through the work on program and department development). This connection, however, was not actively utilized in the research or in discussing results. Although my involvement as a teacher and developer naturally connected with my research, I aimed to keep these roles separate. My involvement is discussed further in Chapter 3.

A case study can be defined as an empirical inquiry to investigate "a contemporary phenomenon in depth and within its real-life context" (Yin, 2009, p. 18). A distinction can be made between a single case study and a multiple case study, where the former is justified to test a theory, or to study a case that is "extreme" or "typical," "revelatory" or "longitudinal" (Yin, 2009, pp. 47-49). The CS program, as an example of setting up an interprofessional design program for sustainability in the context of higher education in Finland, offers not only an arena to test theory, but also a longitudinal view on the development of learning interactions that challenge conventional modes of teaching and management.

1.1.3. Case of study: Creative Sustainability in Aalto University

As the new innovation university, the Aalto University in Finland — three universities merged together from art and design, business, and technology and science in 2010 — created new openings for interprofessional teaching. During the merger, two cross-school Master's degree programs were initiated as pilots to facilitate interprofessional teaching. Another of these was titled the "International Master's Degree Program in Creative Sustainability," a multi- or interdisciplinary cross-school study program in sustainable design.[6] This CS program became an area of collaboration and interaction for four departments in the new university (see Figure 1), all of which had already identified similar areas of interest in their teaching.

[6] The other was a degree program on International Design Business Management (IDBM), with a focus on global business innovation and management. The IDBM study program began as a minor in 1995, between the Department of Design at UIAH and the Department of Organization and Management at HSE (see: idbm.aalto.fi; see also Leiviskä, 2001).

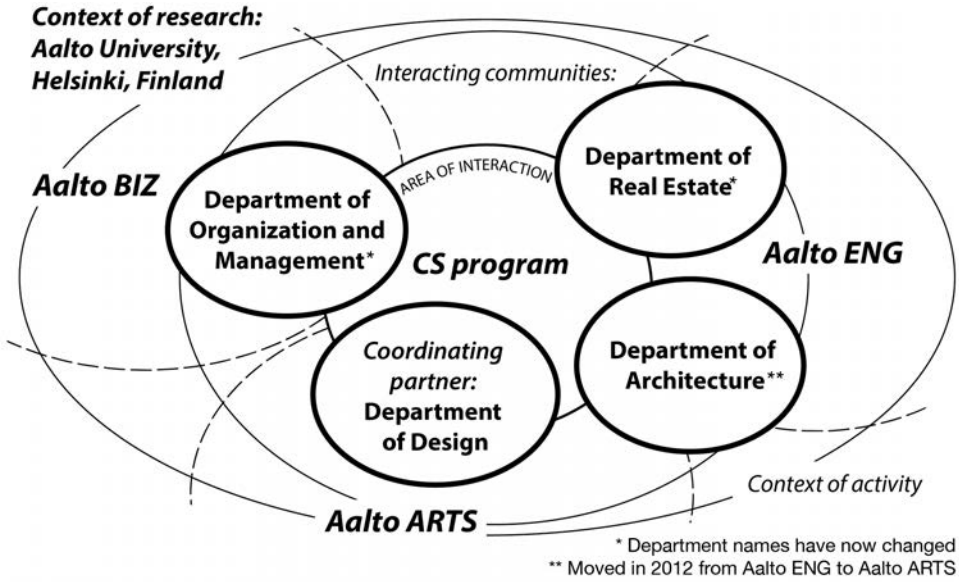

Figure 1. *The interacting communities in developing and implementing the CS program between 2010–2015.*

Source: Author

In 2009, I was personally introduced to an opportunity to work as a project coordinator and secretary in the CS preparations. As a recent graduate in industrial and strategic design (in 2007), with a growing interest in academic research, this new study program seemed to offer a perfect case to test theory and practice on design and interprofessional learning for sustainability in general.

Before the CS launch, ideas for the educational content in CS were already rather clear: in many ways they reflected developments in national innovation policies and ideas on improving education, and the earlier experiences of collaboration between the universities (see Chapter 3, section 3.1). The expected outcomes of the interaction, however, remained vague, and the roles that participants took were also partly developing organically. Even the program name and focus — "creative" interprofessional design for sustainability — raised questions and expectations.

Experienced as an open arena by the actors, CS became a community aiming to interprofessional knowledge-building for sustainability. At the same time, however, it became an arena to challenge conventional practices in managing interprofessional education, teaching, and design collaboration itself.

Gathered data

The data gathered between 2010 and 2015 consist primarily of in-depth interviews with the academics involved in initiating CS (Interviews I; four interviews), teachers of shared introductory studies (Interviews II; eight interviews and two follow-ups), and selected students from CS Design that were involved in

developing the CS community (Interviews III; six interviews and two follow-ups). These three broad groups of actors are also defined as the main actor groups in the making of the program, to be assessed in terms of their respective systems of activity and in continuous interplay during the CS interaction and development. The main focus of the analysis is on these three sets of interviews with supportive data (see section 3.3). This material is supported by a multitude of researchers' field reports and written background material, among other materials.

Data and other materials were analyzed qualitatively and thematically, and the findings structured utilizing an activity theory (CHAT) approach, which is based on the notion of artifact-mediated activity (e.g., with tools, instruments, signs), focusing on learning-as-process (Vygotsky, 1978) and on iterative, expansive learning and development (Engeström, 1987). The findings (Chapters 4–6) derive from the thematic analysis, supported by additional materials, and are then connected with the interlinked systems of activity that play a role in learning activity and in the program implementation and development in general.

1.1.4. Structure of this thesis

This work is structured into six chapters. This first chapter introduces the topic and its context, the general research inquiry, and the focal case. The methodology and analytical approach are also briefly introduced. The second chapter creates a more detailed oversight of the contextual background, focusing on interprofessional collaboration and meaning-making, and on teaching and learning sustainable design. This material is then utilized in setting up the conceptual framework for the assessment.

The third chapter introduces the case and its historical context in greater detail. The analytical approach and the research questions are revisited and refined further. The data gathered during the development of the program are presented. At the end of the chapter, the elements are structured according to their temporal interplay.

The fourth chapter assesses and analyzes the interviews and other data according to the model of interaction and its three identified phases of interest. Based on this, supported by the refined analytical framework, the findings are connected to the model of interaction. The fifth chapter structures the insights from the interaction together into a framework for interprofessional learning in an academic context, and integrates all findings into suggestions for the further development of similar programs and into insights for future practitioners in sustainability and design.

Lastly, the outcomes are discussed in the sixth chapter of this work, drawing everything together and reintroducing the main findings of the work. This concluding part is then followed only by an afterword, appendices, and references.

1.2. Sustainable Development Challenging the Design Academia

The growth of mass production and consumption can be perceived as a key feature in our modern world. Alongside the emerging consumer society, contemporary design has matured as a discipline, initially connecting strongly with styling and advertising, and then gradually with the manufacturing industry on a larger scale in relation to functionality, efficiency, and management (Sparke, 2013). Design as an activity, however, has evolved to denote a more general process of problem-solving, and this connection has gradually become evident as design professionals have moved their focus away from the industrial line to management and to support interprofessional collaboration in innovation and societal change.

The general domain called "the environment" is "inherently interdisciplinary" (Callicott, 2010, p. 506). SD links environmental, social, and financial considerations into a broad dialogue on the perceptions of progress of scientific and laypeople. In this process, design as a problem-solving strategy and a collaborative practice of iterative reflection can help further to mediate shared meanings.

Design for sustainability (DfS) connects to various strategies, to decouple and mitigate the impacts of production, and to tackle consumption on a wider scale. Such approaches include top-down approaches on the producer side (such as life-cycle approach, eco-design, and servitization); structural and behavioral changes on the consumer side; and the systems design approach, combining the two. Sustainability, however, challenges the conventional roles and processes in planning, making, and learning. As a result, in relation to SD, both design education and action have to question the dominant models of production and consumption, and knowledge production and future professional practice.

1.2.1. Design in modernity

The new aesthetic of modernity "owed its existence to engineers" but was "re-interpreted by designers" (Sparke, 2013, p. 16). According to Penny Sparke (2013), gradually, from the early twentieth century "an essentially rationalist approach" began to dominate design discourse (p. 144). The phrase "form follows function" started to gain meaning as modern architects and designers aimed both to "reject the status-ridden definition of design" that expressed the old bourgeois "Victorian material culture" and to align design with "the efficiency culture of mass-production industry" (Sparke, 2013, p. 144).

The emerging design activities had similarities to any problem-solving activity; as they were taken into the academic domain, they also connected with discourses on what counts as knowledge and how it is constructed. The term "design science" was introduced in the early 1960s by R. Buckminster Fuller[7] (Fuller &

[7] R. Buckminster Fuller (1895–1983) was an American architect, systems theorist, and designer.

McHale, 1965). Buckminster Fuller (1969a) defined the design process with a model that he described as "the design science event flow," progressing first through the processes of research and then moving to more generalizable design practice, and "finally to regeneration" to create "a new stock of material on which the designer may again act" (p. 319).

Alongside the traditional field of design history, after the middle of the twentieth century a new field started to emerge that was focused on understanding the methods used in design processes. This called for perspectives that could see analogies across the multitude of fields where design had started to mature as a practice. Hence, the first people that acknowledged the design process and methodology as something specific were from interdisciplinary backgrounds. Besides Buckminster Fuller, influential contributors to the initiation of this field of study included Chris Jones in the UK, and Herbert Simon and Horst Rittel in the USA.

Design methods for general problem solving

Around the late 1950s, engineer John Christopher Jones[8] published several articles around engineering design, including a seminal article called "A Systematic Design Method" (1959). Jones' emerging ideas about design emphasized its ability to integrate rationality and intuition as a general framework. He collected his theses into a book called *Design Methods: Seeds of Human Futures* (1970) that made an influential contribution. Its main points were that designers should be enabled to work at "higher levels of system and community design" and that designers' methods should be made more transparent (Margolin, 2010). A new cross-disciplinary Design Research Society was founded in 1966, continuing the discourse with Jones as its vice-chair. These developments also marked a starting point for the design methods movement in the UK. Later on, the early initiatives on scientific study of design action developed into a field of inquiry to study "design itself" and to develop and improve the "theory of practice" (Boradkar, 2010, p. 279) that can be called design studies.[9]

The Design Methods Group was established at the University of California, Berkeley, in 1967 (Margolin, 2010).[10] Buckminster Fuller had already popularized his view on design science (Fuller & McHale, 1965) and discussed design in relation to education (Fuller, 1963) and ecology (1969b). Another design theorist, Herbert Simon,[11] wrote his famous book *The Sciences of the Artificial* in 1969, in which he analyzed the "artificial world" created through design. Simon perceived design activity as a process which aims to improve this artificial world, and developed an understanding of administrative decision-making (also in the

[8] John Christopher Jones (1927–) is a Welsh designer, who studied engineering at Cambridge, but became an influential design theorist after working as an industrial designer in the UK in the 1950s.

[9] The field of design studies is also known as the science of design, or design theories and methods (DTM) (Boradkar, 2010).

[10] Horst Rittel (1930–1990), a German who taught at the College of Environmental Design at the University of California, Berkeley in 1963, was the leading figure in the Design Methods Group (Margolin, 2010).

[11] Herbert Simon (1916–2001) was an American political scientist, sociologist, and economist working most of his career at Carnegie Mellon University in Pittsburgh, Pennsylvania.

economic sphere). He defined design as the process by which we "devise courses of action aimed at changing existing situations into preferred ones" (Simon, 1969, p. 130).

Horst Rittel was an American design theorist connected to the Design Methods Group who, together with Melvin Webber, became famous for coining the concept of "wicked problems." In their seminal work (1973), they addressed "Dilemmas in the General Theory of Planning" and, more specifically, "policy problems" that cannot be "definitively described" (Rittel & Webber, 1973, p. 155). According to their view, a wicked problem is a problem without a right/wrong or true/false solution. Instead, continuous iteration and reflection is needed. In response to criticism of the attempts to identify a general, systematic design methodology, Rittel introduced "second generation design methods" (1984, p. 317), which are more dialogue-based and have their emphasis on context-dependent (or "issue based") knowledge creation.

Simon (1984) challenged Rittel and Webber's idea of wicked problems by proposing that there is a structure even in "ill-structured problems," which was his interpretation of the concept. According to Simon (1984), such problems merely required a better structure to interpretation. However, in contemporary design action — and even more so in connection with sustainability — "many design problems are so ill-defined and complex that they can only be called wicked problems" (Whelton & Ballard, 2002, p. 3). In contrast to Rittel's constructivist view and perhaps more suitable to postmodern understanding, the simplistic view of Simon was rather positivistic and based on progressive modernist ideals. In the end, though, wickedness remains a matter of interpretation and perspective.

Divergent and convergent reflection on meanings and things

According to a general view, design activity is a divergent and convergent process: the inquiry and action expand from an initial challenge or a design idea to revisit the problem setting and context, then converging into a refined artifact (i.e., design concept, brief, or a product, service, system). Similarly, the double diamond model describing the design process, developed by the British Design Council[12] (2005), consists of four phases of action with two diverging and converging cycles, first during the strategic research phase ("discovering" and "defining") and then in the implementation phase ("designing" and "delivering"). These two cycles also resemble Fuller's two steps in the "design science event flow" (1969a): the first was a subjective process of research, the second developing toward a material form.

In line with the double diamond model, the design process may be perceived to begin from a given (or identified) problem, its first phase (discovering), focusing on creating a detailed understanding of the problem, and a (design) concept for further action (possibly including a detailed product specification). After the first

[12] The Design Council is a government-funded institution in the UK helping people and organizations to better understand design and use it effectively as part of their strategy.

phase, the resulting understanding is reflected in the initial problem description. Similarly, after the second phase (delivering), the outcome of the process (often a product, service, or system in use or markets) is analyzed by comparing the results in reality with the specifications that drove the work. In this sense, gathered information diverges into future reflections, to be reflected back into future action.

In facing the complex challenges that contemporary design action often tackles, however, the double diamond model seems overly simplified and streamlined, and fails to explain the processes leading into the initial brief. Another view — especially fitting for cases of complex problem settings — is to refer to the beginning of a new development process as a "fuzzy front end" (Sanders & Stappers, 2008, p. 2). It is during this phase that a group or an organization formulates a shared understanding of the challenge, a design idea to be developed, and decides whether or not to invest resources in future action. Design action becomes even more important in this phase.

Design as an activity is often connected with future. In Klaus Krippendorff's view (2006), designers can consider "possible futures [...] evaluate their desirability [...] and create and work out realistic paths from the present towards desirable futures" (pp. 28–29). Di Salvo et al. (2011) identify two ways of connecting design with the future: forecasting, or taking up an issue and forecasting it to raise discussion; and backtracking, or looking into history and showing a change. Transition management (see Geels, 2002) and transition design can "combine forecasting and backcasting" to formulate future visions or concept designs," but these need to be "released, tested and adapted in experimental or participatory settings" (Mazé, 2014, pp. 4–5).[13] In this respect, this end of a design activity expands into discussions on the perceptions of meanings of things, and connects these with future artifacts and actions.

For Krippendorff, contemporary design can propose "realizable artifacts," making sense "to most, ideally to all who have a stake in them" (2006, p. 24). Design is thus intimately involved with the meanings that stakeholders in the process attribute to the artifacts in focus. Human beings invent symbols to represent things, allowing them to "share their minds with one another" and to co-create meanings of things (Briggle & Christians, 2010, p. 220). This meaning-making activity is a "dynamic and dialectic process" that binds together three agents, "a designer," "a design," and "a receiver" (Kazmierczak, 2003, p. 48). In this process, however, the "non-designer" "is not in full or arbitrary control of meaning" and the meanings are instead "induced in the receiver" by the design and its structure (Kazmierczak, 2003, p. 47). Consequently, the design activities can also aim at higher levels of focus — toward cultural mediation of the processes, materials, and meanings in the societal domain — increasingly addressing, too, the structures in which the collaborative meaning-making is taking place.

[13] Mazé (2014) calls this domain of design "futurity."

Contemporary design activities

During the latter half of the twentieth century, in continuation of the efforts in "scientizing" design (Bayazit, 2004) with increasing interprofessional interplay, the contemporary design studies started to interact, if not even relocate, among engineering, management, and business schools. The various components in design practice — a creative process and iterative reflection, studio work, conceptual design processes, testing and prototyping, and interprofessional collaboration and project-based work — all originate in different disciplines that have been in interplay with the academic design practice (art, engineering, computer sciences, business management).

In many respects, contemporary design education is still based on the educational program of the Bauhaus school,[14] where "architects, painters, and sculptors" combined "multiple perspectives to design education" with an emphasis on "workshop" or studio work (Boradkar, 2010, p. 284).[15] In design education, this interplay between art and technology has persisted, although design activities have expanded further, toward, for example, a user or management focus, or even system sciences and social change.

By the beginning of the twenty-first century, the focus in design activities had shifted from material concerns to experience and interaction (Sanders, 2006b), to "the design of global competitiveness and renewal" and the "design of organizations and practices" (Aminoff et al., 2010, p. 16), and eventually to sustainability as a guiding concept in itself. Today, most definitions of design practice broadly refer to the contemporary professions of architecture, engineering, and planning (Boradkar, 2010). Connections to the common processes of problem-setting and solving, and to collaborative mediation on the meanings of things, however, increasingly linked design activities to interprofessional collaboration in general, and gradually also to the interaction between institutions and societal domains on a larger scale.

In contemporary design activity, several types of approach, method, and tool are used, several processes take place, and the focus is on several levels of interest. Depending on the type of design activity, the specific tools and methods used can be: 1) guiding the overall design process (approaches, strategies, and frameworks); 2) guiding conceptual thinking (for example, mind tools like brainstorming, conceptual mapping, mind mapping, and other diagramming, etc.); 3) guiding collaboration in design (simple project management and co-design methods and tools); and, if sustainable design is in focus, 4) guiding sustainability considerations in design activity (tools for sustainable design). These methods are often if not always supported by physical artifacts (e.g., sketches,

[14] Staatliches Bauhaus, commonly known simply as Bauhaus, was an art school in Germany that combined crafts and the fine arts with industrial production. It operated between the years 1919–1933 in three different cities (see Wingler, 1969). The tradition continued in the New Bauhaus in Chicago in the US (founded in 1937), and in the Ulm School in Germany (1953–1968) (see Boradkar, 2010).

[15] The agenda gradually expanded to include seeking unity between art and technology, showcased in a 1923 lecture "Art and technology: A new unity" by Walter Gropius, the founder of the school (Boradkar, 2010).

models, mock-ups, prototypes), but also by various conceptual approaches. The infamous "design thinking"[16] can take place at both process and management level, through a reflective and holistic approach with "abductive" and "integrative reasoning" (Hassi & Laakso, 2011, pp. 5-6). Design-driven innovation connects new technologies with developments in the meanings of things (see Verganti, 2009) and with changes in collaboration and work processes (Marttila, 2011b).

British designer Richard Buchanan became famous for revisiting Rittel and Webber's wicked problems[17] and connecting them more strongly to design thinking (see Buchanan, 1995). Buchanan also became a famous advocate of design thinking as a specific approach to planning, applicable to various levels of problems (Buchanan, 1998). He specified four broad "disciplines" where these design activities could be found (p. 9): 1) communication (signs and words); 2) construction (things); 3) strategic planning (action); and 4) systemic integration (thought). Later, he elaborated this view into four orders of design: 1) graphic design; 2) industrial design; 3) interaction design; and 4) environmental design (Buchanan, 2001). In line with Buchanan's view, the NextDesign Leadership Institute has divided contemporary design activities into four levels aiming at different system scales (VanPatter, 2009; see Figure 2): 1) a traditional approach to design that links with product details (or aesthetics); 2) design involving a systems or network focus (e.g., focusing on product-service development; see section 1.2.2); 3) design focusing on organizations and innovation; and 4) design focusing on social transformation.

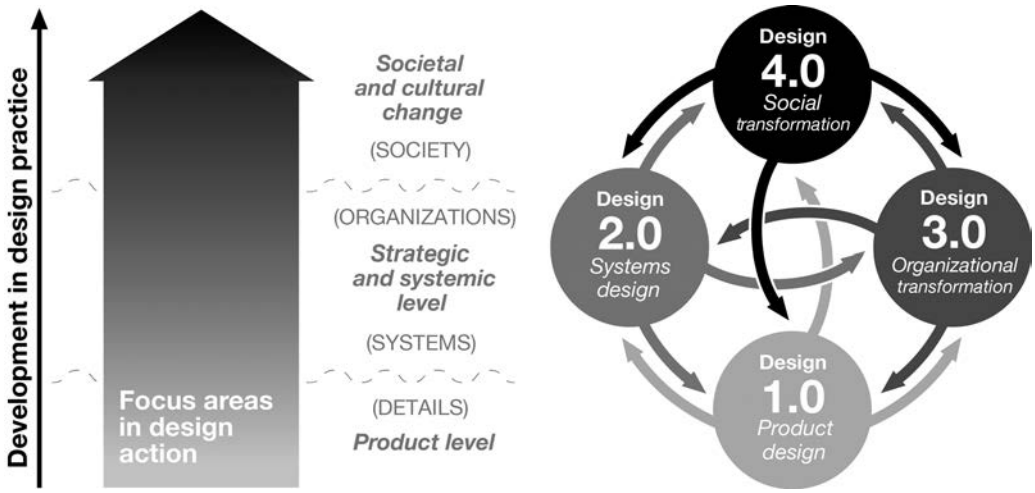

Figure 2. *Development in focus areas for activity: from design 1.0 to design 4.0.*

Sources: Diagram on the left by author; diagram on the right developed from Aminoff et al. (2010), based on VanPatter (2009)

[16] The concept of design thinking was repopularized in the 2010s by IDEO (a famous global design consultancy) CEO Tim Brown (2009).

[17] Buchanan's widely influential paper, "Wicked Problems in Design Thinking," was published in 1992 (see Buchanan, 1995), pushing wicked problems and design thinking into the mainstream design discourse.

Ceschin and Gaziulusoy (2016) typify similar areas of design action as four innovation levels, focusing on the product, product-service system, spatio-social system, and socio-technical system, according to the level of detail, toward systems, organizations, and eventually society as a whole (cf. VanPatter, 2009). In the context of sustainability, however, perceived as a "socio-technical challenge," the ability to "design for system innovations and transitions" can be perceived as the approach with most potential as it "embodies" all others (VanPatter, 2009, p. 21).

Lastly, according to Keinonen (2009), contemporary design can be perceived not only as an instrument or competence, but also as an agenda. As an agenda, design as a term connects several fields into a shared interaction. This has become visible not only in contemporary business, where professional design-connecting action is considered essential for innovation (Verganti, 2009), and in sustainability that connects with design from several directions, but also gradually in education and learning.

1.2.2. Designing for sustainability

Like industrial practices, contemporary design professions can be easily perceived to be connected with excess production, material use, and over-consumption. In this sense, design practice is a destructive element in terms of our contemporary unsustainability. Sustainability in design, however, has a long history. It connects with meaning-making on all levels of societal action and holds potential for change.

In a nutshell, contemporary sustainable design is based on a design philosophy that seeks to maximize the quality of the man-made environment, including products and services, while minimizing or eliminating any negative impact on the natural environment (McLennan, 2004). As ideas around greener products have matured, new strategies and methods addressing the whole product lifecycle and its production chain have emerged. The ecodesign process (also known as design for environment; DfE) focuses on creating a comprehensive understanding of the environmental impacts of a product in all phases of its lifecycle. Design for sustainability (DfS) goes further, adding social (and economic) dimensions into the assessment, attempting to go beyond the product and innovate around how certain design offerings can be created with fewer materials and environmental impact. Sustainability in design, however, extends even further, into collaborative meaning-making and reflection on the practice itself.

Alison Knight (2009) distinguishes the development of sustainable design in three waves, the first of which arose in the 1960s and 1970s along with the first environmental action groups. The second wave occurred when several disasters hit public awareness in the late 1970s and 1980s, and consumer opinion started to emphasize eco-friendly products. The third wave was initiated by UN efforts and the Brundtland Report in 1987.

Design and unsustainability

Sustainability in design already has some history. Early examples can be found in discussions from the 1960s, when new radical thinking emerged and strongly influenced the design field, reacting against the ideas of the modernist movement. The radical design movement was particularly concerned to highlight the growing alliance between design and consumption (as in Marttila, 2010). This discourse eventually introduced some revolutionary approaches, including design with a "holistic vision of the environment" (Sparke, 1990, pp. 185–203), also entailing future frameworks for sustainable design, universal design, and inclusive design, as well as for user-centered design, co-design, and system design (Fuad-Luke, 2009). During the 1970s, these topics remained under discussion among designers and eventually left a lasting mark on design.

In relation to industrial product design, MIT design graduate Victor Papanek became famous for criticizing the lack of social (and ecological) responsibility in design activities. In his words, "there are professions more harmful than industrial design, but only a few" (Papanek, 1971, preface). In his 1971 book *Design for the Real World: Human Ecology and Social Change*, Papanek introduced his idea that "designers should develop a sense of social responsibility" to distinguish between people's wants and needs (Sparke, 2013, p. 118). By the early twenty-first century, the ideas following his call for social responsibility had "acquired a new resonance" and design projects "underpinned by social ideals rather than by a desire for economic profit" have risen to mainstream (Sparke, 2013, p. 118).

From a strategic perspective, a two-fold approach is needed in sustainable design, because efficiency (producer's approach) and sufficiency (consumer's approach) are at interplay. The EU's Sustainable Consumption and Production (SCP)[18] framework is a clear example of such a strategy, combining regulations and guidance for companies, and support for consumer interest groups and collaborative projects.[19] According to this view (as in Azar et al., 2002), policies, regulations, and economic incentives can be used to induce a change in industry and business, to promote the use of more sustainable materials (transmaterialization) or a decrease in material usage in general (dematerialization). The consumption domain, on the other hand, aims to induce structural changes in production and consumption patterns and behaviors.

However, as the original criticism already pointed out, the challenge exists in relation to modernist ideals, and to responsibility and ethics. Sustainability and sustainable development, in the end, connect to (global) equality, roles, access to participation, and transparency. This further extends the scope to challenge the dominant social structures and processes.

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[18] SCP is a developmental policy promoted by the EU that acts as a "dynamic framework to improve the energy and environmental performance of products" and "foster their uptake by consumers" (European Commission, 2008, p. 2). As a strategy, SCP aims to meet sustainable society through development within existing policies, practices, and industries (The Royal Society, 1997).

[19] For example, the European Eco-Management and Audit Scheme (EMAS) was introduced in 1993, resembling the ISO 14000 standard-based certification process. Other, more sector-specific examples include ecolabels, energy ratings, and recycling directives (e.g., WEEE in relation to e-waste), to name a few.

Approaches to sustainable design

In developed consumer societies, the most common ways to promote more sustainable consumption have been the top-down ecodesign approach (covering strategic methods such as lifecycle design and assessment); servitization and system design strategies (aiming for functional economy; see Stahel, 1997); and novel social or technological innovations restructuring the practices of use (e.g., mobile ICT for settings with low infrastructure).

Lifecycle design and lifecycle assessment (LCA) as concepts have agency in the domains of theory and application that design thinking may not have (Clune & Lockrey, 2011). The systems approach acts as a similar connecting concept in other contexts. As such, the terms work as an invitation to create new collaborations across different fields of action. In the context of sustainability, however, interprofessional collaborations should be afforded better possibilities to redefine meanings and structures in collaborative meaning-making.

The following three examples showcase these strategies as approaches to sustainable design. Ecodesign focuses on the producer side; the systems design approach works as an intermediary area, combining producer and consumer as actors; and the critical and communicative approach focuses on transforming the structures of production and consumption.

Ecodesign approach

Ecodesign focuses on mitigating the impacts of production and/or use of a given product. Both transmaterialization and dematerialization strategies are utilized. One main component in ecodesign is the lifecycle approach, extending the focus on the product's or system's negative environmental impacts along its lifecycle phases — material extraction, production, distribution, use, and end of life — including all intervening transportation steps necessary or caused by the product's existence (ISO 14040; Marttila, 2014). Lifecycle design (LCD) is the application of the lifecycle framework to the product system design (Keoleian & Menerey, 1993). The product system includes product, process, distribution, and management/information components (Keoleian & Menerey, 1993). LCD originated in industrial production and management in the latter half of the twentieth century and has been supported by several governments on a policy level since the 1990s.[20] It is a fundamental part of a sustainable design process, involved in almost all of its strategies and methods.

There exist a variety of LCA tools and methods for measuring ecological impacts. As a process (see Marttila, 2014), LCA has been described as a cornerstone of current practice in industrial ecology (Matthews & Small, 2000; see section 1.2.3). It is a part of the ISO environmental management standards (ISO 14040; ISO 14044), promoted by the European Union (European Commission, 2001) and the UNEP (2002), and is thus a well-recognized concept across industries.

[20] See, for example, EPA's Life Cycle Design Guidance Manual (Keoleian & Menerey, 1993).

Systems design approach

The systems design approach is an approach to artifacts and their organization that considers them as parts of a dynamic system. In essence, while the ecodesign approach creates a basis for understanding material impacts, the systems design approach enables their potentially radical improvement. It can be seen as the application of systems theory,[21] aiming to create a comprehensive understanding of the components and the dynamics of a system under development to improve its eco-efficiency, social implications, and/or economic structure. One of the main methods to achieve this is optimization of the system and its interactions, resulting from a more refined stakeholder assessment and collaborative design.

The systems design approach aims to improve systems, but it may also aim to restructure the system into a new shape. Such transformation is different from mere incremental development, inducing innovation by introducing new actors to the system, by restructuring the value-chains or by redesigning the design offer itself. In their 1976 report to the European Commission, "The Potential for Substituting Manpower for Energy," Walter Stahel and Genevieve Reday conceptualized an economy where biological and technical material travels in constant loops (the circular economy), and the impacts created by products can be assessed per service-unit, referring to the moment that the product is used to serve a purpose.

A "functional economy" is "one that optimizes the use (or function) of goods and services and thus the management of existing wealth (goods, knowledge, and nature)" (Stahel, 1997, p. 91). Products, as design objects, offer interfaces to the functions and services they offer, and impacts can be assessed per single usage. Examples of this approach are, for example, material input per service-unit (MIPS) assessment, and product-service system (PSS) design that moves the focus of design action toward the design offering, and the whole system and systemic efficiency around it.

Designers can also introduce sustainable behavior and systemic efficiency with a range of feedback from environmental and social performance (see, for example, ecolabels and eco-feedback technologies; Lilley, 2009). Further on, new ways of use (e.g., services and new ownership models) can introduce changes to the practices of consumption and production. Distributed production, rapid manufacturing, and 3D printing are other recent takes on industrial manufacturing that have been considered as potential strategies to induce more sustainable production (see Kohtala, 2016).

However, sustainability might not be truly considered in real practice in these contexts, and their effect might even be inverse in introducing more production. Neither the circular nor the functional approach can sufficiently mitigate the effects of consumption if the economy keeps on growing exponentially.

[21] Systems theory aims to discover the general principles of system behavior, based on the emergence of systems research and systems science in the 1950s (Flood, 1993).

Critical and communicative approach

Contemporary design activities also seek transformation through collaboration and communication. From open source ideals and crowdsourcing to transparent information, and from playful interaction to critical art, design action can also help to develop structures that promote sustainable activities for a larger audience of actors. Since the beginning of the 2000s, several design action-supported grass roots initiatives have emerged (consider, for example, Restaurant Day and Cleaning Day events, urban renewal in general, carrotmobs, and so on). In these movements, the designers often play the activist role, either being themselves activists or being "activists for hire" (Thorpe, 2008, p. 2). Alistair Fuad-Luke (2009, p. 27) defines design activism as involving "design thinking, imagination and practice" that is applied "to create a counter-narrative aimed at generating and balancing positive social, institutional, environmental and/or economic change." As such, it represents the redirective process, that Fry (2008) describes as necessary for sustainable design (see section 2.2.1).

Constructive provocation with a critical design approach (Dunne, 2005) can induce social friction, which can be perceived to be at play whenever people challenge existing norms in a positive way (Jensen & Lenskjold, 2004; Marttila, 2011c). This approach is clearly visible, for example, in media campaigns of the Occupy Movement (for example, by the Yes Men); it takes a critical theory-based approach to design and uses designed artifacts as a critique or commentary on consumer culture (Marttila, 2010). "Culture jamming" and its famous examples in *Adbusters* magazine's fake ads have a similar approach to design action (Lasn, 1999). Such social movements affecting and connecting to contemporary design are "an accumulation" of several different actors and activities "held together by shared beliefs" (Thorpe, 2008, p. 5). As approaches to design practice, they are evolving new social capital[22] to shake existing thought patterns and to provoke society and behavior within it (Marttila, 2010).

When it comes to sustainability, however, many of these examples of design action and approach have a slightly naïve sense to them. They may increase efficiency within a single domain, but they do not necessarily tackle consumption in general. They may also introduce further problems. Their approaches follow the mainstream in many ways, being mostly only extensions to the existing capitalistic logic (Fry, 2008, p. 152). As a result, it seems evident that none of the approaches will work alone. Instead, they must be connected and their contribution to design knowledge must be assessed in a systematic and collaborative pursuit to induce sustainable transformation in society as a whole.

Designing transformations for sustainability

Social innovation refers to "changes in the way individuals or communities act to solve a problem or to generate new opportunities" (Jegou & Manzini, 2008); it is

[22] Social capital can be defined as "the collective benefits that individuals achieve when they interact" (Harju-Luukkainen & Vettenranta, 2013, p. 77).

as a process often supported by professional design action.[23] Open innovation[24] (e.g., open source development, crowdsourcing) emphasizes open source knowledge creation that promotes the sharing of ideas and technologies for distributed production and/or collaborative meaning-making. In relation to the above, do-it-yourself (DIY) design, or do-it-together collaboration, is also a current trend empowered by the online communication tools provided by the modern internet. In this view, sustainable design can be about "hacking" practices of consumption and production. However, open innovation is not always that open (Faste, 2011),[25] and there is also a lot of social innovation that never makes it into the discourse (for example, in many indigenous cultures, or even urban but under-empowered groups).

In design action within the contemporary complexities — and even more so in relation to sustainability — the discoveries do not arrive neatly from one point, and their delivery will not neatly perform (only) the ideals in reality that were suggested. Instead, any design process requires invested resources (e.g., time, money), and the decisions to invest these resources to begin a design process are influenced by cultural, institutional, organizational, disciplinary, and personal aspects. Furthermore, in the context of complex and ill-defined problems of sustainability, to sufficiently validate an outcome, the assessment of the problem has to include a wider focus in participation and action from its beginning.

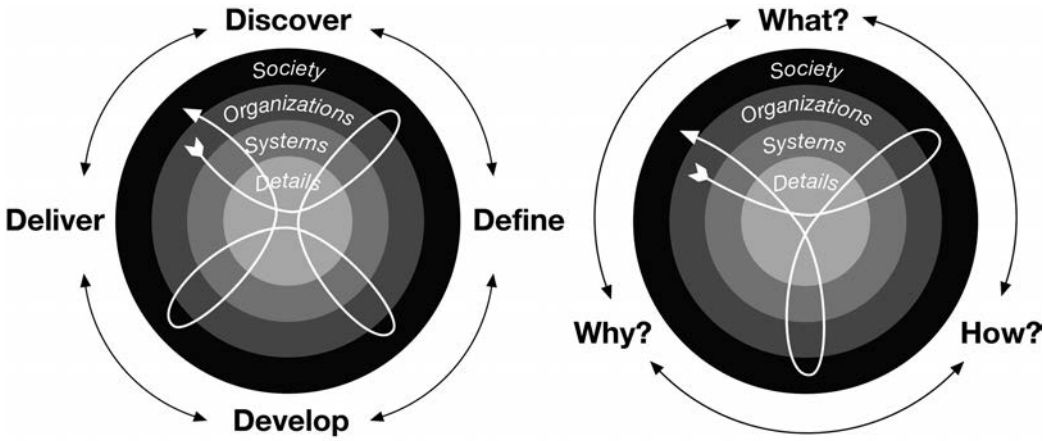


Figure 3. *Divergence and convergence in a transdisciplinary design process.*
Source: Author

As a result, the two parts of the design process, as described in the double diamond model (see section 1.2.1), must be more open and connected. The delivering phase must connect to the discovering phase in a circular manner, emphasizing an iterative approach (see Figure 3). In this process, reflections on

[23] Examples such as the Sustainable Everyday Project (www.sustainable-everyday-project.net) or DESIS network (www.desisnetwork.org) present case studies within which people have been self-organized to meet their everyday needs in new and sustainable ways.

[24] Open innovation is a term popularized by Henry Chesbrough (2003).

[25] Open innovation has many challenges in areas such as management, focus, and ethics (Faste, 2011).

the implications of/for future action need to be collaboratively mediated on various levels of focus, ranging from details all the way to the potential societal impacts. At the same time, the initial brief (the identification of what is the problem to be tackled and the goal of activity), and the reasons and chains of causation that resulted in the detailed concept for sustainable design action (How will this be implemented?) need to be opened to the outside audience (Why would this be implemented? — relating to expected outcomes).

1.2.3. Learning sustainability in design

In today's complex world, universities are still largely responsible for knowledge production and distribution, with the leading research bodies acting as the "gatekeepers and standard bearers" (Duderstadt, 2000, pp. 48–49). However, in the contemporary working life — and increasingly in education — experts are "more and more rarely alone," rather building "multidisciplinary and shared expertise" and breaking the "boundaries of different academic disciplines and educational orientations" (Nummenmaa et al., 2005, p. 53). Transdisciplinary, interprofessional knotworking is the emerging mode of collaboration in work settings that move toward co-configuration (Engeström, 2008; Engeström & Sannino, 2010). A similar approach has gradually been pursued in the educational context.

For academia, design is involved in several processes of planning, acting as an instrument to support collaborative meaning-making. At the same time, design connects to the developing professional competence to structure informed action in various disciplinary fields; and yet in relation to both design education and practice, the sustainability challenge results in similar emphases to interprofessional and transdisciplinary collaboration in general, connecting to "radical" transformation and "socially distributed" knowledge (Bruun, 2000, p. 13; Marttila & Kohtala, 2014). In discussing sustainability, the prioritization and balance, the roles of actors and beneficiaries, and the interconnected anthropocentrism of the concept itself, potentially have to be contested.

At the same time, the educational setting for sustainable design must address the ontological challenges in contemporary academic work. Can there be freedom of action if the environment for activity is constrained? Does learning design hinder other professional learning? Can whatever change be pursued? To a designer and to design education, these questions become larger professional inquiries.

This focus on the processes of planning and decision-making moves the emphasis toward education and learning: Consequently, the UN designated 2005–2014 the United Nations Decade of Education for Sustainable Development (DESD). Furthermore, at the UN Rio+20 conference, there was international agreement to "promote education for sustainable development, and to integrate sustainable development more actively into education beyond the UN Decade of Education for Sustainable Development" (UNESCO, 2014, p. 8). This progress has also become visible in Finnish universities, where sustainability has become an important area of teaching, research, and the evaluation of impacts.

Dimensions of and approaches to sustainability

Overall, the work of the Brundtland Commission (WCED, 1987) and the following Agenda 21 (UN, 1993) implies that SD must be based on balancing environmental (conservation of resources), social, and economic demands for progress. These three are the so-called "three pillars" of sustainability, (CEE, 2007, p. 12), the "three interlocking circles" (CEE, 2007, p. 12) of different dimensions of focus, or the three Es of sustainability: the economy; employment, equity, or equality; and ecology or environment. SD exists as a balanced output of these three (see Figure 4).

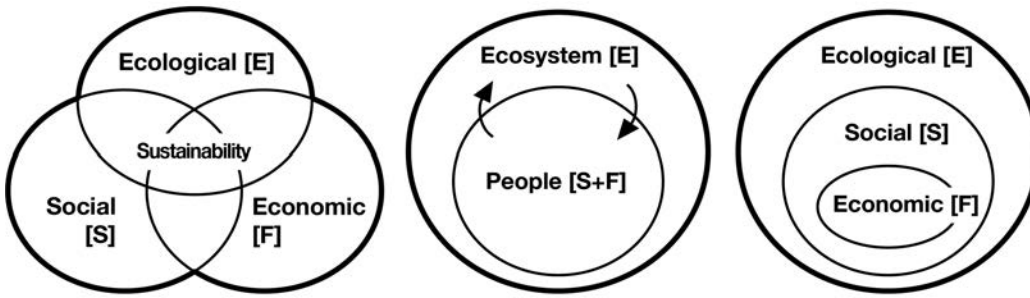


Figure 4. *Diagrams of sustainability: The interlocked circles model (on left), and the nested sustainability models.*

Sources: IUCN (1991); Willard (2005)

The concept of SD, as the Brundtland Commission (1987, §1) defined it, has a strong anthropocentric approach. The nested model — the "egg of sustainability" (Figure 4, right) — by the International Union for the Conservation of Nature (IUCN, 1991) puts more emphasis on the ecological dimension, placing both social and economic systems within ecological constraints.[26] IUCN (1991) defines SD in its publication with UNEP and World Wildlife Foundation (WWF) as an activity providing "real improvements in the quality of human life" whilst at the same time conserving "the vitality and diversity of the Earth" (IUCN, 1991, p. 8).

SD aims not only for ecological balance, but for equal opportunities between people. The Brundtland Report recognized the "neglect of economic and social justice" (WCED, 1987, §26) as a barrier to promoting sustainable development. The report suggested that "new dimensions of multilateralism are essential to human progress" (WCED, 1987, §79), thus calling for new processes in international decision-making and politics. This institutional dimension was formally introduced by the United Nations Commission on Sustainable Development (UNCSD) in 1995 as the "fourth dimension of sustainable development" (Spangenberg, 2002, p. 295), bringing forth questions on

[26] If we look at the etymology of the terms, "economy" is elaborated from the Greek "oikonomos" [household manager], from "oikos" [house] and "nemein" [to manage]; "ecology" derives from "oikologie," from "oikos" and "logia" [study of]. In a common sense, understanding must come before management (see http://www.etymonline.com).

participation, governance, and power in the global society. Culture has also been referred to as the fourth pillar of sustainability.[27]

Contemporary theories on sustainability seek to consolidate different responses to environmental and cultural problems (Jenkins, 2012; as in Fichter et al., 2013). In this discourse, a "strong" sustainability approach prioritizes the environment. At the "weaker" end, the concept of industrial ecology (IE) can be defined as a "systems-based, multidisciplinary discourse" focusing to study material and energy flows through various industrial systems and seeking to understand "emergent behavior of complex integrated human/natural systems" (Allenby, 2006, p. 28). Strategies of industrial ecology include closing the material cycle (reuse of raw materials), increased resource efficiency (eco-efficiency), digitalization (dematerialization), sterilization strategies and shared use, and consumer- and market-driven sustainability.

The concepts of weak (or industrial) and strong (or deep) ecology represent the two extremes on this same spectrum, the former proposing technological solutions to tackle the problems of sustainability, the latter with an emphasis on sustaining the natural environment.[28] These two discourses can also be perceived as corresponding to the ecologically-oriented (eco-centric) and technology-centered (techno-centric) positions in environmental ethics. The latter could also be called as an anthropocentric view. Whereas industrial ecology calls for progress in technology and economic domain, the deep ecology view often insists on more radical actions to preserve the environment. SD aims to merge the two views (see Table 1).

Table 1. *The extreme views on sustainability.*

Worldview	**Eco-centric**	**Techno-centric**
Approach to sustainability	"Strong sustainability"	"Weak sustainability"
Approach to natural systems	Deep ecology	Industrial ecology
Approach to change (in natural systems)	Sustaining	Developing
Synthesis	Sustainable + Development	

Source: Author[29]

[27] For example, in discussing Agenda 21, the members of United Cities and Local Governments (UCLG) emphasize culture as the fourth pillar of sustainable development (see http://www.agenda21culture.net/sites/default/files/files/documents/en/zz_culture4pillarsd_eng.pdf).

[28] The precautionary principle (to exercise caution in new developments) and the proactionary principle (to pursue progress proactively) toward science are also related to these two perspectives.

[29] This table was strongly influenced by Dr. Bernard Dusch (2015) and his presentation on sustainable design in March 2015 at Aalto University.

The different perspectives on SD also call for reflection at their boundaries. However, modernist reasoning is essentially based on “interpretive power” (Pratt, 2002, p. 26) and the one in a position to use it. As a result, a critical inquiry into modernity has to ask how this access is “constructed and enforced” and what happens to contesting claims laid to this power by an “unauthorized party” (Pratt, 2002, p. 27) outside the core of decision-making. Consequently, sustainability calls for dismantling of the fixed concepts of modernity, and the “decolonization of knowledge” and “the decentering of the center” (Pratt, 2002, p. 22) as a philosophical approach.

In the context of sustainability, there is a growing awareness that to answer the contemporary environmental problems, “changes need to take place throughout the entire society” (Jamison, 2001, p. 18). Hence, if the project of modernity (Habermas, 1997) reaches its height in the contemporary unsustainability, then postmodernity must open up new ways for sustainable being. The change of landscape for the forthcoming age of sustainability must denote not only new sustainable technologies, but also new approaches to meaning-making.

Thinking about SD and the human future, one must ask: what do we ideally want? What type of governance and rules exist, and on what are they based? Must the world be a just and fair place? How much poverty can be tolerated, and what consideration should be given to future generations? What rights do other species have? How important is it to sustain the current biosphere or human culture? These questions call for assessment of one's worldviews and values.

Education for sustainable development (ESD)

Based on the Brundtland Report, the United Nations and UNEP created a voluntary action plan for sustainable development for the 1992 Rio Summit, called Agenda 21 (see UN, 1993). Agenda 21 identifies “information,” “integration,” and “participation” as the “key building blocks” for sustainable development (Allen et al., 2003, p. 16). Similarly, the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2014) definition of education for sustainable development (ESD) calls for the inclusion of key sustainable development issues in all teaching and learning, requiring a “participatory” approach and “critical thinking” skills (p. 33). According to the UNESCO definition (2014, p. 9), ESD is recognized as “an integral element of quality education and a key enabler for sustainable development.”

According to UNESCO (2014), ESD aims to develop “the knowledge, skills, values and attitudes that empower [...] to contribute to sustainable development [...] for environmental integrity, economic viability, and a just society for present and future generations” (p. 33). In teaching and learning, ESD puts emphasis on “innovative, participatory teaching and learning methods that empower and motivate learners” and promotes skills like “critical thinking, understanding complex systems, imagining future scenarios, and making decisions in a participatory and collaborative way” (p. 33). ESD is also perceived as “transformative education” aiming at “reorienting societies towards sustainable development” (p. 33).

In respect to design education, innovation activities — future reflections as well as participatory approaches — are already involved. Sustainability as a context of interprofessional and transdisciplinary learning, however, moves the focus further to participatory decision-making, complex systems intelligence, and transformative action for sustainability. Across ESD, there are "fundamental similarities" with design (Armstrong, 2011, p. 35) in relation to "meaningful social interaction, personal reflection, real life problem-solving, and a broad view of knowledge." However, to unleash the potential in ESD, coordination of the "pedagogic approaches" is also needed (Armstrong, 2011, p. 35). This draws the focus to how such participation and commitment to change are perceived.

Learning design for transformation

Modernist thinking calls for the capitalistic commodification of resources, products, and services, but also of labor and ideas. Its processes of commodification also alienate things from their origins, resulting in concentrations of abstract ownership and power (Sayer, 1991). According to Sayer (p. 3), the "very antinomy" of the individual and the society may be understood as "a uniquely modern perception." A similar dichotomous interplay between universals and particulars can be found at the core of sustainability. Gradually, modernity has introduced ideas of the domination of science and technology, the rule of (universal) law, and the "pre-eminence" of politics and ideology into the realm of public life (Sayer, 1991, p. 2).

Already the first UNDP Human Development Report[30] discusses "restructuring" technical cooperation in order "to help build human capabilities and national capacities" (UNDP, 1990, p. 5). In the context of academic sustainability, however, there remains the risk that "basic [human] needs," or the needs of sustainability, become "translated by a society" into "demands for scientifically produced commodities [and into] standards which the technocrats can change at will" (Illich, 1970, p. 3). As a result, in relation to SD, both design education and action have to question the dominant models of production and consumption that have been traditionally dominated by "the hegemony of a technocratic world-view" and a "never-ending pursuit of newness and innovation and progress" (Jamison, 2001, p. 10). In transformative approach to education, these demands and standards must be critically challenged.

In design practice, sustainability transformation calls for changes in the roles and agencies of both designer and consumer. In design education, this calls for challenging the ways we create knowledge and how it is utilized in the processes of decision-making. In such a context, reflective and collaborative problem-based learning help connect theory to future experience and competence (Poikela & Poikela, 2005). Transformative pedagogies aim to "democracy of thought and action" (Senteni, 2007). The "postmodern transformative pedagogy" (as in Senteni, 2007) builds on Bruno Latour's actor-network theory (Latour & Woolgar,

[30] Human Development Reports are annual reports released by the United Nations Development Programme (UNDP), looking into development in the quality of life using the Human Development Index (HDI).

1979; Latour, 1993), and on theories of communities of practice (CoP; Lave & Wenger, 1991; Wenger, 1998; Wenger et al., 2002) and expansive learning (Engeström, 1987). In essence, such approaches to learning introduce changes to the educational setting, which is still "dominated by Cartesian oppositions"[31] (Senteni, 2007), and the dichotomic features of modernity — also in relation to the distinction between a professional and a layperson itself.

But how are the pedagogies in contemporary design education answering the challenge of interprofessional sustainability? How has the management evolved, and what kind of changes are needed from the perspective of effective learning? Overall, higher education, like all intellectual pursuit today, is confronted by "a collective challenge that is also an imperative and a possibility": to create "a global and relational account of modernity" (Pratt, 2002, p. 22). In this account, sustainability and collaboration become challenged from various perspectives, at the same time becoming stronger, more reliable factors to take into consideration when implementing similar learning.

1.2.4. International comparisons

Although comparisons between different interprofessional programs for sustainability do not really make sense, as such programs are far too much grounded in their institutional and historical context and in earlier collaborations, some select examples of similar programs are presented briefly. To date, several interprofessional programs on sustainability have emerged. In Europe, in line with the work done at EU level, several universities are gradually acknowledging the need for multi- and interdisciplinary study and research opportunities, even extending toward transdisciplinarity in the sense of societal interaction and outreach (see some exemples in Table 2). Several other examples can be found in the US and other countries outside Europe. In this comparison, however, the CS program represents a rarer case example, as in it, despite the extended interaction between disciplinary fields, its students still graduate according to their disciplinary degree programs.

In summary, similar efforts exist across sustainability education, focusing to reorganize professional design education (in the broadest sense) toward a more interdisciplinary and transdisciplinary setting. Such efforts, while not mainstream in design academia or higher education in general, connect with problem areas that involve complexity and collaboration, and SD is often portrayed as such.

[31] Cartesian views, based on René Descartes' thinking from the seventeenth century, separated the mind from the corporeal body.

Table 2. *Some examples of multi- and interdisciplinary sustainability Master's degree study programs in Europe.**

Linnköping University (http://www.liu.se/) Linnköping University (LiU) in Sweden is "working actively with environmental issues through research into the environment and sustainable development," and is offering "a range of environmental study programs and individual courses relating to the environment." LiU is also collaborating on environmental issues with trade and industry, the public sector, charitable organizations, and the general public. LiU was the first university in Sweden "to introduce interdisciplinary thematic research." Example interdisciplinary sustainability study programs: - MSc in Sustainability Engineering and Management - MSc in Science for Sustainable Development
Universitat Autònoma de Barcelona (http://www.uab.cat/) The Autonomous University of Barcelona (UAB) is a public university located in Barcelona, Spain. It consists of 57 departments in the experimental, life, social, and human sciences, spread among 13 faculties/schools. UAB has the fundamental purpose "contributing to environmental research and with the objective of identifying potential interdisciplinary research areas." Example interdisciplinary sustainability study programs: - MSc in Interdisciplinary Studies in Environmental, Economic and Social Sustainability, with specialization in Global Change, Ecological Economics, Urban and Industrial Ecology and Environmental Technology
Utrecht University (http://www.uu.nl) Utrecht University (UU) is a university in Utrecht, the Netherlands. It consists of 15 departments and schools spread across seven faculties. Among its institutes is the Copernicus Institute of Sustainable Development, the scientific institute for sustainability research and teaching at Utrecht University that contributes to "the transition to a sustainable society through scientific excellence in a multi-disciplinary environment." Example multidisciplinary sustainability study programs: - MSc in Sustainable Development, with specialization in Energy and Materials, Global Change and Ecosystems, Environmental Governance and International Development

* Reviewed in Fall 2015

1.3. Theoretical and Methodological Choices

Overall, this research sheds light on how professionalism emerges in design education, what type of learning is needed in interprofessional sustainable design, and how it can be better set up and managed. In the context of sustainability, however, the challenges call for an expanded knowledge base for action and assessment.

1.3.1. Theoretical approach

The cultural-historical theory of activity (CHAT; Vygotsky, 1978) was founded to connect two opposing conceptions in psychology during the first decades of the twentieth century (Miettinen, 1999).[32] At the time, consciousness was studied as "an autonomous agent independent of and opposed to the material environment," and yet its processes were increasingly studied based on "reflectology and behaviorism" in terms of "stimulus-response" connection (Miettinen, 1999, p. 173). The CHAT concept of "mediated action" (Vygotsky, 1978) was formulated "to transcend these two opposing but equally unsatisfactory explanations," to structure the relations between human agents and objects being "mediated by cultural means and artifacts" (Miettinen, 1999, p. 173). Consequently, the CHAT framework provides the means to connect the dialectical logic between human and material aspects in interaction (see section 2.1.3).

Yrjö Engeström (1987) developed Vygotsky's model on activity, introducing aspects of interest in relation to the cultural context (community) and the processes (rules) and hierarchies (division of labor) that affect the interaction and mediation. His work also presented the concept of expansive learning (Engeström, 1987). According to Engeström (2000, p. 969), the development in practice is structured around an "expansive learning cycle" (see section 2.3.2) in which the "subject of learning" transforms from "isolated individuals to collectives and networks" (Engeström & Sannino, 2010, p. 5). In approaching such constellations of actors and artifacts, the focus is drawn to the interaction that takes place between them.

Meaning-making in networks and systems

According to the CHAT view, meanings are always formed in a "joint, collective activity" (Miettinen, 1999, p. 174; see also Leont'ev, 1978). As a result, more recent advances in CHAT theory (cf. Engeström's work) are focusing on an "activity system" as a "community of actors who have a common object of activity" (Miettinen, 1999, p. 174). The mediated structure of activity in the CHAT framework provides an "essential" ingredient for such analysis, "studying the change between entities," relating to "the capacity and knowledge of the subject, the system of means (tools and representations) used, and the object to be constructed" (Miettinen, 1999, p. 183). In this process, the "intentionality

[32] Lev Vygotsky (1896–1934) was a Soviet psychologist and one of the founders of the approach known as cultural-historical psychology that later acted as the cornerstone of the CHAT approach.

mediated" by visual and conceptual "models" also becomes important (Miettinen, 1999, p. 189) to support the processes of internationalization and externalization between the problem context and the artifacts that are used in collaborative mediation and reflection.

Another theory in artifact-mediated action, actor-network theory (ANT; see Latour & Woolgar, 1979) emerged as an approach to study technology and science and their development and assessment.[33] In approaching meaning-making, ANT reflects on connections between material (things) and abstract (ideas, concepts) dimensions. Human and nonhuman actors are studied in a symmetrical network, assuming that all relations are both material and semiotic. In the ANT view, the nature, culture, and production of new knowledge are at interplay, similarly to CHAT, which is "work and object-oriented" (Miettinen, 1999, p. 175). Both tackle "the problem of transcending dualistic oppositions between nature and society, between the subject and object" (Miettinen, 1999, p. 175) to find "explanatory principles" to reach "outside" these dichotomies. Consequently, according to Miettinen (1999), both CHAT and ANT can be used as "approaches to study technical innovations" (p. 170). In Miettinen's view (1999, pp. 174–175), the "concept of science and technology making" that is the focus of ANT studies is parallel to the concept of "object-oriented, environment-transforming human activity developed by materialistic dialectics" in CHAT.

In considering mediation, ANT can be perceived as "symmetrical" whereas CHAT is "dialectical" (Miettinen, 1999, p. 171). However, according to Miettinen (1999, p. 176), the ANT approach encounters increasing difficulties when moving from the "methodological plane toward empirical analysis," where the symmetry of the network is challenged by realities in developing real world inquiries. According to Miettinen (1999, p. 170), the limitations of "the concept of generalized symmetry" become evident "in empirical studies of innovation." Firstly, the symmetrical ANT assessment "does not supply any criteria for defining the nature and scope of actors in a heterogeneous network"; secondly, such assessment may lead to "asymmetrical" analysis with marginal contribution from "designers, users" (stakeholders in the outset of focus) and "nonhuman entities"; and thirdly, ANT analysis does not provide "any explanation for the intentionality and competence of humans" (Miettinen, 1999, p. 170). In developing a lens for analyzing innovation networks, Miettinen (1999, p. 183) concludes that the "object-oriented mediated activity" in CHAT as a perspective remains the more functional approach. In the context of higher education, where contributions and actions are largely constrained by academic structures and roles, the interaction remains asymmetric, yet with clearly defined actor roles, work environments, and objectives.

Mediating meanings in communities of practice

Disciplinary activities, while perceivable as general professions, take place in complex networks of smaller communities of practitioners and academics.

[33] ANT is often associated with science, technology, and society (STS) studies, a rather new interdisciplinary field gradually becoming established.

Practice theory is a theory of how social beings create the world in which they live. It studies the dialectic between social structures and human agencies, and their dynamic relationships (Dougherty, 2004). Practice theory (PT) links to the theory of structuration by Anthony Giddens (1984), a theory on social systems based on the analysis of both structures and agents, without giving primacy to either. Community of practice (CoP), a concept closely related to social practice theory (Riedy, 2017), was coined by Jean Lave and Etienne Wenger in their book *Situated Learning* (1991), and later expanded by Wenger (1998). The structural characteristics of a community of practice (Wenger et al., 2002, pp. 27–29) are a common "domain of knowledge," "community" as a shared "social fabric," and a "practice" as "the specific focus around which the community develops [...] its core of knowledge."

In the twentieth century setting, communities of professional disciplines and activity have developed practice gradually in relation to various contexts, developing continuous integrations of material, competence, and meaning (Shove, Panzar, & Watson, 2012). However, in the contemporary academic setting — and even more so in interprofessional learning — such an approach can be contested, as such constellations become increasingly loose, fluid, and potentially reconstructed. This development also links professional education and real-world practice, moving the emphasis to problem-based learning in collaborative projects.

The management of interaction with several interacting communities in a loose network, however, calls for a new type of understanding. Garvin (1993) defines the three critical factors essential for organizational learning as meaning, management, and measurement. These aspects extend from the CoP domain (continuing from the meanings set by the participants) and become essential in looking at development in organizational practice.

Grounded theory on interprofessional learning

Grounded theory methodology (GTM) is also an important component of this research (as discussed in 3.2.1). GTM (Glaser & Strauss, 1967) was developed because of criticism of how "existing theories dominated sociological research" (Willig, 2013, p. 69). It seeks context- and data-driven theory, instead of being based on existing "analytical constructs, categories or variables from pre-existing theories" (Willig, 2013, p. 69). In this work, GTM is visible in the process of analysis and in how the theories connect to the assessment and to the building of the research framework. In the process, the theories and their insights that were introduced in the interviews and other materials become part of the data, and the result is new theoretical constructs.

However, the findings rely heavily on CHAT-based elements and, in this sense, this work distances itself from GTM. In summary, while the insights from ANT and PT have affected this study, and GTM has offered a method to connect these theories in analysis, CHAT was chosen in the end as the main theoretical body to analyze and structure the findings of the research.

1.3.2. Components in the assessment

As a case of interprofessional learning for sustainability and sustainable design, CS offers an arena of assessment for transformation in interprofessional design action, in its teaching and learning, and also in the context for interaction. In CS, such transformation is taking place on various levels: in developing new collaboration, in creating a new interprofessional community focusing on sustainable design, and in developing a platform to challenge teaching and learning, or academia itself. In this respect, studying these elements of interaction through distinctive categories of actors and activities becomes sensible. In academia, such actors are rather naturally formed from student groups, the teaching community, and the management.

The interplay between various actors in CS initiation and development can also be modelled with a temporal and hierarchical structure in mind, focusing on 1) setting the stage for the CS program, or priming; 2) the implementation of courses and learning contents; and 3) individual learning, with reflection on overall program management. These areas of activity — albeit sequential in developing the program content — can be seen as overlapping phases of activity with different participants, instruments, and practices involved in an interplay. They also serve as the analytic components in structuring this study (see Figure 5).

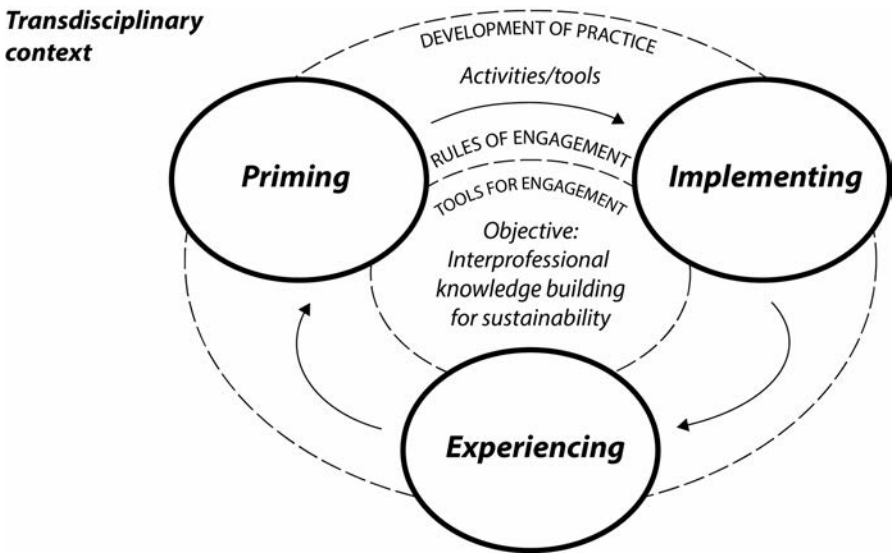


Figure 5. *The analytic components in the CS interplay and in this study.*
Source: Author

Supported by CHAT elements, the reflection on interaction between these phases also connects to the dynamics between various actor groups. At the outset are the involved communities, practice (development of practice), and outside actors (transdisciplinary context; see Figure 5). At the core, there is a shared objective. Between, the interaction is supported, but constrained, by shared rules and tools

in engagement (see Figure 5) evolving through internalization and appropriation, connecting externalized signs into future artifacts and action.

Developing understanding of the interacting systems and phases of activities has been crucial in structuring the assessment. For example, in relation to experiencing and learning, aspects such as personal background, learning transactions, professional growth, and community interaction are taken into consideration. In implementing teaching, the focus extends to professional background, teaching approach, development of teaching, and community interaction. Finally, the reflection on priming these activities in CS considers the historical context, driving ideologies and expectations, status and development, and community interaction. Consequently, the findings from the general areas of analysis are drawn together and their interplay analyzed from the perspective of sustainability.

Building theory on CS interaction

When sustainability challenges academia, and interprofessional and transdisciplinary studies are introduced to academia, there can be clashes between different learning and teaching styles, disciplinary perspectives, communities of practitioners, and professional traditions. However, for a collaborative process, these need to be brought together. Hence, the question is what are the mechanics that help in this process? Furthermore, as sustainability challenges the contemporary design academia, another question concerns what types of change this denotes in design education and in the future practice itself. Finally, as sustainability extends outward from a singular view and promotes constructive heterogeneity, it expands the mediation to areas of participation and politics.

As a result, the main contextual elements of the assignment — design as a practice and profession, and sustainability challenge — expand into four broad questions:

- *How is sustainability articulated, and what type of change (in practices, in society at large) does it denote?*
- *What is the role of design as a practice of collaborative meaning-making and a discipline that connects several professionals and also laypeople views?*
- *How could design better support interprofessional and transdisciplinary action?*
- *In what ways can this be supported in education, and what type of change does this mean for conventional teaching, learning, and management?*

These questions are studied further in the next chapter, based on which the refined research questions are presented in Chapter 3 (see section 3.2.3).

1.3.3. Research contributions

The contribution of this work is threefold, ranging from historical to theoretic to practical. In recording the process of the initiation of the CS study program, this work acts as a historic contribution. In developing the lens for the study and analyzing these developments against the existing theories on interprofessional design education, this research contributes to theory building. In suggesting actions based on the conclusions of the analysis, the work has also practical contributions.

The first analytical outcome is the identification of thematic categories of interest that emerge from the case and its background context (Chapter 4). In the summarizing analysis (Chapter 5), these findings are then connected into systems of activity in CS and integrated into a common systemic view on the phases of work. In the process, the barriers, conflicts, and untapped potential in relation to both the developments of the program and its goal of developing a new understanding of interprofessional design collaboration and learning for sustainability are revisited.

When sustainability challenges academia, and interprofessional and transdisciplinary studies are introduced to the interaction, there can be clashes between different learning and teaching styles, disciplinary perspectives, and professional traditions. However, for a collaborative process, these need to be brought together. Hence, the question is what the mechanics are that help in this process. Furthermore, another question is what types of change this denotes in design education, and in the future practice itself. Finally, as sustainability extends outward from a single view and promotes constructive heterogeneity, the inquiry expands to areas of participation and politics.

The desired outcome is a development of the understanding of interaction between students, teachers, and management in education, to promote transdisciplinary sustainability action, transformation in teaching and learning practices, and better utilization of the tools, instruments, and processes in the interprofessional collaboration itself.

2. LEARNING INTERPROFESSIONAL DESIGN FOR SUSTAINABILITY

Sustainability and sustainable development as terms are the result of modernity in both their verbal meaning and their conceptual sense. They have become meaningful only through the ecological crisis caused by industrialization and consumerism — the development itself — and through the modern man-nature dichotomy.

Interdisciplinarity as a phenomenon is studied in research fields including "humanities, social sciences, and science and technology," focusing on "research collaboration [...], teamwork, knowledge management, distributed cognition, social cognition, epistemology," and so on (Bruun et al., 2005, p. 34). Instrumental interdisciplinarity has emerged from the science-based areas of novel economic activity, such as the fields of computer technology, biotechnology, and biomedicine, and other high-technology industries, with a goal of producing collaborative output, but not challenging the assignment itself (Klein, 2010, p. 22). Critical interdisciplinarity, however, as the other extreme, challenges "the dominant structures of knowledge and education" with the "aim of transforming them" (Klein, 2010, p. 23). When extended to the wider society, this approach evolves to become transdisciplinarity.

Gradually, the academic field of sustainability sciences has emerged, building on biology (Carson, 1962),[34] systems science (Meadows et al., 1972),[35] ecological assessment, and, lately, climate physics — see, for example, the Intergovernmental Panel on Climate Change (IPCC) — or even behavioral psychology. Similarly, during the twentieth century development of design into an identifiable industrial practice, its activities have gradually been acknowledged from an academic perspective and taken into interplay with other scientific fields. As a result, a new range of insights from both professionals and laypeople have been introduced into design as an activity and as an area of professional learning.

The above contextual aspects have been extensively studied in literary material and can be broadly divided under the topical areas of this work: transformative sustainability, design professionalism and practice, interprofessional collaboration, and interprofessional learning (for sustainability). The first area of inquiry acts as a context, guided by the UN, UNEP, and UNESCO descriptions (e.g., of SD and ESD), but also by the criticism of techno-positivistic views of thought and action. The second is approached through its historical and disciplinary context, but also as a component in collaborative problem-solving in general. Thirdly, theories on

[34] *Silent Spring* by Rachel Carson, which raised awareness of hazardous pesticides, was published in 1962 and can be seen as "the starting-point for environmentalism" (Jamison, 2001, p. 43).

[35] *The Limits to Growth* by Donella Meadows et al. (1972) is the "best-selling environmental book in world history," as mentioned in the Club of Rome's *The Limits to Growth: The 30-year Update* (Meadows et al., 2004). The book predicted the overshooting of planetary limits and foresaw a social, economic, and environmental collapse.

interprofessional meaning-making and scientific progress are discussed. Furthermore, learning design is discussed from this perspective in connection with both pedagogical theory and transformation for sustainability in practice.

Approach in the literary review

A literature review identifies, analyzes and synthesizes "all available research relevant to a particular research question, or topic" (Kitchenham, 2004, p. 1). The idea in the literature review of this work was to revisit secondary sources perceived to be relevant to the primary study, but also to add new insights to the analytical framework as they were introduced to the process. The motivation in the review was to identify gaps in current research, to create a consolidated understanding on an established but a fragmented topic of interprofessional sustainability, and to understand how and with what evidence theories in this field are supported.

Sustainability as a context connects with various theoretical bodies of work, and with practical action. The related literature was identified through several search methods, the main approach beginning from various official documents (e.g., UN descriptions of SD and ESD) and then searching article databases (e.g., Google Scholar, Elsevier, JSTOR, etc.) with various keywords. Expanding the main theoretical approaches and discourses toward pedagogy and management, snowballing, and the identification of sources through contacts made during the research process expanded the scope of the analysis.

This chapter looks into how these discourses have formed and evolved over the last decades, in more detail in more recent decades. It lays down a basic understanding of interprofessional collaboration, and analyzes how inter- and transdisciplinary activities in design and education are connected to sustainability and to the pursuit of sustainable transformation in real-world practices.

2.1. Developing Interprofessional Meaning-Making

The increasing professionalization and specialization in design practice, along with many other contemporary practices, took place during the twentieth century. In parallel with the increasing specialization and professionalization in design, the specialization within academic disciplines progressed. Initially, this helped to expand the body of scientific knowledge, but eventually the distances between the disciplines grew to affect the ways in which they perceive the world, to produce new knowledge, and to use it to guide action. Recently, a growing number of institutes and new actors, from private enterprises to government agencies, have been adopting interdisciplinary practices (Bruun et al., 2005, p. 24). These processes involve different actors from the realms of business, scientific research, and politics; in the process, their values and knowledge interact through hybridization, producing novel innovations, scientific knowledge, and societal policies (Nieminen, 2004, p. 26). As a result, a novel interest in increasing interprofessional activities has emerged, seeking better integration of meanings, knowledge, and activities across professional fields.

From multidisciplinary collaboration to inter- and transdisciplinarity

In the 1970s, academic recognition began to acknowledge that disciplinary specialization carries its own risks — particularly the inability to recognize possible negative side effects, to consider long-term implications, and to meet the needs of society at large (Marttila & Kohtala, 2014). One seminal event in this evolution was the first international conference on interdisciplinarity organized by the Organization for Economic Cooperation and Development (OECD) in Paris in 1970 that emphasized a need for new, interdisciplinary initiatives in higher education. The OECD report following the conference, “Interdisciplinarity: Problems of teaching and research in universities” (Apostel, Berger, Briggs, & Michaud, 1972), showcased the risks of overspecialization and the benefits of an interdisciplinary approach in relation to complex contemporary problems. In this OECD publication, transdisciplinarity as a term was coined for the first time, defined as “a common system of axioms that transcends the narrow scope of disciplinary worldviews through an overarching synthesis” (Klein, 2010, p. 24).

According to the OECD classification (OECD, 1998), in multidisciplinary research several disciplinary perspectives are “juxtaposed side by side,” each perspective having its own autonomy (Klein, 2010, p. 17). While a wider approach on “knowledge, information, and methods” is fostered, the disciplines remain separate and “the existing structure of knowledge is not questioned” (Klein, 2010, p. 17). There is little cross-fertilization among the disciplines and no explicit goal to achieve synergy in the outcomes (Pohl, van Kerkhoff, Hirsch Hadorn, & Bammer, 2008).

Gradually, if the “integration and interaction” become more “proactive” (Klein, 2010, p. 18), this collaboration transforms toward interdisciplinarity. In this sense, interdisciplinarity as a term denotes a more comprehensive, integrated, holistic, or even unified understanding of the given issue, calling for more sharing and

merging of vocabulary, frameworks, methods, and mental models (discussed in more detail in Marttila & Kohtala, 2014, p. 451).[36]

Transdisciplinarity aims at building collaboration between research and practice, with experts and laypeople. It refers to research and action in which "problem solutions emerge in the contexts of application" (Stehr & Weingart, 2000, p. 43). Transdisciplinary research aims to better fit "academic knowledge production to societal needs for solving, mitigating, or preventing" complex contemporary problems (Hirsch Hadorn, Pohl, & Bammer, 2010, p. 431).[37] As such, it expands outward from the academic boundaries, calling for "more normative and socially responsible" research processes "than what was perhaps considered appropriate in traditional science in the past" (Marttila & Kohtala, 2014, p. 451).

2.1.1. Disciplinarity and the development of scientific understanding

A discipline can be perceived as a focused area of study in an academic field or profession.[38] Before the twentieth century, the scientific fields were broad and general, but as the amount of scientific knowledge started to rapidly increase, scientific specialization progressed and the modern disciplines evolved.[39] Today, the disciplines represent "the eyes through which modern society sees and forms its images about the world, frames its experience, and learns" (Stehr & Weingart, 2000, p. xi). They connect the emerging theories in science with applications in professional work, and govern almost all areas of interaction with their specialist, expert knowledge and practice.

Disciplinary specialization can also be explained from the cognitive perspective. As human beings have a "restricted capacity for information acquisition and processing" (Bruun et al., 2005, p. 37; see also Simon, 1955), they require "instruments and behavioral heuristics" to operate effectively (Bruun et al., 2005, p. 37). As such, the contemporary disciplines provide means for the specialization that is needed to comprehend the complexities of our modern society and its functions. This segmentation into "disciplinary compartments," however, can also be perceived as an obstacle to the progress of science (Bruun et al., 2005, p. 5). The mental frameworks introduced through the disciplinary background may also hinder the ability to understand or be influenced by methods and theories from other fields.

The "norms of the discipline" may be perceived as the "accumulated wisdom that guides activities" (Bruun et al., 2005, p. 38). These disciplinary norms keep

[36] Alternatively, the term "interdisciplinary" has been used to refer to disciplines that have been integrated from two fields, e.g., bio-chemistry, astro-physics, medical radiology, or population genetics (François, 2006).

[37] "Trans-sectoral transdisciplinary problem solving" is a prominent approach in several "Europe and North-South partnerships" (Klein, 2010, p. 25).

[38] Originally referring to the cataloging of new, scientific information, the term "discipline" was gradually connected with professional designations in German universities at the beginning of the nineteenth century.

[39] In the twentieth century, the "hard" science disciplines could broadly include mathematics, physics, chemistry, biology, geology, and astronomy. The "soft" social science disciplines could include economics, politics, sociology, and psychology.

control over the use of concepts and methods, and remain valuable for science within their disciplinary context (Bruun et al., 2005). Disciplinary norms, however, also introduce different spatial and temporal scales to the activity (Dovers, 2010, p. 185; see Table 3), and result in different disciplinary "presumptions, assumptions, metaphors and explanations" (Dovers, 2010, p. 184). Consequently, the structures introduced in disciplinary education and practice often also become components in the epistemic approach of a particular person in their professional life.

Table 3. *Disciplines with different scales of focus.*

Discipline/sub-discipline	Typical spatial scale	Typical temporal scale
Neoclassical economics	Individual, household, firm, reach of economy, trade	Short term: months, years
Ecology, ecosystem theory	Longer term	Longer term
Community ecology	Community	Shorter term
Law, common law	Legal tradition	Long term
Statutory law	Jurisdiction	Enactment, repeal
Psychology	Individual, group	Days–years
Sociology, anthropology	Groups	Decades

Source: Dovers (2010, p. 185)

Through their incorporated elements of governance, contemporary disciplines are also in many ways the holders of power in modernity. Disciplines, however, are not just "the intellectual structures" in which we "transfer [...] knowledge from one generation to the next," but also social structures that are made up of "human beings with vested interests," "acquired reputations," and "established social networks" (Stehr & Weingart, 2000, p. xi). The essence of "discipline formation and evolution" is a "self-referential communication," in which the "communication is 'closed' [...] and the evaluation of relevance and quality of research is limited to members of the respective disciplinary community" (Weingart, 2010, p. 8). As a result, all inquiries into knowledge "inevitably" examine "the prevailing systems of power and control" (Brown, 2010b, p. 107).

Developments in understanding scientific problem-solving and progress

The late nineteenth century philosophy of pragmatism was continuing the debate on inductivist views for scientific problem-solving processes[40] based on the notion "that the meaning of a proposition" can be found in "the practical consequences of accepting it" (McDermid, 2017). Overall, pragmatists were initially interested in how scientific understanding is constructed and argued for. After the emergence of pragmatism and its continuation in the twentieth century works of John Dewey

[40] Inductivism is the traditional model of scientific method explained in 1620 by Francis Bacon. In the Baconian model, scientists observe natural phenomena and pose axioms that are confirmed or refuted.

in education,[41] for example, in which he renamed the approach instrumentalism (McDermid, 2017), increasing emphasis was put on the idea that inquiry depends on real doubt and is affected by both the environment and internal beliefs and expectations.

By the beginning of twentieth century, the scientific thinking emerging from the rationale of modernity had led to new perceptions on what science can be and what it should be. After the middle of the century, Karl Popper,[42] an Austrian-British philosopher, introduced a new approach to define scientific knowledge. In one of his most famous books, *The Logic of Scientific Discovery* (1959), he analyzed the progress in developing scientific knowledge and argued that instead of established truths emerging from earlier theories, scientific knowledge should be based on the potential "falsifiability" of the newly emerging concepts. Popper rejected the classical inductivist views on science and proposed that instead of axiomatization, in which the scientific community develops knowledge based on ever better informed — and evermore established — axioms, scientific knowledge should be justified by its potential for empirical falsification (Popper, 1959). Popper's view was an effort to combine the positivist and constructivist domains of scientific inquiry into a new post-positivist approach to knowledge-making.

Popper's views were debated and criticized at the time, but they worked as a basis for further development. Thomas Kuhn (1962) disregarded the optimism of such scientific honesty, and instead emphasized paradigms from where the scientists work and the fact that such paradigms resist change, suggesting a reversion back to the initial problem of axiomatic development of science. Imre Lakatos made an attempt later on (Lakatos & Musgrave, 1970) to look at the development of scientific inquiries not as either/or, but rather emphasizing the aspects that may make such paradigms more responsive to change, refining a concept of the research program that can be either regressive or progressive. From this point onward, a colleague of Lakatos, Paul Feyerabend (1975), continued to argue that instead we should aim for more anarchistic scientific programs.

Feyerabend further refined this idea in his book *Against Method* (1975), in which he argued that Popperian critical rationalism was an inadequate approach. Whilst according to its principles, ideas have to be proactively developed "so that they can be criticized" and "exhibit their weak spots" (p. 153), the institutions in power remain. For Feyerabend, the question is whether such scientific progress can serve "human interests" and "human freedom [...] from hunger, despair, from the tyranny of constipated systems of thought" (1975, p. 156). To further the inquiry, Feyerabend asks "how can we analyze the terms in which we habitually express our most simple and straightforward observations, and reveal their presuppositions?" (p. 15). According to him, the answer is to seek an "external standard of criticism" (Feyerabend, 1975, p. 15).

[41] John Dewey (1859–1952) was a famous American philosopher and educational reformer. He is known for books such as *Experience and Education* (1938), revisited in section 2.3.2.

[42] Karl Popper (1904–1992) worked as a professor of logic and scientific method at the London School of Economics between 1949 and 1969.

Popper's view and its developments, however, drew focus to how problem-setting in science is understood, elaborated, and structured, and how the problem-solving process connects to knowledge-building. In principle, according to this view, scientific inquiry develops through an evolutionary process that happens in the interaction of cultural (and scientific) paradigms in an interplay with contemporary disciplines. To acknowledge this, development called for more communicative and more historically informed (and ever iterating) understanding of problem-setting itself.

New types of science-making

In contemporary academic research, a similar interplay between the positivist and constructivist perspectives remains, but contemporary interdisciplinary and transdisciplinary emphases have expanded the scope further. In their book on promoting interdisciplinary research, Bruun et al. (2005) identify two main views on the production of scientific knowledge: 1) the hierarchical model that works as a realistic snap-shot of the modern structuring of scientific knowledge-making (resembling the Popperian model); and 2) the rhizome model, based on the terms "rhizome" and "rhizomatic," used by Deleuze and Guattari (1987) to describe a theory of knowledge production that allows for multiple, non-hierarchical entry and exit points in representation and interpretation (Marttila & Kohtala, 2014).

Bruun et al. (2005) base their notion of the rhizome model on their criticism of two earlier theories on interdisciplinarity. Another is the theory of finalization in science,[43] suggesting that after disciplines mature (thus forming a disciplinary paradigm), they eventually become connected to concerns external to science (transdisciplinary activities). The other is the Mode 2 thesis by Gibbons et al. (1994) that emphasizes the different nature of knowledge created in interdisciplinary collaboration.

In their Mode 2 thesis, Gibbons et al. (1994) call the "transgression of conventional boundaries between science and society" transdisciplinarity (Bruun et al., 2005, p. 47) — a cognitive and epistemological framework that is "generated and sustained in the context of application" (Gibbons et al., 1994, p. 5; as cited in Bruun et al., 2005, p. 47). However, as Bruun et al. (2005, p. 49) note, if this context is understood too broadly, everything counts as Mode 2 activity; if it is understood too narrowly, the theory fails to account for a major part of activities. As a result, the distinction between the two modes seems "not watertight" (Bruun et al., 2005, p. 59). Overall, the new mode of science-making is bringing in the interprofessional emphasis in academic collaboration and transdisciplinarity connecting to real-world problems. This also moves the focus in learning closer to real-world practice.

[43] The theory of finalization in science is a theory suggested by Böhme, van den Daele, et al. (1983, cited in Bruun et al., 2005, p. 46), that builds on "cycle of stages" in disciplinary evolution, from the "early explorative stage" to the phase when one theoretical approach becomes dominant, and eventually to a phase when this is connected to more general theories (Bruun et al., 2005, p. 46).

2.1.2. Networks and communities developing practice

As discussed earlier (see section 1.3.2), a development in professional and academic understanding is taking place in networks of actors, projects, and communities. In this process, the interaction is constrained by the institutional and social structures, as well as by the instruments and tools in use and the sequencing of the activity. Overall, these aspects become a focus in various theories, elements of which are drawn on to guide the assessment in this study.

Actors and networks developing meanings of things

The cultural-historical activity theory emerged based on the contrast between intentional and instrumental, circumstantial action. In CHAT, subjects orient their activity toward an object, supported by instruments and tools that are material (or conceptual) artifacts. In this process, the activities and meanings connected to the artifacts are mediated and transformed through a process of internalization and externalization. Besides a theoretical approach, CHAT is considered a "framework aimed at transcending the dichotomies of micro- and macro-, mental and material, [and] observation and intervention in analysis and redesign of work" (Engeström, 2000, p. 960). Due to its connections to structured, collaborative mediation on meanings and action, it fits well into the study of organizational development and learning.

Another theory into artifact-mediated action, actor-network theory (ANT; Latour & Woolgar, 1979), is an approach to tackle the complexities of studying technology and science, and their development and assessment in complex contemporary systems. In the ANT view, concepts are mediated and translated (resembling the CHAT internalization) from materials and inscribed (externalization in CHAT) into new materials that act in guiding the new interaction. According to Lopes (2011, p. 314), the ANT concept of inscription refers to "the way technical artefacts embody patterns of use," translation to "stability and social order" that are "continually negotiated as a social process of aligning interests" and punctualizations as "black boxes[44] [...] used to deal with bounded rationality." Similar interaction is also described in the CHAT approach, although CHAT emphasizes the distinction between material objects and human actors.

In sociology, the term "boundary object"[45] refers to a concept or an artifact of information (i.e., sample of data) that is shared by several experts and that is used in collaboration within a specific project or area of interest. In interprofessional integration, disciplinary practices, concepts, and theories may be "influential sources of interaction" (Klein, 2000, p. 112). When approaching the "edge of knowing," two different perspectives meet, and as a new perspective is introduced to a familiar issue, the "frameworks through which one views and interprets experience" must change (Beard & Mälkki, 2013, p. 29). The change in perspective involves "a struggle at the liminal space" or at the "in-between zone

[44] The term "black box" refers to artifacts (technical objects) that operate as expected while simultaneously hiding the complexities that constitute them.

[45] Boundary object as a term was introduced by Star and Griesmer (1989), and has since been used to explain interactions in interprofessional collaboration (Klein, 2000, p. 12).

between the old and the new conceptions" (Beard & Mälkki, 2013, p. 29; see also Mälkki & Green, 2013). Such change also denotes "epistemic development" (Beard & Mälkki, 2013, p. 30). At the edge of knowing — or at epistemic boundaries — our "beliefs, attitudes, values, shared assumptions, sources of acceptance, relationships, and a sense of understanding the world" (Beard & Mälkki, 2013, p. 30) become involved in the inquiry.

Successful boundary crossing and the resulting transformation in (conceptual and material) artifacts and in translations of hybrid knowledge lead to "negotiated knotworking" between the participants (Engeström & Sannino, 2010, p. 13), developing new materials (Shove et al., 2012) on which the future interaction can build. Hence, well-functioning processes of epistemic translation can be key to the renewal of knowledge fields (Bruun, 2000; Marttila & Kohtala, 2014).

Communities developing practice

In assessing disciplinarity, it is expressed not only in the academic context but also in professional practice performed by various communities (Lave & Wenger, 1991; Wenger, 1998). In CoP groups, four characteristics can be identified: the members interact with each other both "in formal and informal settings," "share knowledge with each other," and "collaborate with each other to create new knowledge," and their group fosters "the development of a shared-identity" among members (Li et al., 2009, p. 2). Wenger (1998, pp. 72–73) describes how "mutual engagement," "joint enterprise," and "shared repertoire" are the three relations by which practice "is the source of a coherence" for a community of practice. Such communities range from "voluntary informal networks to work-supported formal education sessions, and from apprentice training to multidisciplinary, multi-site project teams" (Li et al., 2009, p. 2).

Social relations cause persons and practices to "change, re-produce, and transform each other" (Lave & Wenger, 1991, p. 68). In their book *The Dynamics of Social Practice* (2012), Shove, Panzar, and Watson focus on the dynamic aspects of social practice and the way practices change. According to Shove et al. (2012, p. 24), practices consist of "active integrations of material, competence and meaning." When competences and materials develop, meanings also transform (p. 33). A change in practice can be induced through "processes of integration" (p. 43) and persistence in the circulation of its elements. This process involves the "packing and unpacking" of these elements and their interdependencies (p. 56). As the elements discussed by Shove et al. (2012) are "linked together to form recognizable practices," practices also link together to form "bundles and complexes" that are either "loose-knit patterns based on the co-location and co-existence" or "more integrated combinations" (p. 81).

Whereas CoPs are often perceived to form "homogenous design communities" (Fischer, 2001, p. 3), a community of interest (CoI) connects a more heterogeneous group of interested people from various contexts to discuss "a particular (design) problem of common concern" (Fischer, 2001, p. 4). As such, CoIs can connect several groups and communities of practitioners together a shared interest, connecting various different practices and perspectives into the

collaborative mediation. According to Fischer (2001), in such interaction challenges emerge "in building a shared understanding of the task at hand" that "is evolved incrementally and collaboratively and emerges in people's minds and in external artifacts" (p. 4). CoI members "must learn to communicate with and learn from others who have different perspectives and perhaps a different vocabulary for describing their ideas" (Fischer, 2001, p. 4).

Experts, specialists and laypeople

In interprofessional collaboration, different experts and other professional practitioners restructure their knowledge around a specific problem context. Depending on the background and persona, the approach to this knowledge differs. Put simply, the specialist values precision and detail while the generalist wants to know a little about a lot of things. These two practitioners may use "different research methods, develop different concepts and terminology, and have very different ideals or goals for their research activity" (Jamison, 2001, p. 35).

The T-movement explains how in approaching different expert contributors, the T-shaped experts (Madhavan & Grover, 1998) — in contrast to I-shaped specialists acting vertically from the professional base to practice — have the cognitive capacity to integrate multiple knowledge bases in their own experience, to understand how other knowledge inputs relate to and interact with their own disciplinary knowledge (Madhavan & Grover, 1998, p. 3). The horizontal top of the T in a T-shaped expert thus refers to the ability to bridge various realms of knowledge and knowhow. A-shaped experts (Madhavan & Grover, 1998) are then people who have their feet in two disciplines at once and are therefore capable of fostering the team's ability to share and integrate knowledge. Hukkinen (2008) suggests the term "hybrid expert" for this role. In comparison with disciplinary specialists (I-shaped), the hybrid experts resemble generalists. In interprofessional collaboration, however, the approaches are complementary rather than opposed (François, 2006): a specialist needs understanding "of his/her place within the scientific and social community," and a generalist must also have a certain level of understanding regarding the "specific disciplinarian knowledge" to contribute meaningfully (François, 2006, p. 622).

Hukkinen (2008, p. 67) emphasizes that the lay knowledge contributed by real-life (or "life-world") stakeholders is actually expert knowledge on the basis of being socially relevant. The quality of the knowledge is therefore based on a criterion of being socially robust rather than scientifically reliable, and its testing involves "public deliberation" (Hukkinen, 2008, p. 67). Such tacit and emergent knowledge cannot be directly taught, but instead only learned "through participating personally in a sustained process of solving problems" (Hakkarainen et al., 2004, p. 22). Such knowledge is formed through the collaboration; at the same time, artifacts (i.e., concepts, tools, theories) in collaboration evolve.

According to Klein (2000, p. 18), the view on interdisciplinarity that emerges "does not deny the value of specialization" or "the inevitability of differentiation," but it does "dispute oversimplifications" related to other professionals. Klein

continues that interdisciplinarity and specialization (disciplinarity) are "parallel, mutually reinforcing strategies" and their interplay, if properly supported, can lead to "a productive tension characterized by complexity and hybridity" (2000, p. 7).

Projects as collaborative constellations

Because of the multitude of participating groups and their approaches, and as the interprofessional process is context-dependent and varies from one case to another, it often calls for a problem- and project-based collaborative action. In projects, new understanding is applied in real-world contexts and communicated further to be connected with future inquiries. Project work differs from conventional professional activity in that it includes the individuals and all the artifacts and norms and rules "indigenous" to that specific project (Blunden, 2009, p. 19). In a project-based collaboration, "the reality of each project is unique" (Bruun et al., 2005, p. 115), and the "implementation and practices [...] vary substantially." A project is also "always directed towards some ideal" (Blunden, 2009, p. 19). Hence, if we take the collaborative project as the unit of analysis, then activity becomes an interdisciplinary concept, because through the project it becomes equally available to other domains of science and theory-building (Blunden, 2009). If we open the project to a wider public, it becomes transdisciplinary.

Collaboration in constellations of people and things also varies according to tradition and evolves through experience. Projects are often based on earlier ones, and the institutions, practitioners, and communities involved traverse with them. As a result, projects are not perceived simply as individual or collaborative enterprises to tackle a given challenge or brief for action, but can be understood in a similar broad sense to when Habermas (1997) discusses the projects of modernity perceived in interplay in everything (project of nation, project of science, etc.). Collaboration, when enacted, constitutes "the definition of 'we' relevant to the given relationship" (Blunden, 2010, p. 10), structuring the way participants can have their say. True collaboration also "always entails an element of dispute of the concept of what is to be attained" and "conflict over how to get there" (Blunden, 2010, p. 10).

A project team differs from a CoP in being tied to a specific goal and being more heterogeneous in relation to knowledge, practices, and roles, but the means of collaboration remain in many ways similar. Furthermore, a project always connects to new projects through participants and content. In contrast to CoPs, this process forms evolving CoIs that focus around a specific topical area of inquiry (Fischer, 2001). In approaching interdisciplinary research and education, a "dialogue between disciplines" acts as a crucial mechanism, and yet it may well take place outside the "conventional organizational charts" (Bruun et al., 2005, p. 24). There is, then, a "concealed reality" to interdisciplinarity (Bruun et al., 2005, p. 25), evident in aspects that are difficult to institutionalize (e.g., informal networks, subjects, and topics). In this process, collaborative projects provide platforms to learn through collaboration, to connect findings from one disciplinary domain to another, and to implement transdisciplinary meaning-making.

2.1.3. The components of interprofessional meaning-making

In successful interprofessional boundary crossing (as well as in developmental transfer), the activities are largely dependent on appropriate tools such as "forms, knowledge repositories, and graphic models" (Engeström & Sannino, 2010, p. 13; see also Lambert, 1999) that can help to expand the shared object of interaction and connect and restructure the components in a new way. The emphasis on a shared object and materials, however, moves the focus to how this interaction and the problem space are set up, and how it connects to future action. At the same time, interprofessional meaning-making can become contested by contradictions emerging from the various conflicting disciplinary, cultural, and institutional perspectives.

Modelling cultural meaning-making

In his early work, Vygotsky studied child development and the development of higher mental functions, focusing on the roles of cultural mediation and interpersonal communication (Daniels et al., 2007). Through the process of internationalization, these become integrated into collaborative interaction and learning, to be externalized into further materials and action. Internationalization can be understood as the development towards knowing-how. The internalization and externalization processes concern "the understanding of context and processes in order to organize them with external artifacts to carry out an activity" (Nussbaumer, 2012, p. 44). A similar process takes place in university teaching and adult learning, in growing the students who will be the future practitioners of a discipline.

In the first generation of activity theory (Vygotsky, 1978), interactions between people and the material world are expressed with triangular linkages between a subject, the involved cultural components, and the subject's response. The second generation (Engeström, 1987) expands this toward instruments, rules, and division of labor (Engeström & Sannino, 2010). The third generation CHAT focuses on relations between multiple activity systems (Sannino, 2011), accordingly expanding the unit of analysis further (see Figure 6).

In the CHAT models of activity systems (Figure 6), the node for subject refers to an "individual or subgroup whose position and point of view are chosen as the perspective of the analysis" (Engeström & Sannino, 2010, p. 6). The node for object refers to the "'problem space' at which the activity is directed" (Engeström & Sannino, 2010, p. 6). This object is "turned into outcomes with the help of 'instruments', that is, tools and signs" (Engeström & Sannino, 2010, p. 6). Object in its general form is connected to societal meanings, and specifically to "personal sense" (Engeström & Sannino, 2010, p. 6). Community and division of labor refer to the group sharing the object and their division of work and power, and rules to the "regulations, norms, conventions and standards that constrain actions within the activity system" (Engeström & Sannino, 2010, p. 6). Simply put, conflicts are then caused by contradictions between the nodes and their involved actors in interacting activity systems.

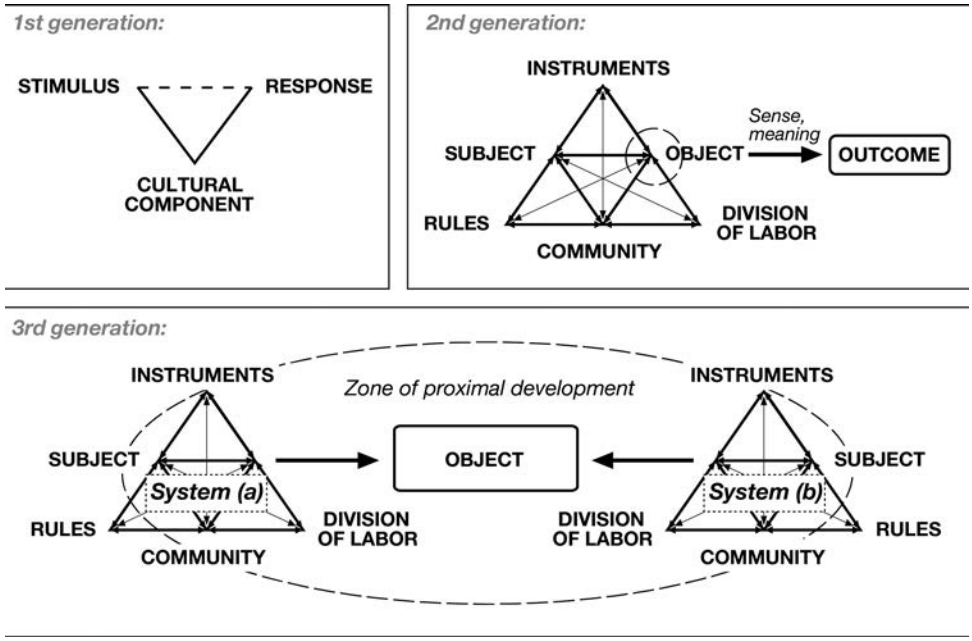


Figure 6. *Three generations of activity theory and their central concepts.*

Source: Author, based on Engeström and Sannino (2010), and Sannino (2011)

In Vygotsky's view (Miettinen, 1999, p. 174; see also Vygotsky, 1981, p. 163), "cultural development takes place [...] on two planes": first "interpsychologically, in interaction between people," and then "as an intrapsychological category" in developing individual thinking. In this view, "forms of material culture are internalized by an individual due to participation" and, on the other hand, externalized into forms of "human activity and thought" (Miettinen, 1999, p. 174). In ANT terminology, inscription is the "result of the translation of one's interest into material form" (Callon, 1991, p. 143) and translation is a process in which "entities and meanings built into technology [...] are related in a sociotechnical network" (Cressmann, 2009, p. 9).

In ANT, the black box concept refers to a technological object or construct, or technique, that hides its inner mechanics and seems "evident and obvious to the user" (Cressmann, 2009, p. 6) as long as it is not questioned, challenged, or opened. Punctualizations, on the other hand, relate to "the process by which complex actor-networks are black boxed and linked with other networks" (Cressmann, 2009, p. 7). This "process of punctualization [...] converts an entire network into a single point or node in another network" (Callon, 1991, p. 153; as cited in Cressmann, 2009, p. 7). In connecting several systems of activity, CHAT, with its diagrams, easily becomes overly complex (Yamagata-Lynch, 2007). Furthermore, ANT punctualizations better emphasize the often limited access to components in other systems of activity, despite having a clear connection.

Table 4. *Three theories and their components for collaborative meaning-making.*

Theory	CHAT	Actor-network theory	Practice theory
Term to describe the sharing of concepts, patterns	Internalization	Translation	Mediating meanings
Term to describe the development of new concepts and activity	Externalization	Inscription	Developing materials
Meaning-making is taking place in…	Nested, hierarchical activity systems	Networks of human and nonhuman actors, with punctualizations	Practicing communities (with tacit competence, knowledge)
Progress measured in…	New, improved activity	New, hybridized meanings	Development of practice

Source: Author

Practice theory moves the focus to collective action and tacit competence, but follows the same logic. A person gradually internalizes the practice and becomes a member of the community. These communities then interact with their practice-based understanding, acting as connected systems of activity, and connected punctualizations in a larger actor network. In essence, these three theories offer slightly different views on cultural meaning-making, and as such their elements are inherently connected (see Table 4).

Epistemic translation in a shared problem space

In interprofessional collaboration, the participants must formulate the rules for work and set the stage for action. As delineated in our earlier publication (Marttila & Kohtala, 2014), the shared problem space is a shared knowledge structure that supports problem-solving activity by integrating goals, descriptions of the current problem state, awareness of available problem-solving actions, and associations that relate goals, features of the current problem state, and available actions. The building of the problem space is thus a kind of "cognitive and social dance" (Marttila & Kohtala, 2014, p. 465) supported by collaborative mediation, iterative feedback loops, and continuous formation of new knowledge and proposals. In this process, concepts and artifacts that represent, structure, and communicate information become increasingly important.

When the problem space is set up, the participants can begin to create a shared language for communication and exchange, translate, and integrate their knowledge (Bruun et al., 2005). In such collaboration, several partial domains of knowledge meet, creating a new partially composed "blend" of "input spaces" (Hukkinen, 2008, p. 71) to act as a "mediation space" (Després, Brais, & Avellan, 2004, p. 475) or a "trading zone" (Nowotny, Scott, & Gibbons, 2003, p. 191; Gibbons et al., 1994) to reflect on the knowledge components in learning.
A similar concept is Vygotsky's (1978) zone of proximal development (ZPD), also identified as the space for expansive learning (Engeström & Sannino, 2010), defining the extent to which learning can occur. In our earlier study, this concept

was referred to as an "opportunity space" (Marttila & Kohtala, 2010, p. 175), and later as a "joint problem space" (Marttila & Kohtala, 2014, p. 456; see also Roschelle & Teasley, 1995; Sarmiento, 2009) or a "shared problem space" (Marttila, 2012, p. 1147). These concepts have differences, but they respond to the same challenge of understanding the co-creation of knowledge and collaborative learning (see Table 5). What results from this process is a new blended or hybrid knowledge that is qualitatively different from its partial inputs (von Ghyczy, 2003; as in Hukkinen, 2008, p. 65).

Table 5. *Different concepts of interprofessional problem/learning spaces.*

Concept name	Author(s)	Knowledge (co-)creation activity
Mediation space	Després et al. (2004)	Mediating collaboratively
Input space	Hukkinen (2008)	Translating knowledge
Joint problem space	Marttila and Kohtala (2014) Roschelle and Teasley (1995) Sarmiento (2009)	Inter-subjective meaning-making
Shared problem space	Marttila (2012)	Interprofessional meaning-making
Trading zone	Nowotny et al. (2003) Gibbons et al. (1994)	Trading information between participants
Zone of proximal development	Engeström and Sannino (2010) Vygotsky (1978)	The area within which collaborative analysis and modelling is possible (enabling expansive learning)

Source: Developed from Marttila, 2012

The sharing of cross-boundary knowledge is a cognitive process that happens through the use of analogies or pattern recognition. From each participant's input, the selective elements and relationships of "familiar input spaces" (Hukkinen, 2008, p. 71; as cited in Marttila & Kohtala, 2014, p. 455) are adopted in the construction of a new mental model. According to Bruun (2000; as in Marttila & Kohtala, 2014, p. 457), in interdisciplinary knowledge-making, the integration of information in a shared problem space may occur simply by one expert having access to another expert's data, or when concepts can simply be transferred from one discipline to another. Bruun (2000) refers to this process as epistemic translation.

In sum, in epistemic translation, the participants must be competent in their own disciplinary knowhow but also able to encounter and analyze another knowledge base, merge mental models, and construct new meaning and knowledge through synthesis and reconciliation (Marttila & Kohtala, 2014). At the same time, the activity requires certain social, participatory, and collaborative skills, devoted to the creation and maintenance of the shared problem space (Roschelle & Teasley, 1995). According to Sarmiento (2009), this twofold competence in analytic and social skills links with group cognition theory, which regards the dialectical relationship between social interaction and the construction of meaning as one of its central principles.

Skills for interprofessional collaboration

The two basic metaphors in interdisciplinarity are "bridge building" and "restructuring" (Klein, 2010, p. 21; see also Nuffield Foundation, 1975). Bridge building takes place when "complete and firm disciplines" interact (Klein, 2010, p. 21).[46] Restructuring, on the other hand, "detaches parts of several disciplines to form a new coherent whole" (Klein, 2010, p. 21) and takes place as ideas evolve, institutions and organizations develop, and people learn. In the process, the existing concepts are integrated into new ones.

Integration is also often discussed as the mode of learning in interprofessional collaboration (DeZure, 2010, p. 373), "connecting skills and knowledge from multiple sources and experiences," "applying theory to practice," "utilizing diverse and even contradictory points of view," and "understanding issues and positions contextually" (Association of American Colleges and Universities, 2004; as cited in DeZure 2010, p. 373). Schooneveldt (2010) identifies three (interconnected) processes of the integrative method in inter- and transdisciplinary meaning-making. In connection with analytic and synthesizing skills, these are 1) systems mapping; 2) context analysis; and 3) "jigsaw hypothesis formation" (Schooneveldt, 2010, p. 144).

Systems mapping denotes viewing the "problem area at various scales, levels and complexities" to "identify potentially relevant knowledge" (Schooneveldt, 2010, p. 144). In context analysis, the "contextual framework of core ideas" (and the "mindsets that created them") will be revisited and interpreted (p. 145). Finally, the "jigsaw hypothesis formation" refers to a process wherein freshly introduced perspectives can change the paradigm of meaning-making and what is considered valuable and meaningful. Such reciprocal reflection takes place between abstract concepts but is always assisted by various artifacts (e.g., tools, instruments, mental concepts, language). Hence, mediation in interprofessional collaboration happens between the understanding of the problem context and its existing setting, and the various instruments used in the activity.

In relation to the future professionalism and the necessary professional expert skills, one can make a distinction between "substantive skills" and "generic skills," the former with a "content specific and contextually situated" focus and the latter "transferable between different contexts" (Abrandt Dahlgren et al., 2005, p. 40). In summary, the skills for interprofessional collaboration include analytical, collaborative, and synthesizing skills. Whilst collaborative skills can be considered rather general (if not professionally implemented, as in designer-driven collaboration), and analytical skills perhaps common in academia and in any critical approach, synthesizing skills are (in the sense of this work) special to interdisciplinarity.

[46] In contemporary studies of social networks, "bridging" is a concept describing the transmission of information from one group (or disciplinary domain) to another (Marttila & Kohtala, 2014).

Table 6. *Skills in interprofessional collaboration.*

Multidisciplinarity	Interdisciplinarity	Transdisciplinarity
• Juxtaposing • Sequencing • Coordinating	• Integrating • Interacting • Linking • Focusing • Blending	• Transcending • Transgressing • Transforming
• Complementing	• Hybridizing	

Source: Adapted from Klein (2010)

Consequently, the necessary skills for interprofessional collaboration (see Table 6) include first of all the ability to identify and map each other's knowledge and perceptions in a given problem context, and to reflect this understanding on one's own. There also needs to be competence to focus, link, blend, and integrate this knowledge into new hybrid combinations (Hukkinen, 2008; Klein, 2010), represented in various artifacts. As a result, according to Klein (2010), the overall skills for inter- and transdisciplinary action can be categorized as hybridizing skills.

New types of knowledge

In contemporary epistemological discourses, knowledge as a concept can be connected with both theory and practice (Poikela & Poikela, 2005, p. 8). Theoretical knowledge refers to "propositional knowledge" relating to knowing-what, and practice-based and tacit knowledge[47] to "procedural," relating to knowing-how (Poikela & Poikela, 2005, p. 8). In a broad sense, this refers to "a debate between Cartesian finite and 'Heideggerian' changing knowledge," the former representing "the modern idea of permanent knowledge" and the latter "the post-modern way" of perceiving "knowledge as changing and dependent on the context of the activity" (Poikela & Poikela, 2005, p. 8).[48]

Christian Pohl and Gertrude Hirsch Hadorn (2007; see also Hirsch Hadorn et al., 2008, 2010; Wiesmann et al., 2008) categorize the types of knowledge involved in transdisciplinary collaboration and their components as: 1) systems knowledge — the analysis of complex empirical questions; 2) target knowledge — needed in defining goals to deal with problems better; and 3) transformation knowledge (see Figure 7; Marttila & Kohtala, 2014). The first connects with knowing-what, but the latter two move the emphasis increasingly to knowing-how. In their

[47] Tacit knowledge (Polanyi, 1966) refers to the notion that knowledge cannot always be adequately articulated by verbal means, only becomes only visible through practice in a particular context, and is transmitted through social networks (Schmidt & Hunter, 1993).

[48] According to *The Internet Encyclopedia of Philosophy* (Korab-Karpowicz, 2017), Martin Heidegger (1889–1976) was one of the most original, important, and controversial philosophers of the twentieth century. The Heideggerian critique of traditional metaphysics and "his opposition to positivism and technological world domination" is visible in the works of the leading theorists of postmodernity such as Derrida, Foucault, and Lyotard (Korab-Karpowicz, 2017).

thinking, the transdisciplinary knowledge must originate and be contested in real-world experiments and interaction.

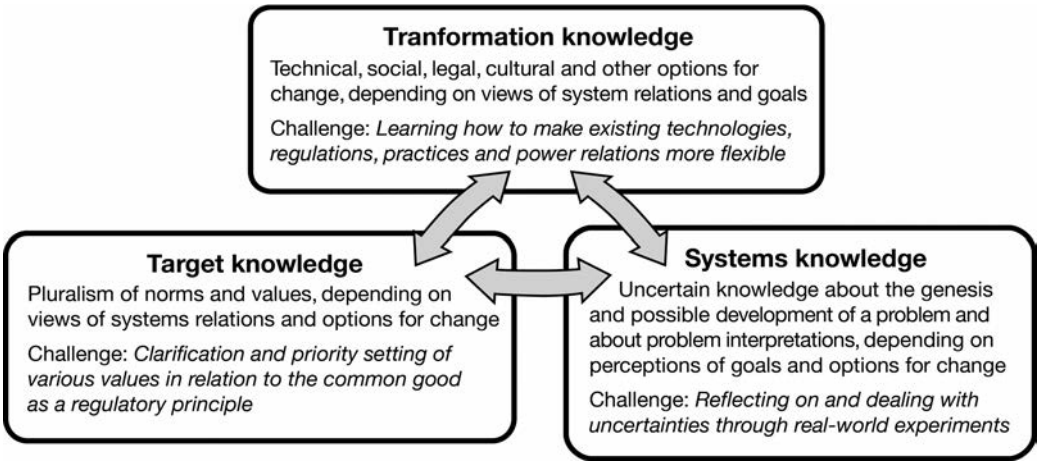


Figure 7. *Interdependent components of transdisciplinary knowledge.*
Source: Pohl and Hirsch Hadorn (2007, p. 38)

As a result, the knowledge in transdisciplinary work is often context-, problem-, and project-specific (relating to knowing-how) rather than universally applicable (knowing-what). In this respect, the knowledge (or a part of it) emerging from transdisciplinary design collaboration can also be described as Mode 2 knowledge (Gibbons et al., 1994) which transcends the "old paradigm of scientific enquiry" (i.e. Mode 1; see Nowotny et al., 2003, p. 179) by being socially distributed, application-oriented, and open for multiple non-hierarchical entries.

2.2. Design in Interprofessional Collaboration for Sustainability

Over the course of the twentieth century, a new academic discourse emerged with a focus on understanding the methods used in design and decision-making processes (see section 1.2.1). Gradually, the emphasis moved to collaborative activities, to support innovation and organizational and even social change. Interprofessional activities represent a "new alliance with government and industry for commercial innovation" (Bruun et al., 2005, p. 24). However, sustainable design also has to address the fundamental problems of our contemporary society and of modernity as its prevailing context of operation. Gradually, the ongoing criticism toward the technological (see, for example, Dickson, 1974) and scientific optimism (or even dogmatism: see Feyerabend, 1975) has led to responses in design; it has also laid the ground for contemporary theories on transdisciplinary design action.

As discussed, contemporary design studies have several connections with engineering and management studies (see section 1.2.1). Civil engineering and planning includes strategic policy-making and urban planning; mechanical, electrical, and chemical engineering can be connected easily to the contexts of production and use; and industrial engineering and process management is in many ways similar to industrial design.[49] While design schools can exist without engineering studies, there are numerous examples of design departments and schools at technical universities.

In the period following the Second World War, engineering education in the US "was retooled to address issues of national defense" (Culligan & Feniosky, 2010, p. 151) and engineering curricula became "more narrowly focused and technically specific." At the beginning of the twenty-first century, new global challenges like "climate change, ecosystem vulnerability, the growth of megacities, water scarcity, the globalization of market places, [and] clean energy needs" forced many engineering societies and educators to re-evaluate their role in the world (Culligan & Feniosky, 2010, p. 153; see also Duderstadt, 2008). The way was paved for the view that to better understand real world impacts of different technologies, the social focus should be integrated with the applied field of technology.

This is also a focal point where contemporary design activities can support engineering and management. By facilitating collaboration, visualizing and prototyping ideas, integrating perceptions and opinions into physical artifacts, and creating concepts for communication and comparison, the designer contributes as a matchmaker in a project team. As we conclude in our earlier work (Marttila & Kohtala, 2014, p. 461), "through iterative facilitation and interaction, a design approach (promoting design intelligence) can help solve the challenges of

[49] The first engineering schools were established already during the eighteenth century. In 1702, there was already a mining and metallurgy school in Freiberg, Germany (Culligan & Feniosky, 2010, p. 148).

sustainability in a truly transdisciplinary way" and promote development from "merely incremental (i.e. ecodesign) to innovative," even promoting "radical system changes."

2.2.1. Design and interprofessional collaboration

Design is a reflective practice (see Schön, 1983) with practical aims, where existing knowledge is iteratively reflected in emerging new problem contexts. Collaborative, transdisciplinary design dialogues (see Wahl & Baxter, 2008) are based on continuous mediation and learning. The emerging knowledge can be used to improve the collaborative culture; to develop better methods, tools, and instruments for interprofessional design education; and to improve practitioners' ability to self-enable and facilitate such co-creation processes. In this process, designers can act as the brokers in interprofessional and transdisciplinary meaning-making.

In an overarching setting of sustainability, the meanings of things are collaboratively mediated. In interprofessional and transdisciplinary design (as discussed in section 1.2.2), this denotes reflection on what is the problem to tackle and the materials to start with, how the process is conducted and managed, and why this action needs to be taken (reframing the problem-setting itself). The inquiry in such a transdisciplinary process, as suggested by Hirsch Hadorn et al. (2008, 2010; see Figure 8), consists of three, interconnected phases focusing on 1) problem analysis ("what" and "why"); 2) problem identification and structuring ("what" and "how"); and 3) bringing results to fruition ("how" and "why") (Hirsch Hadorn et al., 2008, 2010). These phases also connect with the three necessary knowledge components in transdisciplinarity, as described by Pohl and Hirsch Hadorn, (2007; see section 2.1.3), linking to systems knowledge, transformation knowledge, and target knowledge.

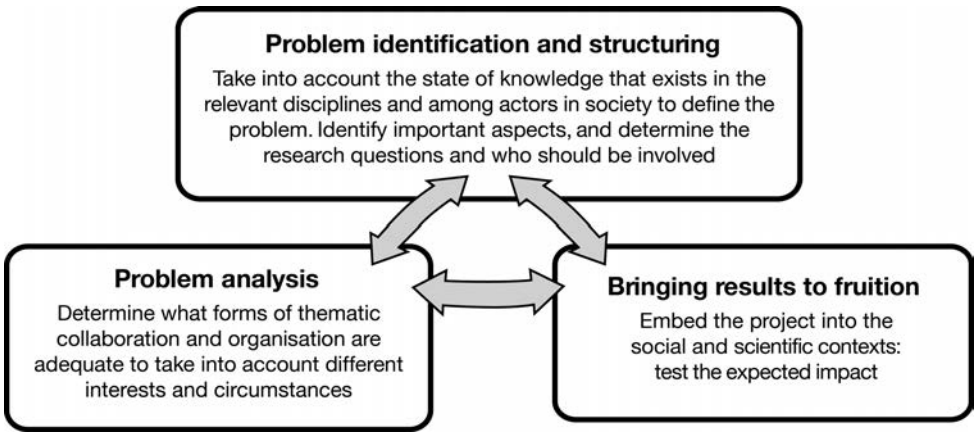


Figure 8. *The three phases of inquiry in a transdisciplinary research process.*
Source: Hirsch Hadorn et al. (2010)

As delineated in our earlier publication (Marttila & Kohtala, 2014) and in connection to design as a method for general problem-solving, contribution to the three phases entails specific design-relevant knowledge and knowledge components.

Framing problems with conceptual design mediation

The notion of frames and framing as a theoretical or methodological tool is applied in several different fields: the generalities of its use are clear. Frames and framing are where people introduce their "structures of belief, perception, and appreciation" (Schön & Rein, 1994, p. 23; as cited in Ylirisku, 2013, p. 49) into collaborative meaning-making. Frames have a familiarity with symbolic concepts (Ylirisku, 2013) and they connect to disciplinary meaning-making. Unlike abstract concepts, however, frames[50] are "woven into the materiality of a situation" (Ylirisku, 2013, p. 67) and have an effect on how a given problem is perceived.

In his research, Ylirisku (2013) defines generic framing strategies in conceptual design covering, for example, the use of "re-articulation" (and visual articulation), the "search for difference," the "enabling of participatory contribution," and the use of an "a priori scheme" (p. 223) to give initial structure for articulation (pre-framing). Besides studio practice, creative collaboration and its facilitation remain key ingredients in contemporary design action. Whereas the studio practice in design already emphasizes an iterative approach (see Schön, 1983), artifactual explorations, and the utilization of tacit knowledge (see Polanyi, 1966), the collaborative approach is furthering the expansion of inquiry.

Schön (1983, p. 40; as cited in Ylirisku, 2013, p. 45) describes how problem-setting is a process "in which, interactively, we name the things [as abstract concepts] to which we will attend and frame the context in which we will attend them." Traditionally, the philosophy of learning has regarded learning activity as the "acquisition of concepts" (Stables, 2013, p. 37). According to Stables (2013), concepts are "types of signs" (p. 37) but within a specific "semiotic system" (p. 44). This semiotic system promotes the sign to take precedence over the actual "concept" (that could be otherwise understood as neutral) both "epistemologically and ontologically" (Stables, 2013, p. 44). In design collaboration, however, working with concepts has a somewhat larger meaning than in other sciences. To a designer, any concept (a design concept even more so) is, from an epistemological viewpoint, a mere *suggestion* for solution by its nature, to be tested in reality and practice for any further validation.

Conceptual designing and the learning within it can be also assessed as project-specific learning (Ylirisku, 2013). A project as a concept can be defined as being "timely-bounded intentional resourceful work to attain a goal" varying from "sub-second tasks to multi-year efforts" (Ylirisku, 2013, p. 82). Furthermore, projects can be considered to consist of sub-projects and of a hierarchical order that relates to goals, division of labor and expertise, and chosen focus (or foci).

[50] For Bateson (1972), frames are connected to how contexts are interpreted as messages of meaning.

According to Ylirisku (2013, p. 216), the design concepts created in projects are "grounded in preliminary work" and thus the understanding of this phase of work becomes crucial. Ylirisku (2013, p. 216) calls this preliminary phase "priming," defined as "the construction of things-to-deal-with in the project." In the cases he studied, the designers seemed to be employing this priming "strategically" as a "situated exploration of the things-to-deal-with" (Ylirisku, 2013, p. 216). Ylirisku (2013, p. 216) notes how the "collaborative construction" of the semiotic resources is a "crucial phenomenon" at the beginning of the activity. Hence, priming can be understood as a beginning for a pre-framing process in which the common structures of interpretation and interaction are negotiated.

Creating the foundations for interprofessional and transdisciplinary design collaboration calls for collaborative setting of the problem space. Not only design activity, but the priming and pre-framing, too, must be collaborative. In the *Oxford Handbook of Interdisciplinarity* (Frodeman et al., 2010), Mansilla (2010, p. 289) proposes a "pragmatic constructionist view" (see pragmatism in section 2.1.1) as an "epistemological foundation" for interdisciplinary learning. Such an epistemological framework has to be "pluralist in its capacity to account for multiple forms of disciplinary understanding," "relevant" in its attempt to integrate perspectives, and must "explain how knowledge advances," including "some form of knowledge quality assurance" (Mansilla, 2010, p. 294). Hence, the integration of various types of knowledge must be addressed at the beginning, along with the potential resulting changes in the processes and outcomes of work.

To facilitate transdisciplinary meaning-making, we need a "transdisciplinary language" of "concepts and models" (François, 2006, p. 618). Consequently, for a designer as the facilitator of collaborative, interprofessional, and transdisciplinary interaction, this approach entails specific competence. This involves 1) contextual, conceptual, and system mapping (analytical skills); 2) facilitation skills such as in co-design practice[51] (e.g., probing, scenario building, collaborative mapping, etc.); and 3) skills for integrating and synthesizing the outputs into hybrid forms (see Hukkinen, 2008), embodying them into supportive objects and activities.

Approaching problems of sustainability with design

Sustainable design is possible only if the unsustainability in real life is first understood appropriately and the problem context is further defined (Clune, 2009). Acquiring robust systems knowledge, however, is challenging, requiring strategies to deal with uncertainties regarding the problem and its development, as well as the perceptions of goals and options for change (Marttila & Kohtala, 2014). Design is "an exploration of how things come into being and act" (Fry, 2008, p. 12): such understanding is a crucial part of the professional design intelligence (Fry, 2008). And yet, according to Fry, this design intelligence must be distinct from the mere "process, product and expression of a professional practice" of design (Fry, 2008, p. 14), also addressing the important values and visions in the collaborative meaning-making process.

[51] For further details, see, for example, Sanders and Stappers (2014).

To change the unsustainable course of our modern (often industrialized and thus commercialized) design practice, the focus of our action must be the ontological foundations of design activity, and refining (and redirecting) its processes to support more deliberative participation and planning. The ontological character of design means in a sense the design of design (Fry, 2008, p. 34). What this ontological character of design brings into the discussion is not the same thing as "crude deterministic materialism, environmental conditioning or the determinism of 'economic rationalism'" (Fry, 2008, pp. 34–35), but instead something related to the way — and to what kind of — knowledge is developed in and through the process.

As a result, to change the course of design practice and in becoming a redirective practitioner (see Fry, 2008), it is required to involve oneself in critical thinking and in the acquisition of new knowledge. Without the consideration of the ontological roots of the design practice, its bringing into "a regime of responsibility" is impossible (Fry, 2008, p. 55). In the process, the "professional and political alignments" (Fry, 2008, p. 55) also have to be opened up, assessed, and iterated. Consequently, in this approach the design action can also be understood as politics (Fry, 2010).

2.2.2. Expanding interprofessional meaning-making with design

Interprofessional activities take place within specific problem contexts, and they combine specific combinations of professionals that, despite in being in constant change, carry knowledge from a context to another. Around each inquiry that emerges and connects outside to other interested parties, a shared problem space is created. In multidisciplinarity, this space acts merely as a meeting place and a way to coordinate collaboration. In interdisciplinary collaboration, however, this problem space acts as a platform for collaborative orientation in the meaning-making taking place between several professionals. In transdisciplinarity, it can act as an agent of change in transforming the societal practices and landscape.

The components in interprofessional meaning-making and transdisciplinary design reasoning — the inquiries on what, how, and why — also connect with the three components of transdisciplinary knowledge (Pohl & Hirsch Hadorn, 2007; see section 2.1.3). In respect of these three types of knowledge, the design professionals can provide their personal and disciplinary perspective and input regarding target knowledge and transformation knowledge. In relation to systems knowledge, the designers can increase its adaptability and attune it better according to stakeholder interests, to promote the creation of systems intelligence (see Saarinen & Hämäläinen, 2010) that utilizes a combination of expert and lay input. This interplay takes place within the domains of knowledge-making, decision-making, and awareness-making (Figure 9).

Figure 9. *Meaning-making in a collaborative, interprofessional, transdisciplinary design process.*

Source: Author

In expanding this process with design action supporting interprofessional, transdisciplinary meaning-making, new ideas on knowledge-making are introduced at the beginning of the process on which the interaction builds, acting as hypotheses to be tested in future action. These can be, for example, theories, models, topics, or experiments. In implementing interaction, new ways of decision-making come into focus, as the transdisciplinary process needs to be collaboratively constructed and evaluated, not only between different departments and disciplines, but also between various actor groups inside and even outside the university. Lastly, new types of awareness-making support experiencing and connect learning to the future development and action.

At the same time, we have arrived at a point where it is clear that we have "competing, even conflicting, interpretations" (Jamison, 2001, p. 28) of sustainability. These perspectives can be located "on a continuum between two opposing poles" (Jamison, 2001, p. 28; as discussed in section 1.2.3). One pole is optimistic, progressive, and business-oriented, and, in some of its variants, has been characterized as signaling a new stage of modernity (e.g., Giddens, 1998). The other is critical, often pessimistic, and tends to question the very idea of modernity and the "myth of progress that is so central to modernist thinking" (Jamison, 2001, p. 28). Hence, an essential step in any action for sustainability is to expand the collaborative meaning-making to challenge these views and to seek intermediary grounds for further action.

Interprofessional meaning-making consists of inquiries into epistemology, ontology, and ethics. The utilized knowledge originates in several domains and is possibly incommensurable (see Feyerabend, 1962; Kuhn, 1962). The knowledge, connecting with understanding regarding the system, goals of action, and the possibilities for transformation (Pohl & Hirsch Hadorn, 2007), is then

collaboratively and iteratively reflected upon, and structured and reconnected. This heterogeneity extends the epistemological perspective (What counts as knowledge?) into the ontological (What type of relations can take place with it?); and as interprofessional, transdisciplinary meaning-making calls for value-sensitive interaction (more so in the context of sustainability), ethics also come into play.

Expanding meaning-making for transdisciplinary sustainability

The question "How are we to live?" connects with the inquiry of "How are we to know?" (Russell, 2010, p. 31). Epistemology, as the theory of knowledge, is interested in what counts as knowledge. Ontology, on the other hand, studies "structures of reality" (Pikkarainen, 2013, p. 51) and the hierarchies and relations that take place within them. It is "the most general area of metaphysics" (Pikkarainen, 2013, p. 51) and can be approached through debates "between doctrines such as idealism, materialism and dualism" (Pikkarainen, 2013, p. 55). In addition, as ethics as an area of metaphysics is interested in how things or their theoretical relations become manifested in our human society, it is also very much involved in interprofessional and transdisciplinary collaboration (Balsamo & Mitcham, 2010, p. 259).[52]

Brown (2010c, p. 287) suggests that in transdisciplinarity, the main challenge is the establishment of an "open transdisciplinary inquiry" (cf. Russell, 2010) in which a "critical inquiry accepts an open ontology, an open epistemology and a transparent ethic" (Brown, 2010c, p. 287). Attention must thus be paid to values and stakes at all stages of the process, which on a practical level requires adequate time and on a facilitation level requires reflexive processes that build "value-consciousness" among participants and researchers (Wiesmann et al., 2008, p. 438; as cited in Marttila & Kohtala, 2014, p. 457). As a result, the facilitation of such collaboration calls for a more sensitive approach, also addressing "the emotional aspects that stem from the ontological challenges" (Beard & Mälkki, 2013, p. 30).

Expanding knowledge-making

Problem-solving for sustainability calls for transdisciplinary knowledge, but not all knowledge is considered equally valuable. Participants that are involved with transdisciplinary design processes can be stuck in their existing professional perspectives and must potentially challenge their epistemic traditions, including their understanding of important knowledge and facts. Furthermore, reflection is needed on cultural and personal presumptions. Sustainable design requires collaborative action that supports progressing boundary crossing, supported by artifacts and concepts as products of the hybridization process. The required transdisciplinary design dialogue (Wahl & Baxter, 2008) aims at iterative, continuous improvement in understanding. At the same time, the scope of activity is expanded outward from professional practice into the everyday world.

[52] Examples of applying ethics in interprofessional collaboration involve, for example, "bioethics and nuclear ethics," "environmental and computer ethics," and "professional ethics of engineering and science" (Balsamo & Mitcham, 2010, pp. 262–266).

In the process of epistemic translation (see section 2.1.2), the participants present their reasoning to others and consider changes in their individual and shared mental structures. Such translation activity is also largely dependent on tools or instruments that can help to expand the shared object. These collaborative "design things" (see A.Telier, 2013) may also later on help in expanding the scope of activities toward transdisciplinarity. Hence, the process and its setting must be: 1) open for several perspectives; 2) sensitive toward different values; 3) transparently and iteratively managed and facilitated; and 4) supported by appropriate tools and conceptual artifacts. Lastly, as in our contemporary knowledge society, the knowledge products are "increasingly valued" (Nowotny et al., 2003, p. 182), and modernity as a context of operation also connects this with interpretative power, expanding knowledge-making is also 5) raising questions on ownership and power.

Expanding decision-making

The processes in making decisions (decision-making in the context of this inquiry) are often different from those involved in problem-solving (Schooneveldt, 2010). In decision-making, good solutions "are [often] found to be problematic later" and several solutions simply "cannot be applied" (Schooneveldt, 2010, p. 143). Furthermore, decision-making often involves "serious time constraints" (Schooneveldt, 2010, p. 143). The "complex institutional arrangements" that are often "dominated by privileged vested interests" (Schooneveldt, 2010, p. 143) hinder development in decision-making processes, and are also often slow to admit mistakes. As a result, according to Bratteteig and Wagner (2012, p. 47), "central to the understanding of design decisions is the concept of power."

According to Bratteteig and Wagner (2012), the exercise of power in participatory design happens on several levels. It connects to "conceptualizing power," "structuring dominance and order in organizations," and acting as a way "in which certain actions modify others" (p. 47). It also connects to the "sharing of power," and several participatory design methods "have been devised to facilitate this sharing," to share the "transformative capacity" as a team (p. 47). Thirdly, there also exists "power related to the decision-makers" that relates to the roles and responsibilities in the process that different people have, and power exercised "in different kind of decisions" relating to the "mutual recognition" of "interpretations" regarding decisions (p. 48). Finally, the exercise of power connects with the "materialization of decision-making" in relation to the artifacts that are in use to convey meanings or represent analogies (p. 49).

Nevertheless, not only the perceptions of the structure of decision-making, but the activities that are implemented, the extent of sharing, the actors that are chosen, the interpretations that are allowed, and the artifacts that are connected to the process also all connect to the design of the process. In the context of sustainability, these areas call for further reflection.

Expanding awareness-making

Design practitioners attach messages and signs to things and could thus provoke people to think about their consumption practices further. Today, a growing number of designers are involved in societal activities and movements. Concepts such as design activism (see Fuad-Luke, 2009; Thorpe, 2008) and critical design (Dunne, 2005) refer to a need to take a more proactive role in relation to the surrounding society (see section 1.2.2).

In design practice, the attached meanings that help to create an "understanding of the function" are helpful in facilitating "a re-cognition of the product," and this applies also to societal functions for artifacts, be they personal or not. This, in turn, positions design in the "interplay between tradition and transcendence" (Ilstedt Hjelm, 2002, p. 10) and between the creation of societal practices. In this respect, design activities have the power to make things visible, to stand out from the white noise of the everyday (Fuad-Luke, 2009), and to question the mainstream landscape promoting the scaling-up of new ideas of development (in connection with transition management; see Geels, 2002).

In transdisciplinarity, awareness-making takes place both outside and inside projects, as well as outside and inside the design process in connection with other areas of meaning-making. In essence, all three are connected and remain connected in the process of mediating meanings with design. Sustainability as a context for design action must stretch this mediation further, from constrained to open, from hierarchical to networked, and from individual to participatory.

Amongst contemporary academia and practice, there is still "confusion" between multidisciplinary juxtapositioning and interdisciplinary integration, and in regard to "transdisciplinary transcendence" in relation to whether to "serve or critique society" (Briggle & Christians, 2010, p. 231). In the context of sustainability, however, this critical emphasis in interprofessional meaning-making expands further.

2.2.3. Design for transdisciplinary sustainability

Transdisciplinary research can be identified as a "label" denoting "collaborative research and problem solving that cross both disciplinary boundaries and sectors of society" (Bruun et al., 2005, p. 31). In a transdisciplinary process, expert and lay knowledge and perceptions merge and form a new type of transcendent understanding around a given problem context and system of interest. The sources of knowledge in transdisciplinarity are thus heterogeneous, deriving from various fields such as the natural sciences, social sciences, lay actors, and various sectors.

In summary, expanding the meaning-making for transdisciplinarity calls for expansion amongst the three general dimensions, knowledge-making, decision-making, and awareness-making. Furthermore, within these domains of action, common issues call for focus. These are 1) the need for opening processes for

networking, sharing, and collaboration; 2) increasing the value sensitivity in such participative processes; 3) managing and facilitating them in a transparent manner (in relation to ownership and power); and 4) inducing dialogues supported with design artifacts (e.g., tools and instruments, concepts and language, rules and roles).

Transdisciplinary design dialogues, implemented through various project collaborations open to the wider public, can help to introduce more qualitative considerations regarding "whole-system health, happiness, well-being, meaning, and quality of life" (Wahl & Baxter, 2008, p. 83) into decision-making and design processes. Collaboration in interprofessional and transdisciplinary design projects (see Blunden, 2009, 2010) can offer a context to mediate on the concepts of sustainability with various experts and other participants. To promote such inquiry, however, the focus in design action must be drawn to activities that facilitate a wider exchange of perspectives and thought, being able also to induce transformations with the general public.

Designing transdisciplinary platforms for sustainability

One crucial step in any action for transformative sustainability is to create platforms to support and expand collaboration across expert fields, but also across other interest groups and interested citizens to induce transformation (see Figure 10). These may be projects or other collaborative constellations of work that connect with specific stakeholder contexts and communities.

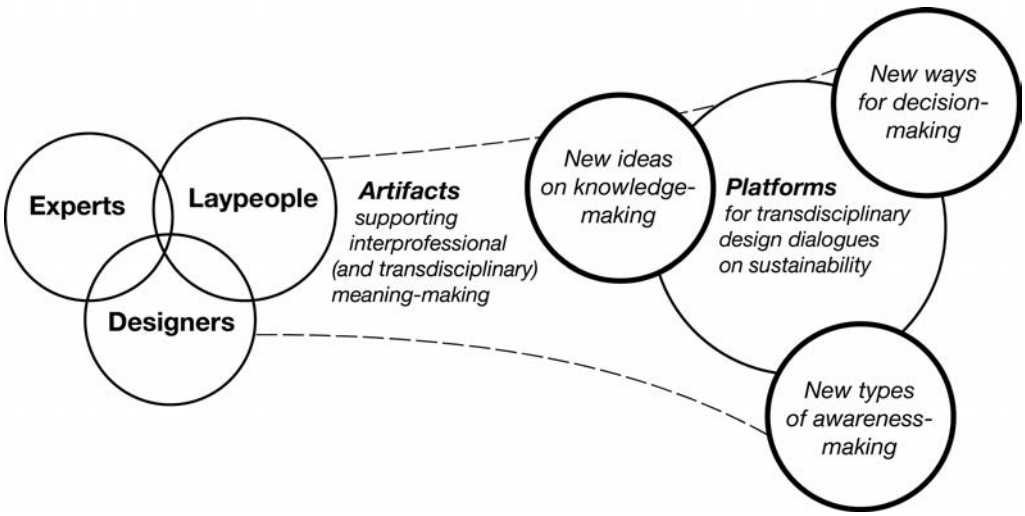


Figure 10. *Creating platforms for transdisciplinary meaning-making and action.*
Source: Author

Project-specific learning can be analyzed on "dramatically different levels of duration" (Ylirisku, 2013, p. 83) but also with a focus on very different units of analysis. According to Blunden (2010), projects can be perceived as "aggregates of artifact-mediated actions, which are always directed or mediated by relations to

other people" (p. 10). As a result, Blunden (2009, 2010) proposes that we join two concepts — project and collaboration (they are "in any case mutually constitutive") — as a "new unit of analysis," to form the new theory on activity (Blunden, 2010, p. 10). These two concepts also emphasize shared premises and sets for framing (see Bateson, 1972). These two aspects become the two main aspects to consider in developing transdisciplinary activities in general.

In inter- and transdisciplinary learning, the important components are collected from the participating actors. By identifying collaborative interests and finding the shared tools and concepts, the collaboration can proceed. The problem of such a reduction, however, is that it may fail to identify valuable information or aspects of the process. As a result, research and action on transdisciplinarity calls for expansive meaning-making and open collaboration. These features help it to transcend from the modernist setting and stagnated institutional, conceptual (i.e., models) or disciplinary structures and processes that resist transformation.

In the context of sustainability — to challenge its modernist contradictions — the role of design should aim higher, toward changes in "worldview, intention, and lifestyle, facilitated by dialogue and education" (Wahl & Baxter, 2008, p. 80). For the still mainstream modern consumer design in which meanings of things are hidden in rational and scientific or desirable and fashionable representations that prove to be shallow or even contradictory at closer inspection, the introduction of postmodern fluidity — if accompanied by critical thinking — adds pressure to extend the mediation in each dimension of design reasoning, to embrace the contemporary networked reality. If we perceive design action involving the interplay between "things and words, distinction and recognition, sharing and innovating" and "object and context" (A.Telier, 2013, p. 76), then its focus must be on existing human practices. From this viewpoint, supporting such an approach to design action, creation is where "participants can access, modify, align, and navigate the constituents of an object, and when needed, expand and contract it" (A.Telier, 2013, p. 76), and at the same time share existing and constitute new knowledge.

In summary, the aim of sustainable design should be to create the supportive approaches, strategies, methodologies, and contexts that enable better awareness, more informed collaboration, and more reflective interaction, with a wide public audience and several stakeholder groups, co-aligned under a new direction. This is where design action, if critically approached, can contribute. Overall, design education and practice seem to offer several invaluable components to both interprofessional work and sustainable transformation. However, questions have been raised on how well sustainable development addresses the underpinning conflicts of modernity (see, for example, Wironen, 2007) in approaching development and human progress. Similar voices have been raised to address design education as a whole (see, for example, Michl, 2014). To understand what might be a more sustainable approach to education and development, we must look into what constitutes education for sustainability. This moves the focus on contemporary design education and the setting of its contents.

2.3. Learning Design for Transdisciplinary Sustainability

In general, academia refers to an environment or community concerned with research, education, and scholarship, or a society or institution of distinguished scholars, artists, and/or scientists existing in a particular field. The two main roles for contemporary academia have traditionally been academic research and higher education (Nieminen, 2004). In Finland at the beginning of the new millennium, there was discussion, as well as actual changes in legislation, to add a third role for Finnish universities: creating practical knowledge for the use of our society (Nieminen, 2004). From the universities' point of view, this third role is a perspective to adopt when studying activities from an economic or societal point of view (Hyvönen, Saarela, & Marttila, 2014). Such a role emphasizes knowledge production for society around existing problems and projects, calling for stronger connections between research and education, extending to other professionals and to laypeople.

Yet, as of today, these roles have continued to change at a fast pace as more and more new knowledge is created outside universities, and universities themselves are being challenged by concepts like life-long learning, online learning outside the classrooms, open source information, and societal and business collaboration in general. As the challenges of sustainability call for more distributed, local-based, case-dependent, and network-structured knowledge and interaction, real-life stakeholders and businesses play a key role in inducing innovations, especially toward more sustainable consumption and production patterns (see, for example, Vezzoli, 2007; as in Hyvönen et al., 2014). If properly educated, designers can contribute to this process.

Allan (1996) differentiates three competences which university education should develop, consisting of "disciplinary competence," "transferable and generic skills," and "academic competence" (Nummenmaa et al., 2005, p. 53). Both transferable and generic and academic competences are connected to "critical thought, reflection, knowledge management, and cooperation and communication skills"; as professional skills, these can also be identified as "very close to the qualifications of experts" (Nummenmaa et al., 2005, p. 53). Sustainability as a context connects this process with real-world practice. Hence, the best way to learn sustainability is "in collaborative and interprofessional teamwork that simulates what they will experience in working life and involves them in real-life projects and problems" (Marttila & Kohtala, 2014, p. 453). This furthers the inquiry, however, to "pedagogical implications of teaching [...] in new types of interprofessional and transdisciplinary learning platforms" (Marttila & Kohtala, 2014, p. 453).

2.3.1. Redefining science-making for interprofessional sustainability

As the contemporary world is driven by disciplinary professionalism, many of its structures and practices are developed in education and in professional work. As

discussed, scientific activities and their practical applications take place in networked constellations of communities that are connected on different institutional, social and personal levels (see section 2.1.2). Amongst such communities, bias might be introduced within the context of the activity. At the boundaries, these disciplinary assumptions on knowledge-making and action may become barriers to integration.

The epistemic views induced by cultural, disciplinary, and personal background affect the way one perceives and rationalizes the world. In a transdisciplinary process, however, the concept of disciplines might prove to be problematic, as these may be hard to define clearly. As discussed in our earlier publication (Marttila & Kohtala, 2014), several experts on interdisciplinarity highlight that the concept of disciplines itself is problematic, as differences between specializations within one discipline (within different communities of practice that link to it) may be greater than the differences between disciplines themselves (see, for example, Bruun, 2000). Another approach is to refer instead to epistemic communities and especially "epistemic frameworks" (Bruun, 2000, p. 29). The concept of the epistemic approach, framework, or tradition remains important because interdisciplinarity requires the integration and synthesis of knowledge and frameworks that meet in an epistemic encounter between the actors (Bruun, 2000; as in Marttila & Kohtala, 2010, 2014). However, because science and higher education are still organized into disciplines, which themselves are defined according to both epistemic contents as well as processes of institutionalization and professionalization (see Després et al., 2004), this research (in line with our earlier publication; Marttila & Kohtala, 2014) will nonetheless refer to disciplines.

According to Bruun et al. (2005), the hierarchical model of scientific knowledge production (see section 2.1.3) embraces the idea that "science evolves through branching into distinct, semi-autonomous fields of enquiry" (p. 35). The idea is that science develops similarly as a tree branches, from a root of "historical background" and a trunk of "shared norms" (Bruun et al., 2005, p. 35). Such branching, however, may lead to isolation, or to "academic tribes" around "disciplines, sub-disciplines, fields, specialties and problem areas" (Bruun et al., 2005, p. 36). Furthermore, in ANT terminology "the scientific method was black boxed in the sociology of science until Kuhn (1962)" (Cressmann, 2009, p. 6).

The contesting model for knowledge production — the rhizome model based on the idea of interaction between paradigms and their respective practicing communities (see Feyerabend, 1975; Kuhn, 1967) — perceives scientific progress as more organic, more networked, and more independently guided, analogous to the subterranean stemming of plants.[53] The rhizome model understands academia as characterized by "constant, uncontrollable flows of information and perspective formation" which "transgress disciplinary boundaries all the time (Bruun et al., 2005, p. 45). It questions the whole concept of disciplines and its essence as a hierarchical structure.

[53] In botany and dendrology, a rhizome is a stem of a plant sending out roots and shoots from its nodes.

To create contrast with the hierarchical model, and to support a broader spectrum to understand the dynamics of science, Bruun et al. (2005) propose the rhizome model as more suitable for contemporary scientific knowledge production. According to the authors (2005, p. 49), the "crucial difference" between the hierarchical and the rhizome model is that whereas the former emphasizes a "disciplinary set of rules" and the "re-production of those rules," the latter focuses on emerging "knowledge connections" rather than "disciplinary essences" that guide their formation. However, both of the discussed models "identify real tendencies in scientific knowledge production" (p. 45) and thus "capture two different aspects of reality" (p. 57). Hence, a balanced view between them is needed.

Potential and barriers of inter- and transdisciplinarity

In approaching interdisciplinary research in an academic context, "there are conflicting views [...] ranging from promotional rhetoric to inflated claims" (Bruun et al., 2005, p. 21), and yet it has become "a major topic in discussions of knowledge production" and organization (e.g., in "funding"; Bruun et al., 2005, p. 21). Furthermore, the evidence of inter- and transdisciplinary activities transforming academia remains thin (Stehr & Weingart, 2000, p. 43). The "commanding role" of universities in the "core of knowledge production" and the role of disciplines "as their organizational structure" remains uncontested (Weingart, 2010, p. 13).

In their study on interdisciplinary research policies at the Academy of Finland, a Finnish state-funded science and science policy expert funding national and international research projects,[54] Bruun et al. (2005, p. 5) identified several barriers to interdisciplinary research, ranging from "genuinely scientific" to those cultural and institutional in nature. From the scientific perspective (i.e., the hard science approach), some theories and methods might be "very difficult to integrate," whereas the "socially constructed conventions" bring forth questions of institutions and ideology (Bruun et al., 2005, p. 5). Further on, besides disciplinary tradition and practice, the different personal histories and support by management play a key role.

According to Bruun et al. (2005, p. 60) specific barriers to interprofessional collaboration and integration (as listed in Marttila & Kohtala, 2014) include:

- Structural barriers, concerning the organizational structures within science, academia and policymaking.
- Knowledge barriers, concerning the "lack of familiarity" towards other disciplinary fields.

[54] The Academy is an agency within the administrative branch of the Ministry of Education, Science and Culture in Finland. It aims to strengthen the position of science and research, emphasizing the "impact of research and breakthrough research by encouraging researchers to submit boundary-crossing applications" (see http://www.aka.fi/en-GB/A/Academy-of-Finland/.

- Cultural barriers,[55] regarding different "cultural characteristics" of a specific field, "particularly the language" and "differences in values."
- Epistemological barriers, caused by differences in interest and worldview between disciplinary fields.
- Methodological barriers, resulting from different "styles of inquiry" confronting each other.
- Psychological barriers, arising when people perceive their "intellectual and emotional investments" around their current practice at risk.
- Reception barriers, relating to communication and perception with the outside society.

Overall, the three first barriers can be perceived as the primary challenges, as the four latter are only able to be met when the interdisciplinary collaboration has already begun (Bruun et al., 2005). For example, only after gaining familiarity with another field (knowledge barrier) and understanding the basics of its culture of practice (cultural barrier) can the dialogues around epistemology and methodology begin. And yet conceptual barriers can also be perceived as more influential than institutional and social barriers (Lawrence, 2010, p. 27), as institutional and social barriers "reflect and reinforce" the conceptual ones. In assessing interaction between several disciplinary bodies in an academic context, these barriers also point to possibly emerging conflicts in interaction (cf. CHAT contradictions; see section 3.2.2).

Interprofessional design collaboration arrives at the epistemic borders of collaborating practitioners, and integration of knowledge in general is needed. This integration of perspectives, however, can also be perceived as a solution of modernity, whereas in approaching sustainability, variability (cf. Milovanovic, 1995) and heterogeneity need to grow in importance. As a result, a due respect and understanding for various epistemic inputs and ways of working is needed. Consequently, to improve the framework for integrative, interprofessional education, the following questions should be answered (developed from Hirsch Hadorn et al., 2010, p. 448):

- Integration for what and whom? What is tackled and who benefits?
- Integration of what? Who, and what perspectives, are involved in the system and interaction?
- What is the context? Is a political or other context for action influencing priorities and behavior?
- Integration by whom? Is the process of synthesis and analysis collaborative, and at what phase of problem-solving do collaborators interact?
- How is the integration undertaken? What are the methods and do they support the agenda?
- What are the measures of success?

[55] The notion of culture is often referring to the disciplinary culture, but may be considered also to cover the national background with similar implications.

The best practices of interdisciplinarity are still measured by disciplinary competence (Huutoniemi, 2010); as a result, initiatives integrating several disciplinary views might be perceived as risky. The integration and creation of new knowledge at the boundaries and between disciplines may be perceived to lack scientific value and rigor (Bruun et al., 2005, p. 38). There might be a fear that the disciplinary core is lost. Furthermore, inter- and transdisciplinary activities can also be criticized for drawing energy from "building on the methods and findings of established fields, or on their integration" (Huutoniemi, 2010, p. 315). Lastly, proactive transdisciplinary activities connecting university research to societal development might simply be perceived as either meaningless (if one considers science to guide practice anyhow, or pays no attention to it) or dangerous (if one considers transdisciplinarity to have the power to change institutions).

Despite the fact that disciplinary proficiency is the only way to measure interdisciplinary success (OECD, 1998, p. 18; as cited in Huutoniemi 2010, p. 311), as long as disciplinary expertise is understood "as the key measure of quality research," the use of it as a concept may also induce further separation of disciplinary trajectories and thus lead "towards the fragmentation of research, failure to communicate across disciplinary boundaries, and the separation of epistemology from politics" (Huutoniemi, 2010, p. 315).

2.3.2. Learning interprofessional, transdisciplinary sustainability

As explained, whereas modernity has been portrayed as a promise that progress is for the better, in contemporary postmodernity, this constant process of rationalization has become the status quo, rendering the concept of progress obsolete and making various metanarratives of progress defunct (Lyotard, 1983). In this sense, sustainable design — as well as its educational programs — becomes challenged in the modernist setting. While it can aim to "improve the machine," it still works under the growth policy that emerges from modernist thinking and is located between its dichotomies between human and nature and the "developed" and "underdeveloped" contexts. To tackle this challenge, ways of teaching and learning are brought into focus.

Throughout the existence of classic, institutional education, classroom education has been most constant (Miettinen, 1990). In approaching education in a positivist sense and from an institutional perspective, its purpose can be perceived to be simply to produce graduates with a given skill for a given profession and practice, and new knowledge through research. The process of learning might be considered as simply "banking" information in a blank mind (Freire, 1970), and the process of creating knowledge as a linear progression. This approach, however, has also been widely criticized (see, for example, Feyerabend, 1975; Freire, 1970; Illich, 1970). Instead, contemporary pedagogies often have a constructive emphasis.

In general, contemporary approaches to design education can be perceived as constructivist: not only is existing knowledge gathered, but new knowledge (and

new types of knowledge and meaning) is created. At the same time, however, as an approach to problem-solving, this process can be perceived in a positivist sense: a problem has been identified, it will be reflected upon, a resolution arises, and a new, iterated problem emerges (cf. Popperian model; see section 2.1.1). In the context of sustainability, however, this process expands into new disciplinary areas of interest and different levels of focus on impacts and outputs. The collective learning cycle for transdisciplinary sustainability (Brown, 2010a) addresses questions like "What should be?" "What is?" "What could be?" and "What can be?" These, in turn, relate correspondingly to "ideals, facts, ideas and actions" (Brown, 2010a, p. 61). In summary, sustainable design as a concept challenges the conventional setting for teaching and learning both inside and outside academia.

Academic education aims to reach the highest levels of learning. Bateson (1972) studied how an organism in its setting learns, and how such interaction evolves from a systems perspective. He identified four distinctive levels of learning (as discussed in Ylirisku, 2013, pp. 70–72) that can be described as:

1. "Zero learning": a coherent recognition of a stimulus.
2. "Learning I": more adaptable and flexible recognition able to see analogies across several different examples.
3. "Learning II": an ability to recognize categories and categorize experiences.
4. "Learning III": to choose to act according to different principles as a strategic skill.

In the context of sustainability, students learn to reflect collaboratively and critically on the concept of sustainability itself, along with the implications that different perspectives on our world bring about, developing collaborative meaning-making in an expansive learning process. Engeström and Sannino (2010, p. 5) describe Bateson's "Learning III and the associated concept of double bind" as a more recent "theoretical root" of expansive learning. In practice, its process calls for interplay between the shared context of action (and the tools and knowledge within it) and the participants (personal and professional skill). Such a "double bind" between physical artifacts and abstract meaning-making (as elaborated in section 2.1.2) can be associated with all collaborative, expansive learning (see Bateson, 1972; as in Engeström & Sannino, 2010, p. 5), in which the abstract concepts are taken into interaction together with the physical and material world at large.

Whilst Freire's (1970) "banking education" can easily be described as mere "zero learning," interprofessional collaboration — by introducing several competing analogies to a subject matter — emerges toward "Learning I" and "Learning II" in Bateson's (1972) terms, and transdisciplinarity toward "Learning III," with its focus on real-world action and learning through the actual use of acquired skills. In many ways, education for sustainability (ESD; see section 1.2.3) suggests a similar expansion in respect to learning.

Pedagogies for interprofessional learning for sustainability

Progressive education is a movement from late nineteenth century education that culminated in many ways in the work of John Dewey, an American philosopher and psychologist who addressed education and learning in relation to experience rather than social class.[56] Progressive education bases itself on experience in practice, with an emphasis on learning by doing and collaboration in learning. In progressive education, both knowledge and the processes for its production are collaboratively constructed. While progressive education still remains outside the mainstream pedagogy in contemporary academia, in relation to transdisciplinary sustainability its principles can again be identified as important.

In the view of progressive education, the environment for learning represents "the total social set-up of the situations" (Dewey, 1938, p. 45; as cited in A.Telier, 2013, p. 27), including both physical and social experiences and qualities. According to A.Telier (2013, p. 28), these qualities include 1) "materiality and the diversity of representations, creative density and connections"; 2) "narrativity, reprogramming, and dimensionality and scaling"; and 3) "configurability." In a sense, these could also be described as artifacts, rules, and roles. In the learning process "characterized by what Dewey called *learning-by-doing*" (A.Telier, 2013, p. 28; italics in original), these qualities become increasingly important.

Interprofessional, interdisciplinary education has to host "powerful pedagogies" to inspire and enable teachers and students to "grapple effectively with the complexity of problems we face" (DeZure, 2010, p. 384). Critical and radical pedagogy find their theoretical roots in the "neo-Marxian critical theory of the Frankfurt School" (Senteni, 2007).[57] The work of Paolo Freire, communicated nominally in his book *Pedagogy of the Oppressed* (1970), is "the most famous example of application of this school's critical theory" (Senteni, 2007). In studying *Pedagogy for the Oppressed*, Freire (1970) discovered that incorporating a political message into literary education in underdeveloped contexts[58] in Latin America motivated people tremendously. Similarly, including value dialogues in the sustainability discourse might improve its popularity among a wider public.

Transformative pedagogy — aiming at "democracy of thought and action" (Senteni, 2007)—is close to critical pedagogy and radical pedagogy. It approaches "co-evolving social and technical processes from a systemic viewpoint in an evolutionary perspective of education and culture" to allow "meaning and capacity" building through "community development, support and networking" (Senteni, 2007). According to Freinet (1993; as in Senteni, 2007), the principles for such education are based on "pedagogy of work" (learn by "making useful products or providing useful services"); "co-operative learning" (based on "co-operation in a productive process"); "enquiry-based learning" ("a trial and error

[56] John Dewey was also known for his role in developing pragmatism and instrumentalism, as discussed in section 2.1.1.

[57] The Frankfurt School (German: Frankfurter Schule), also known as the Institute for Social Research at Goethe University in Frankfurt, Germany, was the home of critical theory.

[58] Throughout his professional life, Paulo Freire (1921–1997) worked within the context of poverty in Latin America and the US.

method involving group work"); and on the "Natural Method," "based on an inductive, global approach" (Senteni, 2007). According to Senteni (2007), the postmodern, transformative pedagogy "draws also upon integrative models" such as Bruno Latour's actor-network theory (Latour & Woolgar, 1979; Latour, 1993), Engeström's (1987) expansive learning model, and Wenger's (1998; Wenger et al., 2002) communities of practice. According to Senteni (2007), all these models "propose the integration of learning" with "the systemic reconstruction of social contexts in which they operate."

In summary (as in Senteni, 2007), the necessary "substrate" of transformative "educational system thinking" is "complexity considered as an inherent part of social interactions" and therefore also as a part of "transformative pedagogical interventions." As a result, the "system" (as the "unit of analysis") "cannot be reduced to its parts without altering its pattern." Instead, it must be perceived as "self-regulating, stabilizing itself through negative feedback loops [...] as well self-organizing." Senteni (2007) continues that such "systems thinking" requires "a fundamental shift in our epistemologies which have been, and continue to be, dominated by Cartesian oppositions." New approaches to academic meaning-making and learning must expand outward from these modern dichotomies.

From experiential to expansive learning

One established approach in the tradition of adult education theory is the concept of experiential learning (Miettinen, 2000), emphasizing the role of experiences in real-world interaction and learning through practice. According to David Kolb's experiential learning theory (ELT; Kolb, 1984; Kolb & Fry, 1974), effective learning takes place in a cycle of four stages: 1) having a concrete experience, followed by 2) observation of and reflection on that experience. This leads to the 3) formation of abstract concepts (analysis) and generalizations (conclusions) that become 4) tested in future situations, resulting in new experience (as in McLeod, 2013, p. 1).

Brown (2010a, p. 77) describes the collective learning cycle, or the "collective social learning spiral," as having four stages: "describe" (identification of the ideals that guide research on facts); "design" (research on facts leading into new ideas); "do" (ideas developing into actions); and "develop" (actions developing ideals). In essence, this is the same divergent and convergent process as in design activity (see Figure 3). According to Brown (p. 61), the transdisciplinary inquiry also comes together "at each of the four stages of [the] collective learning spiral," resembling the experiential learning cycle as described by Kolb.

Effective collaboration helps in learning "as students construct joint explanations" (Hmelo-Silver, 2004, p. 257). Expansive learning, as described by Yrjö Engeström (1987; see section 2.2.1), is "a process of concept formation" (Engeström & Sannino, 2010, p. 20), resembling many process models in design and education. Expansive learning denotes a process "in which the learners are involved in constructing and implementing a radically new, wider and more complex object and concept for their activity" (Engeström & Sannino, 2010, p. 2). Expansive learning (Engeström, 2000) can be described with the "expansive learning cycle"

that resembles Bloom's cognitive process, consisting of the following seven phases: 1) questioning, 2) analyzing, 3) modeling, 4) examining the model, 5) implementing the model, 6) reflecting, and 7) consolidating new activity.

In his work, Kolb (1984) also elaborates on different learning styles derived from his ELT framework. According to McLeod (2013, pp. 3–4), these styles can be defined as "diverging," to be able to "look at things from different perspectives" ("feeling and watching"); "assimilating," to seek "for a concise, logical approach" ("watching and thinking); "converging," to "solve problems and [...] find solutions to practical issues" ("doing and thinking"); or "accommodating," to pursue "hands-on" work relying on "intuition rather than logic" ("doing and feeling"). McLeod (2013, p. 3) also notes that "everyone responds to and needs the stimulus of all types of learning styles to one extent or another"; hence the styles overlap in all learning.

In a collaborative context, the approach to learning calls for further expansion. From the perspective of sustainable transformation, not only the outcomes of learning but also the process itself must be put under greater scrutiny. Working with real challenges and materials (as often in studio practice in design) helps to frame concepts collaboratively and prime action in an improved manner, and offers several entrance points into learning. As an example of collaborative learning, teamwork based, tutored peer-learning within a collaborative project work context — a process quite familiar in contemporary design education — seems to fit this description well.

Problem-based learning for transdisciplinary sustainability

The challenges of sustainability represent often wicked problems (see Rittel & Webber, 1973), calling for expansive learning with collaboratively constructed and iterated inquiries. Problem-based learning (PBL) has been applied for several decades in various different fields of education (Poikela & Poikela, 2005). PBL involves several elements considered essential in effective learning, such as "self-directed or autonomous learning, critical and reflective thinking skills" and "the integration of disciplines" (Poikela & Poikela, 2005, p. 8). PBL draws attention to how problems and their solving processes are approached and structured, centering on complex problems "that [do] not have a single correct answer" (Hmelo-Silver, 2004, p. 235). Instead, the requirements for the process are collaboratively identified and discussed in groups that engage in "self-directed learning" (Hmelo-Silver, 2004, p. 235).

In PBL, a reflective process is essential (cf. Kolb, 1984; Poikela & Poikela, 2005). According to Poikela and Poikela (2005, pp. 15–18), this reflection takes place through three "mirrors" between the domains of "self," "process," and "product," residing in a given context also involving "society" and "working life." In this process, the first mirror can be found between "self- and process assessment," applied to "learn reflective skills for assessing themselves, their performances and their relations to other actors" (Poikela & Poikela, 2005, pp. 15–18). The second mirror resides between "process and product assessment," used to reflect on "goals and the criteria for achieving them," and the third "between product

assessment and contexts (society and working life)" (Poikela & Poikela, 2005, pp. 15–18, parentheses in original). According to Poikela and Poikela (2005, p. 9), "the integrative knowledge from and between theory and praxis is needed for constructing experience."

What distinguishes PBL from various other approaches to teaching and learning (Poikela & Poikela, 2005, p. 7) is that "as a teaching technique, as an educational strategy, or even as a philosophy" it calls for "changes in the whole learning environment" — in "organizational context," curriculum design, "teaching and learning approach," and in methods "of assessment and evaluation." And yet,(Poikela & Poikela, 2005, p. 8), the PBL approach to teaching and learning can fail for numerous reasons, often in relation to a lack of commitment, investment in resources, or insufficient evaluation strategies (see, for example, Savery, 2006). While the use of PBL "as a tool for the individual teacher" may have "only minor implications for the curriculum" (Poikela & Poikela, 2005, p. 11), defining PBL more holistically as an educational framework means holistic considerations of several elements such as the organizational context, curriculum structure, and teaching and learning approach in general. Understanding the PBL-based curriculum as "a learning environment" moves the emphasis to "strategical and methodological views on the development of multi-subject knowledge, shared expertise and a multiprofessional work culture" (Nummenmaa et al., 2005, p. 47).

According to Nummenmaa et al. (2005, pp. 63–64), three main lessons of PBL-driven curriculum development can be identified as the following: 1) curriculum development should begin with "an open examination of the prevailing situations and practices"; 2) developmental activities should be producing "a system of learning based on collaboration (learning as belonging)" — a "learning partnership" between teachers, students, and administration, all of whom are "involved and committed"; and 3) a "reflective development" process connecting with personal experiences and "shared meaning making."

Managing transdisciplinary learning in a postmodern academia

As discussed earlier, transdisciplinarity is an ambiguous term interpreted and used in multiple ways (see section 2.1.3). Its general features, however, can be identified in: tackling the complexity of science and "knowledge fragmentation"; accepting "local contexts and uncertainty"; and implying "intercommunicative action" that requires "close and continuous collaboration during all phases of a [research] project" (Lawrence, 2010, pp. 17–18). In a similar manner, according to Doucet and Janssens (2011, p. 2), transdisciplinarity is based on three major elements: 1) the integration of theoretical (disciplinary) and practical (professional and lay) knowledge; 2) the ethical dimension; and 3) and the importance of "experimental, designerly modes of inquiry." In its expanded scope of action, transdisciplinarity also denotes transcendence of the boundaries of academia and the traditional process in which academic collaboration takes place.[59]

[59] Post-normal science (Funtowicz & Ravetz, 1993) and post-academic science (Ziman, 2000) are breaking free "of reductionist and mechanistic assumptions" about the relation of things and the way systems operate (as in Klein, 2010, p. 26).

In her article on a philosophical framework for transdisciplinarity, Russell (2010, p. 39) suggests an "open critical inquiry" as a suitable system for such knowledge production. She describes that such inquiry would recognize "that knowledge production is embedded in social contexts" and that the inquiry should accept the "plurality" of the perspectives and information on which the action stands, and that our knowledge can be "fallible" (Russell, 2010, p. 39). She concludes that the "open critical approach" in a transdisciplinary process must include an account of knowledge, which accepts "the explicit accounting for all three knowledge [and meaning-making] commitments — the ontological, epistemological and ethical"; that the accounting of the above is "characterized by 'openness' rather than 'closed' orientations"; that being open denotes not only the expansion of collaboration, but also that "any decision made will remain open to revision and improvement"; and that only the interplay between the three different worlds, in science and practice, can "legitimize ethically driven transdisciplinary inquiry" (Russell, 2010, p. 53).

Consequently, the guiding principles for a transdisciplinary process (Russell 2010, pp. 56–57) are identified as:

- Partiality, plurality, and provisionality of knowing.
- Foundations for reliable knowledge: that all knowledge "needs to be assessed through a social process of critical deliberation."
- Validity and critical rationality: that in addition to instrumental and practical rationalities, critical self-reflection is also needed.
- The ontological commitments: that the world is open and "unfolding dynamic and heterogenous complexity," and that what is considered real may address both "physical and cultural things."
- Including both facts and values in inquiry processes and validation.
- Openness across the three philosophical commitments (epistemology, ontology, ethics) and the three rationalities (physical, subjective, and social world).
- Including ecological conditions in human interests and knowledge.

In summary, managing interprofessional academic collaboration in the context of sustainability should pay attention to all the above aspects to unpack the cultural and disciplinary views and to achieve a synthesis that is open to outside criticism and further work. For any participant, such a process calls for an expansion of his or her perspective and an appreciation of new perspectives. For a designer, as the facilitator, this entails new emphases in the activity itself. Such an approach, however, can become contested from the institutional perspective.

2.3.3. Transforming learning and making with design

In a 1993 book continuing the work he started for his dissertation (1990; see Chapter 3, sections 3.1 and 3.2.4), Reijo Miettinen studied the changes in education at Helsinki Business College with a CHAT perspective. In Miettinen's study (1993, p. 240), the main "tools" that are identified to be utilized in developing teaching are measurements to react to changes in professional life, theories and practices on learning, and the means of evaluating results. The subject is the teacher (the focus of his study), the object the student (and her future professional life and practice) (Miettinen, 1993). Rules and division of labor are laid out by well-planned structures of collaboration in a community that extends into social networks of outside collaborators (Miettinen, 1993).

In the CHAT view, and in the expansive learning model based on it (Engeström, 1987; see sections 2.1.3. and 2.3.2), the learning activity progresses through sequential phases, supported with instruments (physical and conceptual artifacts) that help in collaborative mediation. In the ANT view, this is how cultural meanings and practices evolve. According to Miettinen and Virkkunen (2005), "representational artifacts" such as "concepts and models" are instrumental in promoting change in human practices; in their view, "designing a set of informational tools and procedures" can "carry on to the new practice" (p. 437). However, in approaching the complex setting of interprofessional education, with several actors, actor groups, and activities, such models become complex and are embodied in material presentations that become overly thin (or then complex) or simply inaccessible to outsiders. In this respect, these instruments or nested activities become black boxed (see note 44) from the other participants: in the context of sustainability, these call to be opened.

One of the key features of interprofessional sustainability is the idea that "designing a system of inquiry" requires the setting of boundaries — of what is included or excluded in the inquiry — and this is based on "a multiplicity of values, interests and purposes" (Russell, 2010, p. 49). Questions of what and how have, however, "preoccupied interprofessional design collaborations with issues of epistemology and methodology [...] around questions of what can be known, the limits of knowledge and issues of uncertainty and indeterminability, and around what strategies, tools and instruments can be applied" (Mazé, 2014, p. 4). As a result, there are no fixed tool palettes for interprofessional learning. Instead, the methodology and practice emerge from the participating disciplines and communities, through their historical development, and these might to a certain extent be conflicting and require further focus in the collaboration.

Similar challenges to education have become increasingly important in relation to design action and interprofessional collaboration. In this sense, design educators (and designers in general) can act not only as participants in the interprofessional collaboration, but also as the creative facilitators and architects of the platforms for action that can help to collaboratively frame and mediate the topical issues of sustainability.

Design-driven action for creative sustainability

Contemporary design is becoming increasingly acknowledged as both a field of professional practice and a research discipline (Friedman, 2002). At the same time, the artistic and creative practice of making must not be lost in this development. Norman and Klemmer (2014) describe the "artistic side of design" as "critical." As delineated in our earlier publication (Hyvönen et al., 2014, p. 444), art has the power "to challenge and make questions, visions and future plans visible to citizens when speaking about sustainable development." Artistic activities support creative self-expression, emotional development and self-realization, through which the individual can analyze reality and by which communities can generate "creative, social, cultural and economic capital" (Ministry of Education, 2003a, p. 6; as cited in Hyvönen et al., 2014, p. 444). Such activities can also fuel sustainable design action with "migrant creative-thoughts" that travel between different meaning systems and are able to reflect on "cognitive references and values" (Vezzoli, 2005, p. 4; as cited in Hyvönen et al., 2014, p. 444), and elicit worldviews and perceived meanings of things.

Since its beginning as a professional field, besides planning, creativity and making have also been closely linked with design practice. In a sense, imagination is "central to the work of anyone who is involved in change in the society in which they live" (Brown et al., 2010, p. 5). This includes artists and philosophers, but also scientists, activists, and leaders (Brown et al., 2010).[60] If we agree that sustainable innovations should be diffused as "improvement, plausible and articulated to fit into different modern contexts" (Vezzoli, 2007, p. 27), art and design are then fundamental parts of this articulation (Hyvönen et al., 2014). As such, design education involves a higher level of creativity, focusing on making and creating rather than just performing (Sanders & Stappers, 2008; see Table 7).

Table 7. *Levels of creativity, with motivation and purpose.*

Level	Type	Motivation	Purpose
4	Creating	Inspiration	"Express my creativity"
3	Making	Asserting my ability or skill	"Make with my own hands"
2	Adapting	Appropriation	"Make things my own"
1	Doing	Productivity	"Getting something done"

Source: Adapted from Sanders and Stappers (2008); see also Sanders (2006a)

Design activity, along with its epistemic and ontological framework, is "problem-based and solution-oriented," including "participatory tactics" that "embrace creativity" (Marttila & Kohtala, 2014, p. 461). Dorst and Cross (2001, p. 425) describe creativity as often being characterized as a "creative leap" in the process of design. According to them (2001), such a leap often takes place through "the building of a 'bridge' between the problem space and the solution space by the

[60] In this respect, imagination, like design, can be defined as a universal human ability.

identification of a key concept" (p. 435; see section 2.1.2). As a result, creativity in the design process actually denotes the "co-evolution of problem space [...] and solution space" (Dorst and Cross, 2001, p. 434): its process contains no magic but it can be staged with a proper setting.

With its emphasis on creative making and action, and on practical iterativity, the contemporary design practice has also been criticized for being unscientific (for example, Friedman, 2002) and "woefully ignorant of the deep complexity of social and organizational problems" (Norman & Klemmer, 2014). Today's challenges, however, call for a new type of design action, and education must follow. Consequently, according to Norman and Klemmer (2014), the new form of design education must be one with "more rigor, more science, and more attention to the social and behavioral sciences, to modern technology, and to business," but it must still involve "art and creativity" as its fundamental ingredients.

Trandisciplinary learning for a postmodern design academia

In interprofessional learning, the challenge remains that the students enter an educational program "with various dispositions" (Ketonen & Lonka, 2013, p. 103). These beliefs are often also "socially shared by their discipline or academic community" (Ketonen & Lonka, 2013, p. 103). Most educational institutes have by now made at least "modest efforts" to promote interdisciplinarity (Pfirman & Martin, 2010, p. 392), visible in the establishment of courses crossing schools, departments, and areas of study, and some have initiated centers and specific programs. These can be perceived as platforms for collaborative mediation in which the interprofessional learning takes place. Several are also fostering constructive or even transformative pedagogies, aiming to improve their practices; furthermore, many are advocating a designerly approach on both the theoretical and practical levels of working.

In addition to general problem solving, communication is an essential dimension in design practice. This competence helps to link projects and their ideas and outcomes on a shared transition path. Strategies such as collaborative ideation, rapid prototyping, and iterative processes of visual and conceptual brainstorming as general design methods and modes of working are also suitable for constructive experimentation on various levels and scales.[61] As a result, the design approach has a clear role not only in defining and communicating sustainability, but also in setting up and evaluating various real-life experiments on different levels of societal activity, and even in managing learning in the complex settings of interprofessional transdisciplinarity.

In researching decision-making under complexity, Lopes (2011, p. 316) suggests that the development in "calculating decision knowledge" relates to ANT translations and the interplay between "human and non-human techniques. Consequently the "decision-maker learning story" connects with ANT

[61] Such approaches resemble the definition of "constructive design approach" by Koskinen et al. (2011) that aims to integrate design and research to stimulate imagination and thinking through experiments with prototypes and mock-ups in the real contexts of use.

punctualizations, or the development of black boxes acting as "simplifications [...] made with others." In this respect, in the complex setting of sustainability, connecting the materials back to the new learning becomes more important. In Lopes' view (2011, p. 316), the "impact of learning" relates to improving practice with increasing experience of using inscriptive artifacts, tools, and instruments. However, in relation to uncertainty, decision-makers rely rather on "a social-web for calculating decision-knowledge used to reframe/reconstruct uncertainty" (Lopes, 2011, p. 319), developing the context for interaction rather than producing a solution. In this process, each participant contributes to information "in order to reframe and reconstruct the problem" and experience (Lopes, 2011, p. 318).

In the contemporary university setting, curriculum development remains as one of the most important mechanisms in setting up education (see e.g. Friedman, 2002), and conventional measures of success (grading, amounts of study points acquired, numbers of degrees etc.) are still prevailing. Curricular goals, however, usually also structure and guide the "labeling" and selecting of "educational resources" (Illich, 1970, p. 78), and from the perspective of interprofessional sustainability this might pose conflicts. Instead, as Illich proposes (1970, p. 78), the goals could be opened and expanded to "enable the student to gain access to any educational resource."

University as a context for interprofessional learning and work moves the focus onto expanding learning and collaborative meaning-making. In connection with the three types of transdisciplinary knowledge (see section 2.1.3) and the three phases of transdisciplinary research (see section 2.2.1), this interaction is constructed in similar sequences. In the CHAT-based view, the learning activities in a higher education context can be constructed in sequential (and partly overlapping) phases of activity (i.e., activity systems) that each develop materials for the consequent action. In the priming phase, the materials and structures for collaboration (models, frameworks, processes) and the interacting communities (with their norms and rules) are set for the future action. In the implementation phase, the teaching activity takes place, with the teacher (or even a student) conducting action based on the materials and students internalizing the learning to develop the expected competences. In the last phase, the learning is evaluated and the developed competence is connected back to the priming of new action, and externalized in the future practice (see Figure 11).

However, in approaching interprofessional learning in an academic context, both priming and assessment — not that often opened to a wider group of collaborators — need to be more reflective and collaborative, and connected to a shared assessment. Such a process can be more easily challenged in relation to the conventional roles, structures, and schedules in academic teaching.

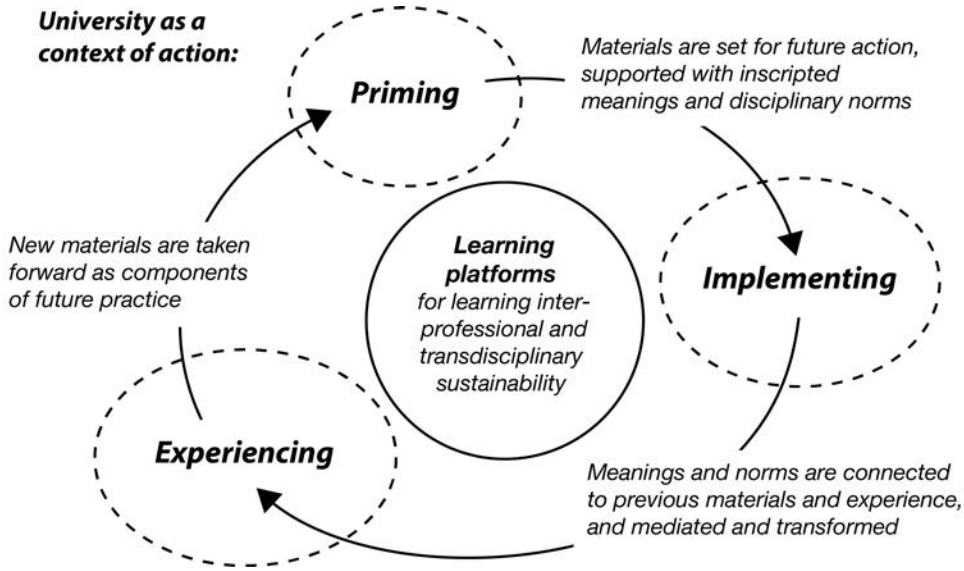


Figure 11. *Developing platforms for learning interprofessional, transdisciplinary design for sustainability.*

Source: Author

Administering inter- and transdisciplinary programs is a challenge that requires "entrepreneurial leadership," knowledge of the best interdisciplinary practices, "curricular design, pedagogy, and assessment," together with the ability to network and collaborate inside and outside the university (Casey, 2010, p. 346). Yet, while the contemporary disciplines have enabled the production of detailed scientific knowledge, only transdisciplinarity and post-disciplinarity can facilitate evaluation, communication, and cooperation across disciplines, synthesizing insights across their divisions and coming together with the wider society in transdisciplinary action.

3. CASE AND ASSESSMENT

As discussed in the first two chapters, the aim of sustainable design action should not only be to fight the impacts of consumption, but also to balance the power relations between different stakeholders in overall societal collaboration and even in learning, promoting sustainable transformation in our everyday (or professional) practice. As a result, new types of interaction are promoted and more emphasis is put on collaboration in real-world contexts. This approach, however, also poses the question of how scientific knowledge is organized between the disciplines, and how activities are organized within and between institutions and society as a whole.

Another crucial aspect in contemporary, sustainable design is interprofessional collaboration. The role of a designer as a facilitator of collaborative mediation, an integrator of meanings and culture, a manager of expansive platforming and project collaboration, and an agent of change, entails changes in what is considered necessary in future professional design action. Contemporary design connects with project work and collaboration, with studio practice, stakeholder interaction, and facilitation, and with the creative process in general; and yet, as a practice, design is also an integral component in our current unsustainability.

According to a general view, contemporary sustainability challenges are inherently connected with education (Senteni, 2014). As universities seek their position in the political and economic structures and challenges in a modern information (consumer) society, their new role in creating practical knowledge for the use of our society comes into focus (Nieminen, 2004; as in Hyvönen et al., 2014). In this process, one must consider also how to understand the societal role of higher education institutions. Through what kind of mechanics do universities link to societal and cultural knowledge creation, and how could this be improved from the sustainability perspective? To better understand the sustainability potential in design education, we must ask how such issues become incorporated into the activities of teaching and learning.

This chapter reflects on the findings from the literary research on design action for sustainable transformation. The case of interest — the CS study program — is introduced. Subsequently, the ingredients from theories (as discussed in the previous chapter) are structured into an analytical framework for this research, and the research questions are elaborated further. Finally, the gathered data are explained in greater detail at the end of this chapter.

3.1. Case: The Master's Degree Program in Creative Sustainability (CS)

In this work, the focus is on interviews and other materials from a particular case — the International Master's Degree Program in Creative Sustainability (CS) — that began as a new and multidisciplinary major degree program in 2010 for students of the three universities from the fields of business, technology, and art and design that had just merged into a new Aalto University,[62] in the metropolitan area of Helsinki, Finland. The focus of CS is on design, engineering, architecture, real estate, and economics. The program is designed for students from four different degree programs and facilitated collaboratively by four departments in three schools of the university; several teachers with different professional backgrounds are involved. The identified areas of competence include strong professional knowledge and competence in process management, design thinking, and a multidisciplinary and systemic approach (see http://acs.aalto.fi/).

The first ideas for a university with an innovation focus were discussed broadly in public media in 2005, as an aftermath of new initiatives to improve the nation's education sector, stressing "the importance of innovations as the main product of all higher education" (Evaluation Panel, 2009, p. 48; as cited in Hyvönen et al., 2014, p. 443). In 2008, the idea of a new Aalto University was established in a governmental plan, and in 2010 it began its activities. A year before, though, CS started already as a minor study program (with 20 ECTS content)[63] with the help of Aalto University pilot funding.[64] The initiation of CS was thus inherently linked to the changes taking place in Finnish national policies in relation to both innovation and university education. The CS program, however, also connected to the initiators' background and to their earlier projects and collaboration. Together, these formed the contextual background for the launching of the program itself.

3.1.1. A new role for the university

In Finland, following the success of mobile and ICT technologies supported by design management processes (i.e., Nokia mobile phones), there emerged "a need to update awareness of design competence," resulting in a new national design agenda (Hyvönen et al., 2014, p. 443) "based on competitiveness in industry and business, skills improvement and diversification, significant strengthening of research effort, and promotion of design opportunities" (Hyvönen et al., 2014, p. 443). The Finnish government's Decision-in-Principle on Design Policy (later the Design 2005! program) underlined how design can contribute to the innovation system (Korpelainen, 2000). Policy objectives suggested that design be integrated into management programs and into undergraduate programs in business and technology, as successful (product) innovation was perceived to be the result of "multi-professional" collaboration (Korpelainen, 2000).

[62] Aalto University is named in honor of Alvar and Aino Aalto, twentieth century Finnish designers.

[63] ECTS refers to the European Credit Transfer System. In Finland, 1 ECTS equals 27 hours of work.

[64] This funding was available in Spring 2009.

At the time, another development was also at hand. By the middle of the 2000s, discussions in Finland on business, politics, and education increasingly challenged the leading role of disciplinary higher education and sought collaborations in which several disciplines would integrate to produce results more relevant to serve the economy. Part of this thinking was based on the idea of increasing the quality of university education, even at the cost of quantity, and better channeling the resources into areas with the potential for growth.[65] At the beginning of the new millennium, there was discussion as well as actual changes in legislation to add a new role for Finnish universities: creating practical knowledge for the use of our society (Nieminen, 2004; see section 2.3.1).[66] Knowledge was considered to be an increasingly important factor in planning and production, and the demand for labor in knowledge-intensive fields was growing (Ministry of Education, 2003b, p. 5).

Innovation education for the future

The Prime Minister's Office report from 2004, "Strengthening Competence and Openness," identified increasing "R&D resources" and channeling them into "innovative growth companies" as one main recommendation for new national policies (Prime Minister's Office, 2004, p. 6). For education, the report suggested a reform to make "education more relevant to working life and more effective" (p. 36). For tertiary level[67] university education, the report (p. 38) suggested (among others):

- Increasing teaching and research resources important for key sectors.
- Improving the capacity of universities to build "internationally competitive education."
- Increasing the financial autonomy of universities.
- Strengthening "professional management and development" at universities.
- Implementing the "international commercialization of education services" in sectors where Finland has top competence.
- Participating in "assessments and in actions intended to improve the quality of [...] teaching and research."

In 2008, based on ideas for future innovation policy development, a Finnish Ministry of Employment and Education workgroup prepared a new proposal titled as the National Innovation Strategy (NIS). The proposal was based on an extensive series of eleven thematic workshops in 2007 and "an international conference

[65] In 2004, a workgroup led by Anne Brunila of the Finnish Ministry of Finance concluded that Finland had too many universities and other institutes of tertiary level education, which should be consolidated. Later on, Brunila worked as one of the seven members of the Aalto University Board, representing "a wide spectrum of sciences and arts, as well as the best social and industrial expertise on both national and international levels" (http://www.aalto.fi/en/about/organization/board/).

[66] Sitra (the Finnish Innovation Fund), a national institution promoting research, elaborates upon the third role for Finnish universities in its publication *Yliopistojen kolmas tehtävä?* (Nieminen, 2004), translated as "universities' third role."

[67] Broadly speaking, primary level education refers to basic education, secondary to vocational education, and tertiary to academic education; however, the differences are not clear or even clearly articulated.

and national seminar" in 2008 (Aho et al., 2008, preface). It identified globalization, sustainable development, new technologies, and the aging of the population as the key drivers of change (Aho et al., 2008, p. 3). As the two future strategic goals, it called forth "sustainably targeted [...] innovation-based development of productivity" and "pioneering in innovation activities" in carefully selected sectors of innovation (Aho et al., 2008, p. 4). As basic strategic choices, the proposal suggested developments in the innovation environment, supporting "a world without borders," "demand and user orientation," and support for "innovative individuals and communities," with a broad "systemic approach" (Aho et al., 2008, p. 5).

The report of Ministry of Employment and the Economy (2009) drawn from the proposal identified higher education as "the key to the public research system" (p. 9). Suggestions for the forthcoming reform of university legslation were to "provide universities with better opportunities to apply modern human resources policies, improve the quality and effectiveness of teaching and research, and strengthen creative and innovative research and learning environments" (Ministry of Employment and the Economy, 2009, p. 10).[68] The report (2009) also defined the "systemic approach" in detail as "a comprehensive method of aligning the business and policy sectors (horizontal) and their associated development activities at different levels (vertical)," referring "comprehensively, to the interconnection and mutual dependencies of various phenomena" (pp. 4–5). In the report (2009), the systemic approach was promoted as "a key concept in implementing a broad-based innovation policy" (p. 4).

Aalto University: a national project

Helsinki University of Technology (HUT), the University of Art and Design Helsinki (UIAH), and Helsinki School of Economics (HSE) already had a tradition of collaboration in the metropolitan region in Helsinki, Finland (see Table 8). Furthermore, as they all collaborated already with business partners, it was natural that they could be essential parts of such an innovation university. Following the dialogues that took place behind the scenes, a year later the president of UIAH proposed the merger of Aalto University's founding schools in his opening speech in 2005.[69]

Aalto University became a national Finnish project. The idea of the new university was established by a governmental decision in 2007.[70] The Aalto University charter was signed in June 2008. In December 2008, the first President of Aalto

[68] Some more specific actions in the renewal of the university legislation in Finland were to increase the financial independence of universities by granting them the ability to gather investments from industry and public, to introduce an optional foundation-based model (used in the merger of Aalto University), and to introduce a new tenure track system for Finnish academic professionals.

[69] This acting president was Professor Yrjö Sotamaa. See http://www.aalto.fi/en/about/history/

[70] A more concrete plan was presented for the establishment of a new university in February 2007 in the memorandum of the working group led by Secretary of State Raimo Sailas. Later the same spring, the initiation of the university was entered into the government program by Prime Minister Matti Vanhanen. See http://www.aalto.fi/en/about/history/

University[71] was selected; she started her work in April 2009. The governmental university renewal in 2009 transformed the Finnish universities from state-bound into independent or, then, foundation-based organizations; as part of the renewed legislation (among numerous other actions), the new Aalto University was established. The university started operating at the beginning of 2010. The first students at the university began their studies in the new academic term beginning in August in 2010. University operations continued, however, on three separate campuses and in separate programs — in many ways as before the merger.

Table 8. *Three universities that formed the new Aalto University in 2010.*

Helsinki University of Technology (HUT) Helsinki University of Technology was originally established in 1849 as the Technical School of Helsinki, close to the city center. The school was renamed the Polytechnic Institute in 1879, and as the university-level Technological University of Finland in 1908. The university began moving its activities to Otaniemi, Espoo (a city next to Helsinki and part of the capital region) in 1955, where the main campus of Aalto University is now located.
Helsinki School of Economics (HSE) Helsinki School of Economics opened its doors as an independent university in 1911, after reorganizing studies at the Helsinki Business College, established only a few years before in 1904. In 1950, the School of Economics moved into its present premises in Töölö district near Helsinki city center, where the business campus currently operates.
University of Art and Design Helsinki (UIAH) The University of Art and Design Helsinki was founded in 1871 initially as the Craft School, and renamed the Central School of Industrial Arts in 1885. For the first century (1887–1986), it operated in a central location in the Ateneum next to Helsinki railway station, but gradually expanded into several other locations as operations expanded and space in the building grew very limited. The university moved to its current premises in the Arabia district in 1986, gathering all the departments under a common address after several decades.

Together, the three universities formed three Aalto schools: School of Art and Design, School of Economics, and School of Science and Technology. From the beginning of 2011, Aalto University School of Science and Technology was further divided into four new schools that were formed from the former university faculties of Helsinki University of Technology. In 2012, the Department of Architecture was moved from the School of Engineering to the School of Art and Design, which was then renamed the School of Arts, Design and Architecture (ARTS). Later on, in August of the same year, the School of Economics was renamed the School of Business (BIZ).

[71] The first president of Aalto University between 2010–2017 was Professor Tuula Teeri, a Finnish molecular geneticist and formerly Vice President at the Royal Institute of Technology in Stockholm.

Sustainability and interprofessional education in Aalto University

From its beginning, Aalto University as a project aimed at diffusing its different fields of study "Science and Arts with Technology and Business," as the slogan originally stated — to induce innovation for society and business in line with the developments in innovation policies at the national level and in international educational research. Quite naturally, the topical challenges identified in NIS are also visible in the vision and aims of the university itself. In its first strategy document, Aalto University identifies relevant challenges and potential in relation to improving the quality of education and promoting interprofessional expertise and partnerships aiming at innovation activities (Aalto University, 2010). However, while in the beginning there were a lot of initiatives to share education among disciplines and topical issues between different departments of the university, the ability to take courses outside students' own degree program is still rather limited to similar program structures to those before the merger, when there were already a number of collaborations across the three universities.

3.1.2. Background and history of the CS program

In Finland, the growth in interdisciplinary and transdisciplinary approaches to scientific research — and to education and society — had already been addressed by several national research projects.[72] This same development and its potential for innovation activities had also been identified as a future opportunity for Aalto University (see Aalto University, 2010), to be present in the form of "multidisciplinary research and education" (Hyvönen et al., 2014, p. 445) and as an outreach toward outside society and business.

One such initiative in Aalto was the launch of the CS program in 2010, a new multidisciplinary Master's degree program that sought to bridge the departments of design and architecture, business management, industrial management, and real estate business. The term describing the nature of interprofessional interaction has developed from "multi-professional" (e.g., Korpelainen, 2000) to "cross-disciplinary" (CS web descriptions, February 2009; official documents in 2009), to "multi-disciplinary" (CS major program launch in Fall 2010), and finally to "inter-disciplinary" (CS web descriptions in 2013), almost in line with the trends in academic and popular talks at the time. By the end of 2015, this term reverted to "multidisciplinarity" in both official descriptions and online.[73]

The CS study program was, naturally, preceded by several types of collaboration by different collaborators in the three formerly independent universities: the context it emerged from emerged through these. For these specific academics, the merger of Aalto University created a window of opportunity for a program such as CS to be developed from a minor, acting as a pilot, to a full-scale degree

[72] For example, in projects by the Academy of Finland (Bruun et al., 2005; Huutoniemi & Tapio, 2014).

[73] Unfortunately, this finding did not connect with other data in research, and remained as only an interesting notion, perhaps just resulting of practical reasons in connecting descriptive texts to communication.

program with less than two years of planning.[74] The aforementioned networks made the initiation of the CS program possible; they also partially made it into what it is today.

Earlier collaborations

The story of CS itself can be perceived to have begun in the mid-2000s in talks between academic professionals who all shared an interest in sustainability. These academics were from the three universities that would form Aalto University later on. Professor Eija Nieminen, head of Designium at the time (the design innovation research center at UIAH) was interested in developing a course on sustainable innovation with a focus on urban sustainability and sustainable business, receiving support from Professor Helena Hyvönen, the department head and later the rector of the whole university (and, during the merger into Aalto University, dean of the School of ARTS). Together with researcher and lecturer Mika Kuisma from HSE, and Trevor Harris, professor of urban planning from the Department of Architecture at HUT (and later Maija Rautamäki from landscape architecture; see Table 9), Nieminen facilitated a multidisciplinary course on these topics: a study module called Sustainable Urban and Industrial Design (CS program documents for Ministry of Education, December 2009). The module was run during the academic terms 2007–2008 and 2008–2009, and more than 70 students took part. The experiences and feedback from this module "strongly encouraged" the creation of the whole CS study program later on (CS program documents for Ministry of Education, December 2009), and were revisited in a book with the same name as the forthcoming program itself (see Nieminen, 2009).

Table 9. *The originators of the Sustainable Urban and Industrial Design module, 2007–2008.*[75]

Eija Nieminen (D.Sc. [Tech.]) graduated from Tampere University of Technology as Doctor of Science, and worked in several industry professions before academia, including the KONE Corporation. She worked as the head of Designium Innovation Center (at UIAH) in 2003–2010. Her CS-related publications include *Green Imperative!* (Nieminen, Kurki, Lönngren, & Sorvali, 2008) and *Creative Sustainability – Case Studies on User-driven Business Innovations* (2009). Since Aalto University, she has been active, for example, in a think tank called Helsinki Sustainability Center.
Mika Kuisma (D.Sc. [Econ.]) has been a member of the Corporate Environmental and Social Research (CESR) Group of HSE (later Aalto University) since 1995. The focus of his research has been on corporate responsibility performance and impact assessment, as well as innovative and eco-efficient business models and practices. He has collaborated with several European research institutes and corporations in international research projects. He also teaches corporate responsibility in Bachelor's and Master's level courses at Aalto.

[74] In minor degree program the contents of study fit usually into some 20 ECTS of studies, whereas a major degree program consists of 120 ECTS, including a thesis work.

[75] This information has been collected from personal bios available in Aalto University web, except with Maija Rautamäki, which bases partly on (Ikäheimo, 2010).

Table 9. *(continued...)*

Trevor Harris (MSc) has worked as a professor of architecture in urban design since 1999 (in HUT and later Aalto University), and later also as director of the Department of Architecture. He graduated as an architect from the Hull School of Architecture, Regional College of Art and Design in 1975, and has run an architecture agency in Finland since 1985, receiving renown with several large-scale projects.
Maija Rautamäki (MSc) has worked as a professor in landscape architecture and landscape planning and management since 1996 (in HUT and later Aalto University). She graduated in 1978 from the same university. She describes ecological landscape planning and conservation as her specialist fields.

Preceding the Aalto University merger, an open call for funding was initiated for projects that would pilot new, multidisciplinary education in the new university. In early 2009, Nieminen, along with the other module originators, started to prepare an application to pilot a cross-disciplinary minor study program on sustainability that would include a portion of shared studies and then educational content offered by each participating department (CS web site, February 2009).

Launching CS minor and major

Following the earlier experiences in sharing education across schools,[76] such collaboration was natural to the involved institutions, and the merger into a common university offered an even better window of operation to test out new ideas. As Aalto University pilot funding was granted for the preparations of a CS minor (in early Spring 2009),[77] Eija Nieminen was nominated as the head of the CS preparation board. With the support of the funding, CS began as a minor study program at the beginning of the academic term in Fall 2009. As a result of the secured financial plan and the topical focus area of the program (multidisciplinarity and sustainability), during this year the preparation board saw rapid expansion in the number of the academics (professors, researchers, lecturers, etc.) involved.

When the funding application for the minor was in the making, the idea already was to develop the idea into a full-scale Master's degree program, the educational content of which would be provided collaboratively. This plan was articulated clearly in the early CS planning documents (CS web site, February 2009). In early Spring 2010, as the reviews for the outcomes of the minor were positive and participating departments saw the collaboration as meaningful, the CS program was given the green light to be developed into a major. In reality, this consisted of several steps for approval by three different academic committees (in three participating universities) during the years 2009–2010, with the support of three departments. This process also faced further challenges, as the whole program

[76] For example, the IDBM study program (see note 6) had been operating between UIAH and HSE since 1995. Another influential collaboration was the Product Development Project (PDP) course, in which many industrial design students participated each year, that was organized between the Department of Design at UIAH and the School of Engineering at HUT since 1997.

[77] CS preparation was selected as one of the key projects of Aalto University in 2009 and was granted 200.000 € for its first two years (CS Master's program application, December 2009).

was initiated while merging into a common university, but these administrative difficulties were solved on the way.

In this phase, new collaborators were invited to join the dialogue (the door was in a sense constantly open), and some joined along with several informal contacts. Furthermore, the Department of Real Estate from the School of Engineering decided to join the participating departments of Design, Architecture, and Marketing and Management. As a result, the group planning the actual CS Master's program expanded (see Table 10). Eventually, in Fall 2010, the first CS major students started their studies.

Table 10. *Academics involved in the CS development in Spring 2010.**

Participating department	Participants' academic positions
Design Aalto University School of Art and Design**	Professor, Head of Department, Design Professor, Head of Designium, Chairman of CS Advisory Board, Design Professor, Dean of the School Professor, Vice Dean of the School
Business Aalto University School of Economics***	Researcher, Organization and Management Researcher, Organization and Management Researcher, Organization and Management Professor, Organization and Management Professor, Head of the Department, Organization and Management
Architecture Aalto University School of Science and Technology****	Professor, Urban Design Professor, Landscape Design Professor, Head of Department, Architecture
Real Estate Aalto University School of Science and Technology*****	Professor, Head of the Department, Real Estate Economics and Valuation

* In addition to the academic members, several people assisted as coordinators, secretaries, and planners, and the board had student members. | ** From 2012, Aalto University School of Art, Design and Architecture. | *** From 2012, Aalto University School of Business. | **** In 2010, a part of Aalto University School of Science and Technology; then, in 2011, a part of Aalto University School of Engineering; from 2012, a part of Aalto School of Arts, Design and Architecture. ***** In 2010, a part of Aalto University School of Science and Technology, then, from 2011, a part of Aalto University School of Engineering.

Development of leadership and funding

Between 2008 and 2010, the preparations for CS were mainly coordinated by the Department of Design and led by professor Eija Nieminen as head of the CS preparation board. By Spring 2010, there was an agreement that a program head would be hired to work in the design department as well. During Spring 2010, the management model for CS was refined further as a "program director-led model"

(CS preparation board minutes, February 2010), including a program director at the School of ARTS, a deputy director from another school, an academic steering group consisting of three or four academic professionals from each school, and an expanded group developing teaching, also including students (CS preparation board minutes, February 2010). Before the operation of CS as a major began in Fall 2010, a new head was chosen outside the program preparation group. Tiina Laurila, alumnus of UIAH and a former teacher of sustainable design at the university (2002–2007), was chosen as the head of CS for a two-year term. Ultimately, she continued to work as the head until Spring 2015, for the first five years of the program itself (as a major) and the span of this research.

The other program mechanisms to govern the academic rigor of CS studies included the introduction of: 1) a Finnish Management Board, "to supervise and evaluate the quality [...] and expertise of the teachers and the overall quality of the program, on a regular basis" (i.e., the academic steering group, as mentioned above); and 2) an International Advisory Board, "to evaluate the quality of the education," consisting of "representatives from each School at the Aalto University and of internationally recognized experts" (CS Master's degree program application, December 2009). Only the former, however, started operations, and only in 2012. Also, the expanded developmental activity was dismissed at the beginning, until students initiated such activities themselves (see section 4.3.3).

After the initial funding for piloting CS as a minor program, a second raft of Aalto pilot funding was received for the CS major and its first five years of operation (2010–2015), after which the situation would again be re-evaluated. At the same time, the educational content and the management culture of the program were locked in for several future years. However, after the five-year period (by 2015), the CS pilot funding was dismantled, as all Master's level educational content at Aalto University and in cross-school programs were again to be financed through department level budgets (see Table 11).

Table 11. *The timeline of the development of CS program funding.*

Time span	Type of funding involved
2007–2009	Sustainable Urban and Industrial Design study module (offered to students of UIAH, HSE, and HUT), funded by Department of Design.
2009–2010	Aalto University one-year pilot funding for CS minor; funding coordinated by CS Preparation Board.
2010–2015	Aalto University five-year pilot funding for CS major; funding coordinated by Department of Design.
2015–	CS funded through participating departments (Departments of Design, Architecture, Organizational Management, and Real Estate).

From the very beginning of CS preparations, the idea was to develop the minor into a major program by 2010. Furthermore, the idea was to continue the development of the program to include a post-graduate (doctoral) study program by 2012 (CS Master's degree program application, December 2009).[78] However, after a period of preparation in 2010, the application for future funding for the doctoral school was refused: initiatives to prepare a university-wide doctoral school on sustainability therefore gradually diminished. Instead, the collaboration in research at Aalto University would take place between the future doctoral programs located in each school and in collaborative projects between departments and units.

3.1.3. Educational contents in the CS preparations

Even before the CS minor, the ideas for the educational content of CS were rather clear. Partly, these are seen in Nieminen's book *Creative Sustainability* (2009), and some are articulated in CS planning documents. In many ways, they reflect the development of national innovation policies and of ideas on improving education, and the earlier experiences of collaboration between the originators of the program. A recurring element in these dialogues is the question of scales of action and focus. Design as a professional approach tends toward the context and systems of use. Urban design and (landscape) architecture create the infrastructure in which the activities take place. Design and business management operate between (see Figure 12).

Figure 12. *Different areas of emphasis in the CS focus of professional activity.*
Source: CS Master's degree program application, December 2009

In the CS minor, the educational content consisted of "multi-scientific theory, seminars, workshops, a common case-studio and an individual learning diary" (CS web site, February 2009). In practice, there was some project-based content offered by each participating department, along with a selection of shared studies, a series of theme seminars, and a workshop on international collaboration. The shared studies — despite being just a few sessions in the first year of CS in the academic term 2009–2010 (only a minor at the time) — would later act as key areas of interprofessional learning. They were the Systems Thinking course, focusing on a design view that would acknowledge systemic relations and

[78] The ideas for the doctoral program were also tested out at the 4S Summer Symposium on Sustainable Systems held in Sannäs, Finland, in June 2010, in which the people involved in the CS doctoral application process were involved in dialogues with doctoral students from around the world.

dependencies, and the Continuous Transformation course, focusing on changing the mindset of contemporary ways of work.[79] Already, at the beginning, the thinking was that these joint studies would bring students from different professional areas together to establish grounds for further course and project work.

Design collaboration was approached in an open manner. Students with or without traditional basic training in design "experience the reality of designing solutions and developing innovation strategies for a complex world" (Hyvönen et al., 2014, p. 445). Students with more specialist skills (e.g., engineering or accounting) were expected to contribute with their special skill, but also as a member of the design team itself. The idea was that disciplinary cores were sustained, as students would still graduate with degrees related to their departments and professional study programs (see Marttila & Kohtala, 2014).

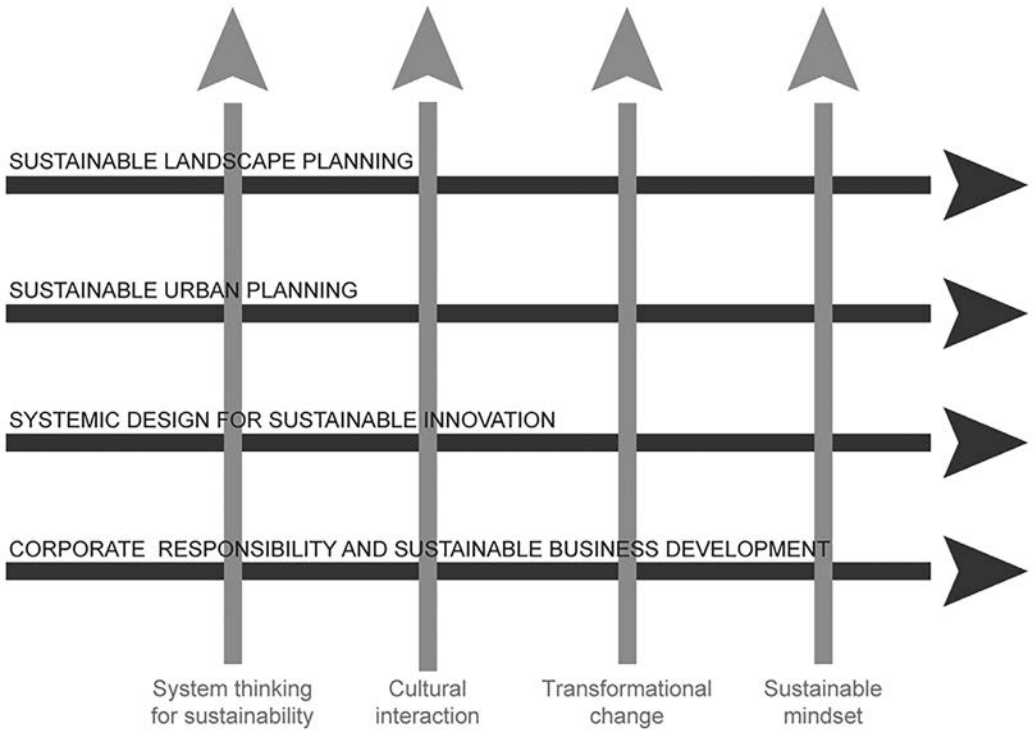


Figure 13. *The horizontal sectors and vertical competence areas in CS.*
Source: CS Master's degree program application, December 2009

In general, and already at the onset, "system theory and thinking" were identified as "the basic model" of the CS approach (CS web site, February 2009). System theory and thinking refers in part to the systemic approach discussed earlier in relation to innovation activities and the National Innovation Strategy. This is

[79] This course was replaced in 2015 with Knowledge-Making for Sustainability course, with somewhat similar emphasis on sensitizing to sustainability as a topic in academia, with extensive textual reflection.

elaborated clearly in Figure 13 describing the educational content of the CS program, including both horizontal sectors of societal activity and vertical pillars of excellence in selected areas important to sustainability. As a clear indicator of connections with earlier ideas of innovation policy development, Anne Stenros from Kone Corporation (former Vice President of Design) acted as an advisory member of the CS preparation board between 2009 and 2010 to present the global business perspective.[80]

Besides innovation activities, the general aim of the CS program was formed from its beginning, to "holistically educate broad-minded, multidisciplinary, creative experts with the ability to solve problems, in order to make the world a better place" (Hyvönen et al., 2014, p. 446). The education in CS was set to promote "a systems approach" and to "[enhance] strategic thinking in various scales in order to support a sustainable future" (Hyvönen et al., 2014, p. 445). Multi-professional collaboration had been already identified as one key future aspect in education (Korpelainen, 2000), and the systemic approach was already emphasized in the National Innovation Strategy (Ministry of Employment and the Economy, 2009). In this sense, the beginning of the CS program seems astonishingly directly rooted in innovation policies on the national level.

In early 2010, some shared themes within the program planning were shared amongst the program preparation board (CS board memo, 19 February 2010). These themes were provided as potential areas of collaboration between the participating professional areas (quotations are translated from the original, written in Finnish):

- Tension between global and local
  This theme includes "questions of scale" and "transitions between different scales" of inquiry and action. "Think global, act local" is a rather oversimplified take on the complexity of our contemporary world, but implications of sustainable design often come on a more local level. CS should pursue a better understanding of the tensions between the two views within the SD context.
- Sustainable development as a cultural concept
  This notion emphasizes the idea that SD is unavoidably a cultural concept, driven by a "value-base" guiding our actions. The focus must also be on how such values become defined and evolve.
- Creativity, innovations, and mobility of ideas
  This aspect underlines that SD requires "another type of orientation" to planning and leadership. The question is from where new ideas emerge, and how they create new societal impacts. In this process, "simulations and scenarios concretize ideas," "utopias are laboratories of change," and "public demonstrations and pilots are new ways [...] into the toolbox of climate politics."
- Assessment and management tools
  These refer to tools to assess and guide development and management. Among the mentioned tools were "LCA and MIPS" (see section 1.2.2), and

[80] Kone Corporation is one of the biggest companies in Finland, and one of the biggest in making escalators and elevators in the world. From 2014 onwards, Anne Stenros also worked as Professor of Practice in the Department of Design, and since 2016 as the Chief Design Officer in Helsinki.

> "Environmental Impact Assessment" in general. This theme acknowledges that tools can be approached from a "manual-for-work" perspective, but also as parts of a more complex, collaborative design process in which "each tool and process raises the voice of a specific actor," introducing her specific problems.

By welcoming all inputs and expanding in an organic manner, CS also developed a specific lens for activities, already visible in the early educational content and especially in its evolution during the first few years of the program. Consequently, and through my personal involvement in the program initiation and early implementation, these years and the program development during them became the focus of this research.

3.2. Research Approach

This research utilizes elements from activity theory (CHAT) and actor-network theory (ANT) as its main components, in connection with additional insights from practice theory (PT). Overall, these theories at the core of the assessment remain important: PT gives a community and practice-driven emphasis; CHAT introduces the institutional, organizational, and developmental perspective; and ANT offers further insight into networks and meaning-making within them.

As a main method of assessment, this work can be perceived as a case study focusing on an example of an interprofessional study program for learning transdisciplinary design for sustainability, investigated "in depth and within its real-life context" (Yin, 2009, p. 13). The interview data are assessed in a qualitative manner, connecting with other data with quantitative aspects (e.g., statistics), as in mixed methods research. The approach and the lens for analysis have been developed iteratively throughout the inquiry. Hence, the study has built up progressively, grounding its progress on gradual, reflective development in understanding, very similar to the process described in the grounded theory method (GTM). Lastly, due to my personal role as a teacher in the program, there has been a deeper involvement than would be the case for an outside researcher.

Structuring the research inquiry

The first chapters of this book consisted of a study of sustainability, design activity, interprofessional collaboration, and education. The main intention was to develop theoretic grounds for the inquiry. At the same time, the gathering of data was progressing, and its methodological choices were connected to the approach. Together, these topics form the general contextual and methodological lens for the assessment (Figure 14).

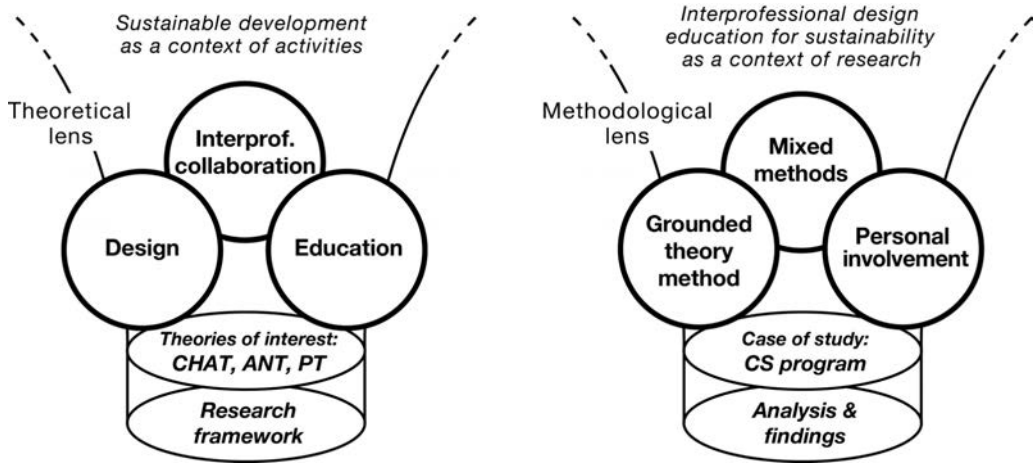


Figure 14. *Development of the research framework and methodology.*

Source: Author

3.2.1. Methodology and approach

In general, the approach in this work has developed rather organically, beginning with interactions during studies, and then maturing into initial research inquiries alongside the work on assisting in the initiation of the CS program, before actually applying to the doctoral school and initiating research. Later on, findings from the interviews, alongside other studies and interactions, fed into the development of the inquiry and the gradual initiation of the analytical phases of assessment.

The assessment combines various types of data (both qualitative and quantitative) under a shared lens for assessment that utilizes understanding from various theories introduced from the field (and through interviews). The method of analysis consists of thematic coding, familiar to most qualitative research. Overall, together with the theoretical insights presented in the next section, these ingredients form the main theoretic and methodological lens for this research.

A case study with personal involvement

I was introduced to the contextual setting of this research during my MA studies in 2007, when I attended one of the courses preceding the CS minor (Sustainable Urban and Industrial Design*;* see section 3.1.2). After graduation, I worked as an assistant in the university's environment program and then as a research assistant in an EU-funded project for learning sustainable design. In Spring 2009, before the initiation of the CS minor, I also had the opportunity to work as an assistant in these preparations. Having already recognized a similar focus of interest in future work, I realized that CS would act as a good case to assess interprofessional design action and learning for sustainability. In 2010, my proposal for the doctoral research was accepted.

Robert Yin (2009, p. 18) defines a case study as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context." According to Yin (2009), one important phase in such a study process is to use propositions that are tested on data to identify similarities in constructs through pattern matching. In case study as a methodology, a distinction can also be made with a single case study and a multiple case study. According to Yin (2009, pp. 47-49), single case studies can be used to test theory, or if the case is "extreme" or "typical," "revelatory" or "longitudinal." In the case of this research, theory is constructed and tested in a longitudinal research process, also involving a revelatory nuance (in connection with progressing interaction in CS, or with the research inquiry itself).

Another methodological approach taken forth in developing the approach was the grounded theory method (GTM), in which the inquiry evolves through encounters in data and connects to various components of interest that emerge in the process of research; "all is data" (Glaser, 1998, p. 9), including theories and personal reflections.[81] In GTM, similarly to the case study as a method, propositions are tested on data. While a similar process of pattern matching is

[81] In GTM there is also a variety of views on the process, and in respect to many of them, this research can be only loosely interpreted as GTM.

undertaken in GTM, the scope of the reflection reaches further from the data to include theories and their conceptual elements. GTM helped to connect the various elements of the inquiry into one process, and the findings to one framework.

Grounded theory methodology

GTM is an approach to research originally defined by Glaser and Strauss, in their seminal work *The Discovery of Grounded Theory* (1967), as "the discovery of theory from data" (p. 2). GTM "was designed to open up a space for the development of new, contextualized theories" (Willig, 2013, p. 69). GTM produces theories that are "grounded" in the data, "specific to the context in which they had been developed" (Willig, 2013, p. 69). Grounded theory as theory "is the end-product of this process," providing "an explanatory framework with which to understand the phenomenon under investigation" (Willig, 2013, p. 70).

In GTM, "all is data" from the "briefest of comment to the lengthiest interview, written words in a magazine, books and newspapers, documents, observations, biases of self and others" (Glaser, 1998, p. 9). The three basic elements of theory generation in GTM are sampling data, coding data, and writing memos (Glaser, 1978). Its research approach is built upon two key concepts: constant comparison and theoretical sampling (Glaser & Strauss, 1967). Similarly, in this research, the development of the structure and the identification of the units of analysis have taken place in the course of the work, and each step taken in the data gathering has refined and iterated the approach for the next one. Furthermore, my analysis has been based on the interplay between various materials, findings, and researcher's field notes. This work was not, however, guided by GTM methodology from its beginning; nor was GTM followed robustly in the data assessment.

However, as my research combines perspectives from several discourses, the assessment of the case is very fitting to the scope GTM. In respect to GTM, although there have been a lot of violations of the Glaserian methodology (Glaser, 1978), several key ingredients are in their proper place. Hence, I perceive GTM as a valuable ingredient in my toolbox for both data assessment and the overall structuring of my approach. Perhaps the GTM methodology defies the positivist logic — or even the constructivist's — but it seems fully compatible with reflective and thus dialectic reasoning in CHAT and with translations in networks as in ANT, and with the postmodern understanding of fluidity in science and discourse in general. This perspective understands knowledge as a result of a progressive but sometimes also abrupt development, and its quality as somewhat larger than simply matters of fact and fiction.

Grounded theory is used as an inductive method to structure the inquiry along the areas of interest identified as the research has progressed. Although not that rigorously, in this work GTM is visible in how the results of the data gathering have contributed to the inquiry itself (for example, interview topics): on the way, the inquiry that was based on CHAT constructs was expanded with concepts of interest emerging from studies in PT and ANT, such as translation and

hybridization used as constructs of interest in interaction between phases of activity. Furthermore, the three phases of CS interaction have themselves emerged as new concepts, albeit similar to existing models, and in parallel to the approach to the interprofessional design process in general (see Chapter 2). However, in utilizing CHAT as the main guiding theory — although the process of research has in many ways also been unorthodox for a CHAT process — this work distances itself from GTM as it would be rigorously performed (with no guiding theory at all).

Mixed methods for organizational practice research

The theoretical and methodological approach taken forward in this research can also be described as a multilevel research approach, a fitting approach to study hierarchically nested social systems such as can be perceived to exist in education (Hofstede, 1995; Hüttner & van der Eeden, 1995). As discussed, in this research the systems of focus relate to learning, teaching, and management, with different motivations to involve themselves in CS activities. In many respects, this understanding also resulted from the data itself. Consequently, in assessing data, this research utilizes mixed methods research, referring to a research mixing qualitative and quantitative data, several methodologies, and also possibly several theoretical paradigms (see, for example, Johnson & Christensen, 2014).

According to Johnson & Onwuegbuzie (2004), mixed methods research can be perceived as a "natural complement to traditional qualitative and quantitative research" (p. 14). The two major types of assessment in mixed methods research are mixed-model designs and mixed-method designs, the former focusing on constructing analysis "by mixing qualitative and quantitative approaches within and across the stages of research," the latter on "the inclusion of a quantitative phase and a qualitative phase in an overall research study" (Johnson & Onwuegbuzie, 2004, p.19).

A crucial feature of mixed methods research "is its methodological pluralism or eclecticism" (Johnson & Onwuegbuzie, 2004, p. 14). Johnson and Onwuegbuzie (2004, p. 16) link mixed methods to pragmatism as its "philosophical partner." In their view, the pragmatic approach manages to transcend the idealist and materialist research discourses. According to the authors, "taking a pragmatic and balanced or pluralist position will help improve communication among researchers" (Johnson & Onwuegbuzie, 2004, p. 16). With the academic context as a focus of research action, they conclude how mixed methods research has "a great potential to promote a shared responsibility in the quest for attaining accountability for educational quality" (Johnson & Onwuegbuzie, 2004, p. 24).

Synthesizing an integrated approach

Activity theory (CHAT) follows the constructivist approach taken in ANT, but takes it to describe activity through a rather positivist, simplified model. It thus acknowledges both intentional action (subject and object) and human abilities (limitations, social dimensions), as well as rules, communities, and tools (similar to a positivist process) as simple and self-evident concepts, whereas ANT

emphasizes full symmetry — to "employ the same analytical and descriptive framework when faced with either a human, a text or a machine" (Cressmann, 2009, p. 3) — for all the components equally. However, CHAT should not be understood as a philosophical stance, but rather as a tool for modelling interaction. Still, the CHAT approach remains sufficiently constructive and flexible, as activity systems and their addressed components are not fixed, but always on the move. Their movement and meaning are frozen in time for assessment and development activities.

In contemporary discourse on interprofessional practice, the interplay between artifacts and human collaborators is discussed, and while different models exist, the early ideas on progressive education in Dewey's work underline how new knowledge is emerging through the interaction between the two elements (see section 2.3.1). However, to take into account the complexities in contemporary knowledge-building activities, artifacts may call for further interpretation. Similarly, in the CHAT view, a "specifically human type of consciousness is needed" to make sense of "associations between heterogenous entities" and to create "new assemblies of materials and humans" (Miettinen, 1999, p. 177). In this view, the ANT approach becomes contested in "decision-making [...] under uncertainty and complexity," as this process emphasizes the separation between "intangible [...] information which is inert, passive and classified as non-human" and "human agents who are active and capable of making complicated decisions" (Lopes, 2011, p. 311).

In his research focusing on decision-making under uncertainty, Lopes (2011) utilizes ANT objects in assessing the interview data and in structuring new theoretical constructs through a GTM process. In his work, the GTM process produces main categories that link with ANT conceptualizations of inscription, translation, and punctualizations (see section 2.1.1). Similarly, in CHAT both the contributed information and the artifacts used in the collaborative process are in focus, but a distinction is made between human actors and their environment.

In developing the inquiry for this research, the focus is on an activity where a group of actors undertake an exercise of collaborative framing and re-framing (as in Ylirisku, 2013) and utilize processes such as translation between epistemic approaches and perceptions of the activity. The development of artifacts, tools, and instruments (to support the process of design and as outputs of interaction) is an essential part of collaborative design activity. In this respect, CHAT offers the main components of the inquiry.

3.2.2. Development of the inquiry

In brief, this research builds on understanding from activity theory, developmental work research, and an expansive learning approach, but develops toward a community approach with a focus on several interconnected systems. It utilizes mixed methods of analysis with a large set of data and interviews from a particular case study. The method of analysis is based on GTM with thematic coding familiar to most qualitative research, and a cultural-historical analysis (as in CHAT) through which the findings in the assessment are related to the context of the interaction. At the end of the work, these findings are structured around a CHAT-based framework to suggest improvement for interprofessional design education for sustainability.

Systems of activity in CS

The focus on practices of interaction in developing and implementing CS — and the communities that are in interplay — remains a main inquiry of this work. Besides the focus of analysis of interaction between disciplinary fields, actor groups, such as the CS initiators, teachers, and students, are studied as separate actors. Finally, in developing an educational program, activity systems can also be understood to be based on the phases of development and implementation in setting up a program for teaching, its implementation, and the learning activities in such collaboration.

Identification of the important actors and activities to be incorporated into the analysis is an essential step in building an understanding of a complex system: such structuration helps to identify the shared motivations and plausible conflicts within their hierarchical interactions. In this study, these actor groups are identified as the CS initiators, educators, and students. Initiators are the actors involved in managing the program, mainly the program directorship and professors involved, but also the department leadership distant from CS, and even the teachers and students taking the lead. Educators are the actors involved in shared CS teaching and its development, involving not only teachers and professors, but also students taking peer learning and teaching roles. Lastly, students reflects the activities of students learning to become disciplinary professionals and experts of practice, but also on the more experienced members of the CS community developing their professional practice.

In approaching the CS interaction, the focus is on several areas of interest. Planning and strategy, content development, the role of discipline and personal history, and various experiences of learning transactions in the support, oversight, and evaluation are addressed. At the center of these systems is a shared space for discussing the motivations and objectives of activity, along with reflection on the communities involved and their rules and conventions (see Figure 15).

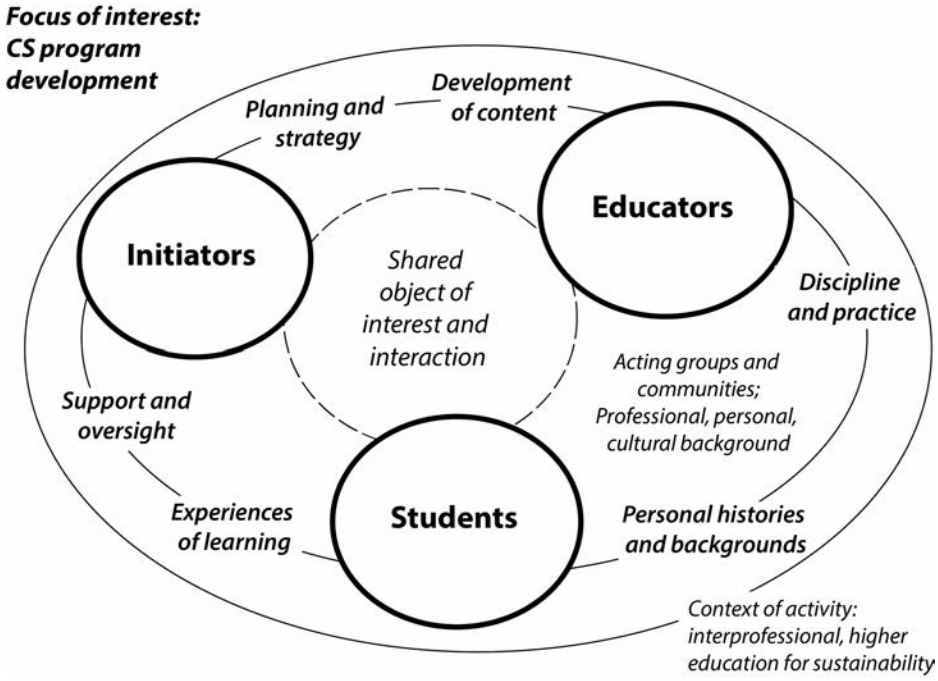


Figure 15. *Identifying the initial analytic elements of interest.*
Source: Author

In general, the CS community in Aalto University represents a kind of community of practice in itself — a group of people who share an interprofessional practice for sustainable design. CS, however, also brings various epistemic perspectives together into a shared dialogue, connecting different communities of practice into a broader community of interest (cf. Fischer, 2001) with common motivations regarding the focus of work. In relation to communities of practice (Lave & Wenger, 1991), the communities of interest (Fischer, 2001; see section 2.1.1) gather various groups of practitioners under a shared focus of interest. In approaching looser and more informal constellations, a concept of assemblages (Deleuze & Guattari, 1987)[82] seems more fitting, also emphasizing the rhizomatic development of new knowledge, exemplified by relations in dynamic networks of interaction and information sharing. As a result, new units of analysis are offered, such as the interaction between professional fields themselves (interdisciplinarity) and within projects (as in Blunden, 2010; see also Ylirisku, 2013).

In CS, different actors are involved in different phases of the program development and implementation, and such units of analysis can be found in the CS preparations phase, in the implementation and development of the program, in its experience as a participant, and in perceiving the development of the CS program as a project in itself, as an interprofessional learning inquiry into sustainability.

[82] As discussed in García Garduño (2017).

Temporal phases in CS interaction

Following the institutional structures and roles in academia, activities in CS development and interaction can be structured into three phases of activity: priming, implementing, and experiencing, as explained in Chapter 4 (see section 4.2.2). These phases of activity take place on several levels in the program, with actors and activities overlapping to an extent. These three also act as phases in developing interprofessional activity in academia in general, as each phase has specific aspects that become especially important in the interplay between various disciplinary approaches in an academic setting.

Firstly, priming takes place both in priming collaboration for CS management and implementation, and within a project and a project team, as well as in developing the program contents in general. In the context of sustainability, and in interprofessional collaboration in general, priming becomes important so that shared goals of activity, language, tools for implementation, and measures of success are identified and the inquiry can begin.

Implementing takes then place, when the stage is set and a shared problem space has been initialized for interaction. Such implementation happens when ideas on course contents and activities are put into action, constrained by the roles of actors and structures that dominate the background. In approaching interprofessional sustainability, these processes — and the transparency and shared agency in relation to them — become crucial.

Lastly, experiencing happens when all is set up, and participants are involved in the teaching and learning activity itself. In interprofessional collaboration and learning, however, there is a special demand for collaborative reflection. Furthermore, as the participants themselves become experts in the interaction, there is a need for better evaluation and feedback, also made on collaborative basis.

Whilst this structure was developed during the analysis itself, in the end it helped to structure the overall findings. In summary, to structure the interaction in interprofessional, interdisciplinary collaboration, and in interprofessional learning in general, the activities can be perceived to occur in three phases, through priming, implementation, and experiencing (see Figure 16). The three phases of interprofessional, transdisciplinary collaboration together form a PIE model for interprofessional collaboration and learning.[83] The collaborative meaning-making takes place within this framework.

[83] This term is admittedly humorously put, but it is theory-driven and well justified in relation to empirical analysis. While considered genuinely useful and important in approaching interprofessional collaboration, the concept is still also catchy enough to be remembered in future action.

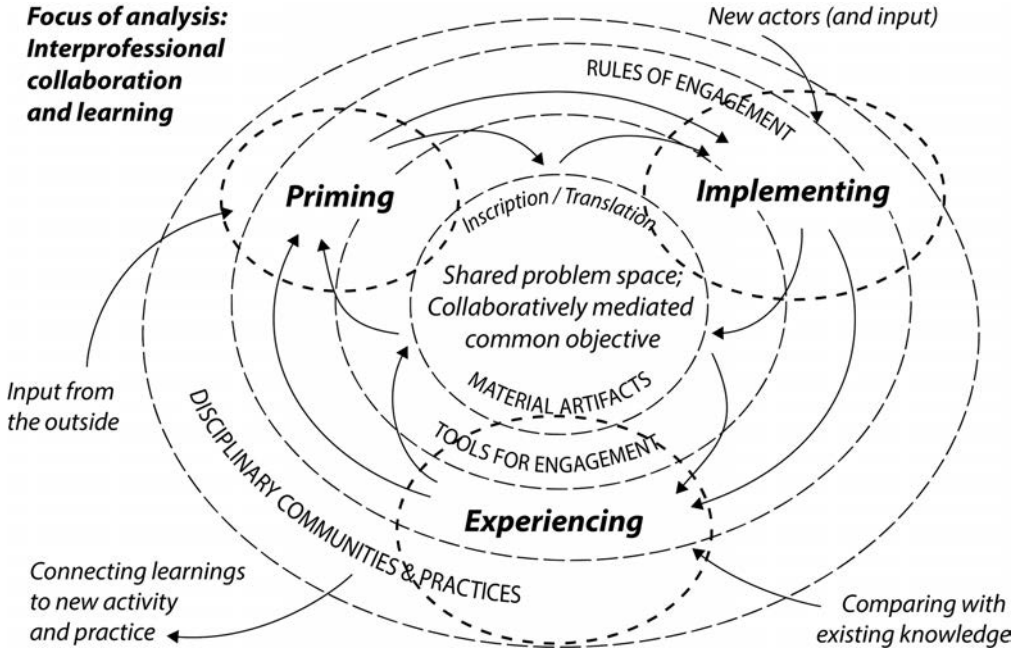


Figure 16. *The dynamics in three phases of interprofessional learning.*
Source: Author

One weakness of CHAT-based analytical reflection is the challenge of connecting several interacting activity systems together. If these connections are described with a "series of triangle diagrams," there emerges "a misguided impression that each activity was isolated from one another" (Yamagata-Lynch, 2007, p. 473). In this work, this challenge was overcome by letting go of the triangular diagrams and instead using only the conceptual nodes. These nodes were then expanded with notions from other theories. In this view, the interaction between the temporal phases also connects to the dynamics between various actor groups. At the outset reside the involved communities, practice, and outside actors; at the core, there exists a shared objective; and in between, activities (and rules, division of labor, etc.) are in interplay among the selected tools and instruments to support interaction.

Developing the analytical framework

The breadth of the context in interprofessional design and sustainability introduces a multitude of theoretical sources to this work. GTM (Glaser, 1978) aims to consolidate theories together through comparisons between them and the emerging data. Naturally, all the presented theories have their own complex histories and means to practice them, but these are not revisited in great detail in this work. Rather, insights from the theory are used to compare different approaches, develop connections between categories and constructs, and develop an integrated understanding of the lens in this assessment. In a GTM process, the aim is not so much to develop existing theory, but to create grounded theories

that are context-driven and categories abstract enough for generalization. However, this work also aims to develop practice in managing education, in teaching and learning, and in design action itself.

The notions from contemporary theories on meaning-making (as revisited in Chapter 2), despite their differences, align in a similar manner, emphasizing reflective processes between actors, networks, or communities, and the material, semiotic (or even tacit) activities. Since 2011, however, the CHAT elements have been identified as the main components in the assessment (see Marttila, 2012). After encountering CHAT in theoretical studies, more emphasis was put on the activity taking place around the introductory CS studies (i.e., the setting of instruments, tools) with a focus on studying the interaction between different professionals, and on the student-teacher interaction and teacher perceptions of the program and its leadership (i.e., activity systems, communities). The educator interviews addressed the development of the course content (i.e., history, background), and its structure and modes of working (i.e., rules, roles, division of labor). Also addressed were the progress of the course and learning processes, including tools and methods used, with an interest specifically in disciplinary variations and meaningful moments of learning. Discussions included reflection on CS as a context of action, and interprofessional design collaboration and sustainability as its context.

As a result, the CHAT-based but GTM-type development of the inquiry in this work is supported by concepts emerging from supporting theories (e.g., PT and ANT), with concepts such as translation and hybridization used as constructs of interest in interaction between phases of activity. The findings are then assessed through the CHAT framework, and eventually structured as a cycle of development in building and developing an interprofessional study program. Lastly, to understand the processes that are important, the focus is structured along the phases of program development and implementation, and the dynamics connecting these phases together.

Progress of data gathering and assessment

The main research data consisted of three sets of interviews spanning several years (2010–2015). Eventually, through the encounters in theory described, the lens for assessment was formed, based mainly on categories and the scope of analysis familiar from CHAT.

The initial general areas of interest in the assessment were the planning of CS content and strategy, and the development of the CS studies. Gradually, based on the encounters at the beginning of the study, the focus moved toward roles and practices in contemporary higher education, and disciplinary and personal factors. Eventually, the focus moved toward the building of professional experience, and experiences on learning in general, also addressing the support and oversight of the program.

From the beginning of the research, the idea was that some students would be interviewed closer to the end of their studies. The specific sample selection, however, remained open for some time. Eventually, as various student-driven activities were initiated (see section 4.3.1) after encountering student interest in developing CS, a set of interviews was implemented with selected students involved in these activities. Thus, the student interviewees were selected according to their involvement: in this sense, only students involved in CS activities were interviewed. In the student interviews, questions related to the specific CS activities in development, but also to more general motivations for being involved in developing the CS community, and perceptions on being a CS student in general. In summary, the conceptual journey to structure the lens for assessment can be seen in the research inquiry development timeline, along with the gathering of main sets of data (see Figure 17).

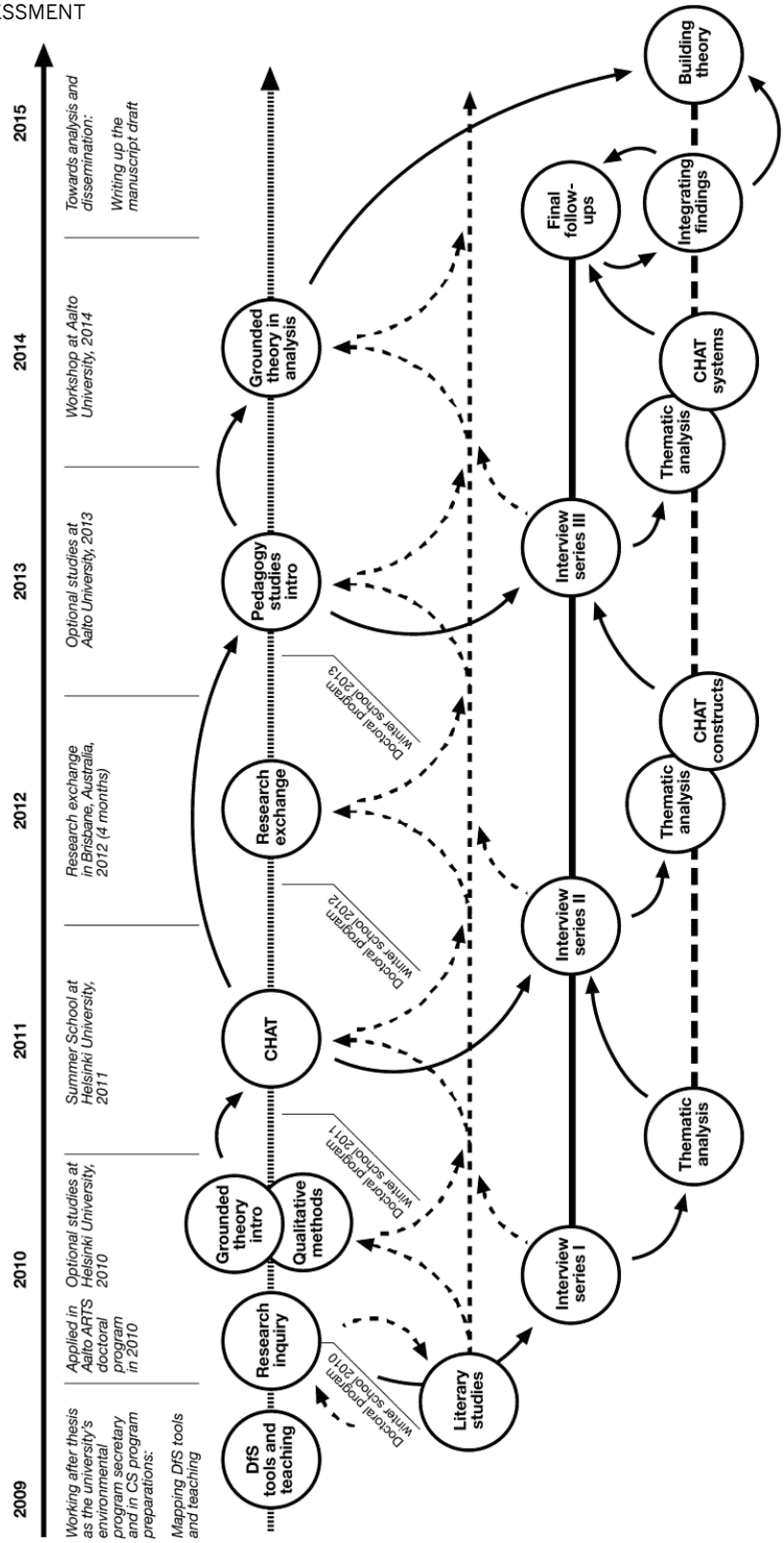


Figure 17. *Timeline for the development of the research inquiry and gathering of data.* Source: Author

3.2.3. Revisiting the research questions

As described in the introduction to this work, the initial research focus related to the types of tool and communication used in interprofessional design for sustainability. Early on, it became obvious that the challenge is more complex: even the definition of these depends of the context and community. As a result, the main terms "design," "sustainability" and "interprofessionality" were analyzed further: the way these terms were used depended on the context and purpose, and they kept taking on different meanings in relation to different discourses.

Consequently, the breadth of the general inquiry kept expanding. Various sub-inquiries were introduced, and the initial research aim extended further toward institutional and professional questions on roles and processes.

The overall inquiry and the methodological insights have developed during the implementation of the research. The process that begun as mapping DfS teaching and the tools utilized in the university progressed to become an inquiry into the development of interprofessional design education. In this sense, the research has fed into the inquiry, and elements from earlier research in several discourses have been integrated into it after encountering these while gathering data.

Summarizing the research inquiry: how should interprofessional design education be approached and improved?

Interprofessional interaction has already been a part of design activity for some time. Design action is, by its nature, interdisciplinary, as all participants are involved throughout the design process, and the outcome is a product of their collaborative effort, born as a product of the gradually aligned collaboration. In the context of sustainability, however, different approaches to meaning-making must be supported or even advocated further.

When considering sustainability as the general field of action, however, a few things become important. First of all, sustainability as an area of action calls for transforming the unsustainable status quo. Often this calls for more critical reflection based on a wider range of perspectives, emerging not only from the professional "expert" domain, but also from laypeople's views of progress. In this sense, approaching interprofessional design education within the field of sustainability also calls for a transdisciplinary approach wherein the initial grounding for the work (content, structure, setting) is opened for further debate.

In the academic context, this opens up a new arena of interaction: the development of learning itself. It seems evident that in assessing education, not only the topical choices of study content, but also the physical, disciplinary, and institutional (contextual) constraints, and the regulative processes (such as the evaluation of learning) must be addressed (cf. Miettinen, 1990). As these aspects emerge within the cultural and historical developments, a critical cultural-historical approach in the analysis (Engeström, 1987) helps to understand them.

In approaching data, encounters from theory aid in structuring the sub-questions. For example, the materials in PT (Shove et al., 2012) relate to the instruments that are used to aid activities (CHAT), but also to disciplinary knowledge that is constituted through actors and actor-networks (ANT). Activities take place in communities of practice (Lave & Wenger, 1991) that are emerging from disciplinary groups, but also groups based on academic roles, and even from assemblages (Deleuze & Guattari, 1987) that can focus around a shared interest, evolving into communities of interest (Fischer, 2001). In such a setting, learning can seek higher levels (Bateson, 1972) and become expansive (Engeström, 1987).

Lastly, in the study of sustainability, the dichotomies of modernity also have to be addressed, ranging from inquiries on the relations between man and nature, and technology and progress, and between the educator and the student. Furthermore, in approaching an educational program — especially in the field of interprofessional sustainable design — all the contributors have their views of the process and their perceptions on best practices. In approaching learning for such design action, even more attention has to be paid to the roles and tools in collaboration; and yet, in this process, the hybridization of perspectives can result in new learning, leveraging both ends of the spectrum.

Refining the research questions

In approaching the collaborative creation of knowledge, it becomes obvious that key questions in its making involve inquiries on participation, access, and ownership. As a result, when approaching education for interprofessional design for sustainability, it becomes crucial to discuss how the collaboration is set up and who gets to define the main topics of focus.

In this sense, the broadness of sustainability as a context calls for various inquiries on how and why some actions can come about, and these questions also become visible in (and can be connected with) the findings from the literature review.

However, to structure the process of data gathering, the general research interest is refined and divided into four specific research questions (see Table 12) grounded on the main components of the background research (Chapter 2) to be used in guiding the actual analysis and structuring the findings.

Table 12. *Developing refined research questions.*

Field of interest	Literature with areas of general inquiry		Research questions
	How should interprofessional design education be approached/improved? (Context = sustainability)		
Transformative sustainability	Sustainability imperative	• How to address urgency? • Sustainability as a balancing act	Research question #1: How is sustainability argued for and/or efforts legitimized, and who should be involved (and where)?
	Sustainability as a concept of modernity	• How to address tensions between conflicting concepts?	
	Capabilities for sustainability	• How to promote dialogues for equality? • How to ensure skills?	
	Transition management	• How to advocate change? • Niche and landscape	
	Transdisciplinary (design) dialogues	• Who to involve? • Experts' versus laypeople views?	
Design professionalism and practice	Design methods	• How to understand process (inputs and outputs needed)?	Research question #2: How has design profession and practice evolved to face the challenges of sustainability, and what insights can it offer to collaboration and transformation?
	Levels of focus in design	• Where to focus? What to connect together?	
	Sustainable design processes and tools	• What possibilities exist? • How to promote responsibility	
	Collaborative design	• What considerations and processes to emphasize? • What tools to utilize?	
	Designer responsibility	• How to structure design collaboration? • What is the designer's role?	

Table 12. *(continued...)*

Field of interest	Literature with areas of general inquiry		Research questions
	How should interprofessional design education be approached/improved? (Context = sustainability)		
Interprofessional collaboration	Interdisciplinary studies	• How to set up interprofessional collaboration? • What skills are needed for collaboration?	Research question #3: What type of competence is needed in crossing professional boundaries, and what are its conditions and consequences?
	Transdisciplinary studies	• How to promote transdisciplinary outreach?	
	Communities and practice	• How to identify interacting communities? • How to improve practices and interaction?	
	Actor-network theory	• What is the relationship between material artifacts and human actors in the process?	
	Activity theory	• How to identify potential conflicts and gaps in activity?	
Interprofessional learning for sustainability	Learning and social justice	• How are power relations addressed and opened up?	Research question #4: How are the processes, roles and outcomes of learning and development conceptualized and managed in interprofessional higher education for sustainability, and how does this affect the practices of teaching and learning?
	Constructive learning	• What methods and tools support interprofessional learning?	
	Expanding learning	• How to promote higher levels of learning? • How to promote horizontal boundary-crossing?	
	Priming, framing and reflection	• How and through what phases are reflection and mediation collaboratively performed?	
	Learning in systems	• How to assess components in education and learning?	
	Transformative learning	• How to promote learning for transformation?	

Based on findings from the four contexts of interest in the literary studies, the general research inquiry is elaborated further into four specific research questions (as in Table 12):

- *How is sustainability argued for and/or efforts legitimized, and who should be involved (and where)?*
- *How has design profession and practice evolved to face the challenges of sustainability, and what insights can it offer to collaboration and transformation?*
- *What type of competence is needed in crossing professional boundaries, and what are its conditions and consequences?*
- *How are the processes, roles and outcomes of learning and development conceptualized and managed in interprofessional higher education for sustainability, and how does this affect the practices of teaching and learning?*

Answering these questions will create further understanding to respond to the secondary goal of improving such education.

The latter part of this work delves into assessing these questions through the data gathered during this research. In the next section, the data are introduced in detail and connected along the three phases of interaction. In Chapter 4, the data are assessed qualitatively to identify important themes in different phases of interaction. Lastly, in Chapter 5, the findings are structured from the perspective of the overall interaction and the CHAT-based framework to provide insight into the temporal dynamics and constraints in the activity. The aim is to answer the above questions in Chapter 6.

3.3. Data and Materials

The research is performed mainly with the support of three sets of interviews conducted with the initiators of the program, held in Spring 2010 before CS started as a major; with selected educators in 2011–2013; and with selected CS Design students in 2013 (with some follow-up to 2015). These data are supported by a multitude of other materials, including researcher's field reports and written background material.

Three groups of actors and phases of interaction in focus

At the beginning of the research, the focus was on the start of the CS major. After the program initiation, the focus moved to the implementation of shared studies, and finally to the emerging activities in developing the CS program and community, and the learning that was taking place. As a result, the general inquiries in the three sets of interviews that were conducted were, respectively, on: 1) how the agenda for the program is set; 2) how the shared, introductory CS studies are set up and implemented and what the results are; and 3) how students of CS Design experience this setting. The focus of the research and data gathering was thus first on how the initiators of the program described their efforts, goals, and motivations; the interest then moved to look at how the educators were able to implement the preferred teaching. Lastly, the work studied how these developments connected to students' perspectives of the program, its main topics (sustainability and the interprofessional design process), and their future profession (see Figure 18).

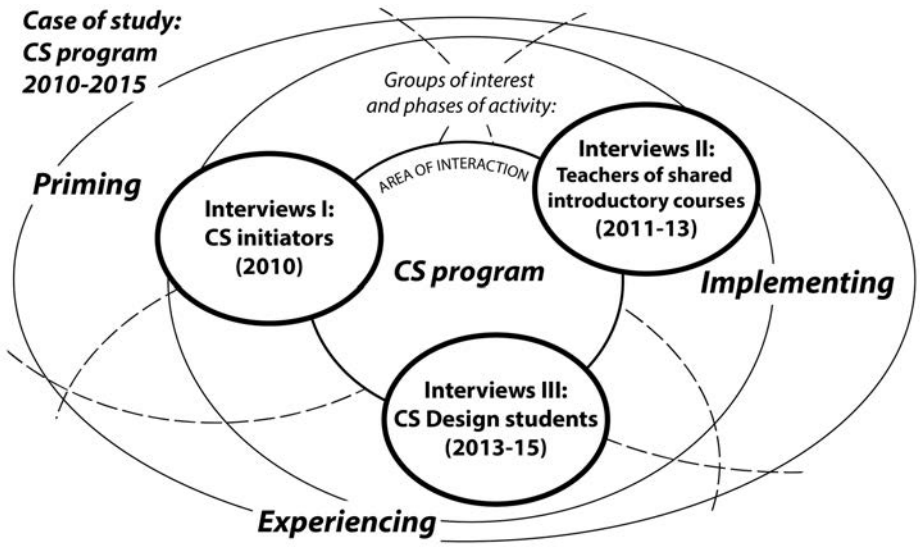


Figure 18. *The interviewed groups of interest through the phases of activity in developing and implementing CS studies.*

Source: Author

The encounters in the program pointed toward three specific types of role and activity in relation to the institutional constraints, including professional roles in academia and the schedules of academic planning. Initiating a program is essentially a higher-level activity involving experienced professors, and yet in implementing studies, these professors might not be present. Furthermore, teachers meet students only during the courses, while students perceive each other's learning journey far more extensively. And yet each course also represents a learning journey for its teacher. While these three phases — initiating the program, teaching and implementing it, and experiencing it as a student — can be seen to progress chronologically, they naturally also overlap, and the program agenda is iterated, management evolves, and experiences differ depending on the annual setting of projects and content. A similar cycle of activity exists in developing study courses and projects.

As a result, like the interviews, the analysis is structured along these phases: this research refers to them as priming, implementing, and experiencing. As phases of activity in developing interprofessional and transdisciplinary knowledge for sustainability, these three phases are also enforced through the roles and institutional structures in the contemporary academic setting (Figure 18). Similar phases of activity were identified in the teacher interviews and in student-initiated project collaboration as the general sequences of structuring interprofessional education and learning.

Interview data and coding

The interviews were implemented in three stages, resulting in three sets of data, their focus ranging from CS initiation to implementation and experiencing it as a CS Design student. Gradually, the understanding developing in the three sets of interviews evolved into three categories and phases of activity in approaching interprofessional knowledge-building for sustainability in higher academia.

Table 13. *Interview data series I–III, 2010–2015.*

Interview series	Time period	No. of interviewees (+follow-ups)	Interview codes*
Interviews I: initiators	2010	4	#1–#4
Interviews II: educators	2011–2013	8 (+2)	#5–#12
Interviews III: students	2013–2015	6 (+2)	#13–#18

* Interviews with follow-ups are marked as #6a, #6b, and so on.

The interviews (see Table 13) were implemented in a mostly casual manner, but supported by a document with questions following a thematic structure, given to the interviewee during the interview (see Appendices 1–3). Analysis of the interview materials was conducted as thematic coding.[84] Initially, the different sets of data were reflected on independently, decoded using a number of codes (see

[84] A thematic code in qualitative research is usually "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute" (Saldaña, 2015, p. 3) to the data.

Appendix 5). Gradually, in line with the GTM process (see Willig, 2013), the various codes were merged into thematic labels depicting the overall "patterns of action and consistencies" (Saldaña, 2015, p. 5). The process of analysis altogether identified 15 thematic labels from the three sets of interviews, supported by three labels that emerged from contextual observations. Finally, as the interplay between actors was assessed in a shared system, the 18 individual labels were integrated into five main thematic categories (as in Chapter 4), and then reflected on in the phases of priming, implementing, and experiencing learning in CS (in Chapter 5).

The overall process of analysis also included extensive deliberation. Its various phases included literary excursions and the codes merged through reflection between data and theory. In this sense, the coding process remains "primarily an interpretive act" (Saldaña, 2015, p. 4). However, through the interplay between various materials, the five main thematic categories depict (albeit on a general level) learning sustainable design in the interprofessional, transdisciplinary context of contemporary higher education.

Supplementary research data

In addition to the interviews, a variety of supplementary materials were gathered, ranging from historical documents (e.g., in relation to National Innovation Strategy) to CS planning and preparation materials (including course descriptions, etc.), and researcher's field reports and written background material (memos), supported by statistical findings (see Table 14). These materials are included in the thematic findings to support the synthesizing of the identified analytical themes.

Table 14. *Supplementary research data, 2009–2015.*

Type	Data/example name	Time period	Number
Observations on CS activities	Descriptions of projects and activities	2010–2015	7*
	Field notes	2011–2015	27*
Written documents	Program planning documents	2009–2015	19
	Course description documents	2009–2015	12
Student questionnaires and feedback	Course questionnaires	2010–2012	4 (courses)
	Student feedback on courses	2010–2013	4 (courses)
	Student feedback on program	2013–2015	13
Statistics	Statistics on applicants	2010–2015	5 (years)
	Statistics on studies (CS Design students)	2010–2015	5 (years)

* These are shared documents: altogether 27 notes, of which seven describe activities, projects, or events.

3.3.1. Interview sets I–III: from priming to implementation and experiencing

In Spring 2010, CS had been operating as a minor study program for almost one whole term, and curriculum preparation and funding were almost ready for the CS major. Following these preparation processes, the first interviews were conducted. This stage included four in-depth interviews supported by a survey form.

In the second stage, the educators, or teachers of the shared courses, were interviewed. This happened after the CS major had already been initiated and operated for more than a year, and included eight interviews with two follow-ups. This time, interviews were organized as discussions around predefined themes, focusing on the experiences of teaching and on interprofessional sustainability as a context of action. As in this stage the program had been running for more than a year as a major, the development of CS was also discussed.

In the last stage, students of the CS Design program were interviewed after their first or second year of study. The students were selected for interviews based on their roles in certain student activities encountered in CS. This stage included six interviews and two follow-ups, with continuation until 2015. The idea was to gather understanding of these activities and the students' involvement, and of how students connected to the knowledge-building and development in the program in general. Perceptions of important learning and the experiences of the learning journey in CS were also discussed, along with motivations and personal background. Lastly, CS as a community was reflected upon.

Interviews I (2010): CS initiators setting the stage

The first stage of the interviews concerned the initiators — the professors and academics who were involved in the preparations for the Master's program. In these interviews, the focus was on understanding different approaches to urban sustainability and the possible professional differences in these approaches, and on understanding the setting in which the CS program would be grounded.

The interviewees were members of the CS preparations board and mainly in professorship positions (3/4) in two of the four schools that would soon initiate the program (see Table 15). The interviewees were from Aalto University's School of Business (Helsinki School of Economics at the time) and the former University of Industrial Arts Helsinki, that would eventually become the School of Arts, Design, and Planning. The selected interviewees were involved in the CS preparation board and interested in being involved in this research, and allocating their time in in-depth interviews.

Table 15. *Interviews with people involved in CS preparations.*

Interview code	Interviewee background	Interview date
#1	Postdoctoral researcher	10 May 2010
#2	Professor	17 May 2010
#3*	Professor	23 May 2010
#4	Professor, Head of Department	21 June 2010

* Interview translated from Finnish by the author.

At the time, the themes in CS interaction centered on urban sustainability (sustainable solutions for products, services, and living environments in urban context), structured around the threefold dimensional model of sustainability (economic, ecological, sociocultural) and three professional areas involved in the program preparations (industrial management, business management, design and architecture). Consequently, the initiator interviews focused on the roles of different disciplines in approaching (urban) sustainability and seeking sustainable urban solutions (see Appendix 1).[85]

In the talks that covered sustainability in urban contexts and from different professional perspectives, the idea was better to understand how various professionals define the concept of sustainability and locate themselves, and how this connects to the setting up of CS as a study program.

Interviews II (2011–2013): the educators implementing the shared introductory studies

After the initial interviews, the actual launch of the CS program as a major took place in Fall 2010. The focus was on implementing the studies themselves: I was personally involved in teaching CS Design. However, after the first intensive year of the CS major, the focus of my research moved toward the actual teaching contents, too.

During the years 2011–2013, six teachers from the shared introductory courses and supplementary courses were interviewed, along with two follow-up interviews (see Table 16). Two interviews were also implemented with visiting guest teachers (of whom one was also a CS student). The shared introductory program to the CS major consisted of six to ten ECTS depending on the degree program, and ten credits for CS Design students (see sections 3.1.3 and 3.3.2 for details).

[85] The interview structure and two of the first interviews (#1, #4) were planned and implemented together with Cindy Kohtala (see Marttila & Kohtala, 2010); two interviews (#2, #3) were conducted solely by the author.

Table 16. *Interviews with teachers of shared CS introductory courses.*

Interview code	Interviewee role	Teaching activity in focus	Interview date
#5	Teacher, doctoral candidate	Shared introductory course, 2011	20 Dec. 2011
#6a #6b	Teacher	Shared introductory course, 2011	21 Dec. 2011 8 March 2012
#7	Teacher, doctoral candidate	Shared introductory courses, terms 2009–2012	6 March 2012
#8*	Professor, teacher	Shared introductory courses, terms 2009–2012	15 March 2012
#9a #9b	Teacher	Supplementary course, terms 2012–2013	31 March 2012 8 May 2013
#10	Teacher, doctoral level	Supplementary courses, terms 2012–2013	24 May 2013
#11*	Guest teacher	Shared introductory course, 2013	9 Oct. 2013
#12*	Guest teacher	Shared introductory course, 2013	13 Nov. 2013

* Interview translated from Finnish by the author.

The second series of interviews was structured around predefined broad themes that were given to the interviewee a day or two before the interview, and a more detailed document with some supportive questions, given at the interview itself (see Appendix 2). The thematic structure for the teacher interviews evolved slightly further during interviews. Initially (for interviews #5 and #6a) the discussion started with a focus on the general setting of the CS program, with reflection on interprofessionality and sustainability as a context for learning, to be followed by more in-depth inquiries related to teaching and the flow of learning. Later on, the order was changed to begin with details about teaching: only at the end were broader CS concepts introduced.

The interviewed teachers acted in the development and implementation of the shared introductory course content, covering parts of the mandatory shared studies in CS between 2010 and 2013 (and partly later developments, up until Spring 2015). A lot of additional material in the form of student feedback or planning documents was also gathered for use in the overall analysis.

Interviews III (2013–2015): experiencing CS as a design student

The final series of interviews focused on students from CS Design. The interviewees were selected from CS Design because the focus of the inquiry was on the role of design as a discipline and practice, but also because the Department of Design was the organizing party of the shared introductory studies, and both CS operations and directorship were located in the School of ARTS. The selected students had also been active in various CS activities.

The first encounters with active students (2012) were related to the Systems Thinking course and perceptions of the program offerings in general. Later on, the selection of interviewees progressed in a snowball-type sampling,[86] with the early interviewees identifying important student activities and potential future subjects. Gradually, as more informal student activities were encountered, the focus in interviews moved from course content to student community development, also addressing various projects that the students were involved in. Altogether six students were interviewed in connection to various activities emerging from the student community (see Table 17; for more details, see section 4.3.1).

Table 17. *Interviews with students from CS Design.*

Interview code	Student's enrolment in	Specific focus in interview	Interview date
#13	2011	Development of CS courses and content	27 May 2013
#14	2011	Development of CS courses and content	31 May 2013
#15a* #15b*	2010	Development of CS courses and content; CS project at WDC Pavilion	24 June 2013 4 Feb. 2015
#16	2010	Development of CS student community	10 Oct. 2013
#17	2011	Development of CS student community	31 Oct. 2013
#18*	2011	Development of CS student community; CS project at WDC Pavilion	26 Nov. 2013

* Interview translated from Finnish by the author.

The student interviews focused on three themes: activities in CS, motivations to be involved in CS activities, and being a CS student in general. Again, the themes of the interview were shared prior to the interviews, and a more refined sheet with sub-questions was available in the interview (see Appendix 3). One of the interviewees also acted as a CS communications officer at the time, in a position opened up in 2012 after finding in CS management that more emphasis must be put on improving program communications (CS web pages, email lists, etc.) and on interactions with various gradually emerging program activities, both on a more formal (CS development activities) and informal (parties, etc.) level. Another interviewee acted as a student representative on the CS academic board that was initiated in 2012 to follow and develop the program content and outcomes.

The interviewed students were from two different years of intake: the two first interviews (#13, #14) were from the 2011 intake, the next two (#15, #16) from the very first year (2010), and then two again from 2011 (#17, #18). The idea was that these students had already experienced the joint CS studies that were part of the focus of the interviews.

[86] In snowball sampling, each identified interviewee is asked to identify further suitable candidates.

3.3.2. The development of the CS program (2010–2015)

In 2010, when the new program director started, she took over responsibility for organizing the shared introductory studies in CS. As CS was developed into a major degree program for the academic term 2010–2011, the quantity of shared CS introductory studies doubled. This meant also that the existing CS introductory courses were developed into a more established form. Besides the shared introductory content, a growing number of advanced course modules were brought into the program.

CS curriculum development: shared introductory course contents

From the beginning, to emphasize a shared toolbox to tackle sustainability, two main areas of shared studies were identified as crucial, rooted in the transformative systems approach. As a result, the shared introductory CS studies consisted from the beginning of courses called Systems Thinking and Continuous Transformation, focusing on the systems design approach, and sustainability and philosophy, respectively. Alongside the introductive seminar series, these two consisted the shared introductory content already in 2009–2010, when CS was still only piloted (see Table 18).

Table 18. *CS minor shared study content in 2009–2010, piloting CS major.*

Course name	Study period (I–IV)*	Responsible teacher(s)/school	Credits (ECTS**)
CS workshop and seminar series	I-IV	Eija Nieminen / ARTS	1
Systems Thinking***	III-IV	Aija Staffans, Nina Tallberg / ENG, Real Estate Katri-Liisa Pulkkinen / ENG, Architecture	2
Continuous Transformation	IV	Maija-Riitta Ollila / BIZ	2

* The study periods as listed here were confirmed in their current structure in 2011.
** The ECTS grading scale is defined in the European Credit Transfer and Accumulation System (ECTS) framework by the European Commission; in Finland, one ECTS relates to approximately 27 hours of work. | *** Also addressed as “systemic design” in some program documents in early 2010, and a “systemic approach” to design later in 2012 CS dissemination material.

The Systems Thinking course (originally known as the systemic approach to design) was taken further by a professor from the Department of Real Estate, Planning, and Geoinformatics, also acting as leader of a research group at the Department of Architecture. Two junior researchers from the School of Engineering assisted her in preparing and implementing the course, and another took over for the subsequent years. Continuous Transformation (known as Transformational Change course in the planning phase) was developed and facilitated by another professor, a philosopher and lecturer in HSE and later the

Aalto University School of Business (CS preparation board minutes, May 2009). Its initial topics were "sustainable philosophy and ethics" (CS preparation board minutes, May 2009). The course aimed to establish the mindset for sustainable transformation and action, and was later split into two parts, the other explicitly focusing on creating the mindset.

During the minor program (2009–2010), CS hosted a ECTS-long introductory series of talks, mainly with rather high-profile visitors (e.g., Minister of Environment) as guest speakers in studia generalia-type open lectures. In 2010, CS began as a major with an introductory course to which all participating programs contributed one session, and then collaboratively facilitated some team exercises on selected topics. Such an idea was also partly based on positive experiences with an earlier cross-school program (IDBM; see note 6). Titled simply Introduction to CS (2 ECTS) and organized by the director, the course lasted for the first few weeks of the program, following immediately after the department-based introductory courses.

For the CS major, new content on philosophical studies on sustainability was initiated, and a new course on creating the mindset of sustainable societies was created. The Continuous Transformation course was developed from a short series of seminars into a more comprehensive workshop with an essay as an output. The Systems Thinking course was divided into two intensive workshop weeks for Fall and Spring terms, and its content expanded. Furthermore, a topical expert was invited to join the teaching and planning.[87] The previous teachers continued as the responsible and organizing partners, but this new teacher introduced a new depth of content through his professional context (see also Ing, 2011). From 2011 onward, the responsibility was again passed on: another systems scientist and professor from the USA[88] took over responsibility as the topical expert and teacher and continued until the end of this study.

By the academic term 2011–2012 (see Table 19), the Introduction to CS course was again redesigned. As a result, the two-credit course acting as an introduction to CS was renamed Creative Teamwork and Project Management, with a new emphasis on preparing students better for team-based project collaborations. During the academic term 2011–2012, the new course was facilitated with two teachers, one a researcher and doctoral student from the Department of Design, the other a lecturer from the Department of Media, both from the School of ARTS.

[87] David Ing, a doctoral student and researcher at HUT (and later Aalto University) since 2003 with a background in IBM Canada and systems science, was invited to join the course development. He also served as president of the International Society for the Systems Sciences in 2011–2012.

[88] Gary Metcalf is also a past president of the International Society for the Systems Sciences (2007–2008). He has served as president of the International Federation for Systems Research since 2010.

Table 19. *CS shared introductory content, academic term 2011–2012.*

Course name	Study period	Responsible teacher(s)/school	Other teacher(s)	Credits (ECTS)
Creative Teamwork and Project Management*	I	Tiina Laurila / ARTS	Cindy Kohtala / ARTS Tarja Toikka / ARTS	2
Creating the Mindset of Sustainable Societies	I	Maija-Riitta Ollila / BIZ		2
Systems Thinking I+II**	II+IV	Aija Staffans / ENG, Real Estate Katri-Liisa Pulkkinen / ENG, Architecture	Gary Metcalf	2+2
Continuous Transformation	IV	Maija-Riitta Ollila / BIZ		2

* Former CS introduction, also working as an introduction to the CS program for all CS degree students. | ** The two parts were titled "Systems Thinking for Sustainable Communities" and "Systems Thinking for Planners and Designers."

Overall, between the academic terms 2012 and 2014, the structure of the shared introductory studies gradually became established in their current form. However, minor changes in the staff and content continued (see Tables 20 and 21).

Table 20. *CS shared introductory content, academic term 2012–2013.*

Course name	Study period	Responsible teacher(s)/school	Other teacher(s)	Credits (ECTS)
Creative Teamwork	I	Tiina Laurila / ARTS	Paola Cabrera / ARTS Angelina Korsunova / BIZ Seungho Lee / ARTS Paula Siitonen / ENG Tarja Toikka / ARTS	2
Creating the Mindset of Sustainable Societies	I	Susu Nousala / ARTS		2
Systems Thinking I+II	II+IV	Aija Staffans / ENG, Real Estate Katri-Liisa Pulkkinen / ENG, Architecture	Gary Metcalf	2+2
Continuous Transformation	IV	Maija-Riitta Ollila / BIZ		2

Table 21. *CS shared introductory content, academic term 2013–2014.*

Course name	Study period	Responsible teacher(s)/school	Other teacher(s)	Credits (ECTS)
Creating the Mindset of Sustainable Societies	I	Susu Nousala / ARTS		2
Creative Teamwork	I	Tiina Laurila / ARTS Susu Nousala / ARTS	Janne Salovaara, Markus Wikholm*	2
Systems Thinking I+II	II+IV	Aija Staffans / ENG, Real Estate Katri-Liisa Pulkkinen / ENG, Architecture	Gary Metcalf	2+2
Continuous Transformation	IV	Maija-Riitta Ollila / BIZ		2

* Janne Salovaara is a CS alumnus (still a student at the time) and Markus Wikholm is his associate from a cooperative called Big Plans Bakery, a sustainability research and action think tank founded by a few CS students together with other interested sustainability professionals from different fields.

Advanced project-based studies

In general, the two main types of CS study content consist of the shared, introductory studies, in which the interprofessional collaboration is established, and the project-based content (or case study-based, as early program documents describe it), to act as a platform to implement the learning and create outreach to surrounding society and business. As described in preparation documents, CS is "utilizing a real case approach [in] projects based on real problems experienced by businesses and government" (CS minor description, 2009). These project cases would be "carried out in multidisciplinary teams" (CS Master's degree program application, December 2009), preparing students for real-world practice. The idea from the beginning was that such project-based content would be offered by each participating department and degree program. Many of these — predominantly CS Architecture and CS Design — were studio type courses, including a lot of tutored but independent group work.

During the first year of the CS program in 2009–2010 — still in its piloting phase as a minor program only — the possibilities were quite limited. Only two degree programs offered study modules with a project case part, and two of the three offered by Department of Architecture were based on existing content (the City Rejuvenated course was new; see Table 22). In this phase, the main CS Design teaching module was combined with both design and business content and titled "Sustainable Design and Business Development."

Table 22. *Core modules offered in CS minor, academic term 2009–2010.*

Organizing university	Course/module name (credits)
University of Art and Design (UIAH)*	Sustainable Design and Business Development (5/15 ECTS)
Helsinki University of Technology (HUT) / Architecture**	City Rejuvenated (10 ECTS) City in Crisis I & II (13 ECTS) Environmental Impact Assessment (10 ECTS)

* Aalto University School of Art and Design from 2010, and School of Arts, Design and Architecture from 2012. | ** Between 2010 and 2011, part of Aalto University School of Science and Technology, then a part of Aalto School of Engineering, after which, since 2012, part of Aalto School of Arts, Design, and Architecture.

During the first few years as a major in three schools between 2010 and 2012, the CS study offerings expanded considerably. Since 2010, CS Design offered two study modules (i.e., course packages) that were also mandatory for CS Design students: the Sustainable Design module (also known as Sustainable Product and Service Design or SPSD) and Design Ethics. Also, several courses in CS Business were added by connecting CS with existing courses. In 2011, the CS program also initiated collaboration with the sustainable global technologies (SGT) program based at the School of Engineering,[89] a multidisciplinary minor program at the Aalto University offering an elective 20-credit special module in sustainable global technologies in civil engineering.

By 2012, the core module offerings in the CS program had gradually stabilized, but with constant small changes in credit and lecture structures resulting from developing curriculums in different departments (several schools were also gradually unifying their study structures), as well as from the topical changes in focal cases and the related research projects. In CS Design, a new module was added as an alternative to Design Ethics, titled Values in Design.

By the beginning of the 2013–2014 academic term (see Table 23), CS Business had started to prepare a "capstone" project course for CS students. This extended, cross-disciplinary project course was partly based on experiences from IDBM, the other cross-school program (see note 6). This new content was also to replace the How to Change the World course project. Another new course was initiated that was very popular from its beginning, titled Design for Government, which was a project course developed by a CS minor alumnus in which Finnish ministries as governmental actors developed interprofessional projects. Finally, in the academic term between 2014 and 2015, only the credits varied: the content otherwise remained the same.

[89] Collaboration with the SGT study program at Department of Civil and Environmental Engineering in Aalto University School of ENG was discussed as early as in 2010, but was established in the CS curriculum only in 2011. The programs, however, do not share joint studies, and SGT is a minor program only. Since 2016, the collaboration has strengthened, and some SGT content is now offered in official CS studies.

Table 23. *Core modules offered in CS, academic term 2013–2014.*

Organizing school / department	Course/module name (credits)
School of Arts, Design and Architecture / Design	Sustainable Product and Service Design (6/12 ECTS) Design Ethics (6/12 ECTS) Values in Design (6/12 ECTS) Design for Government (6/12 ECTS)*
School of Arts, Design and Architecture / Architecture	Sustainable Building Design (10 ECTS) Sustainable Urban Design (10 ECTS) Sustainable Landscape – EIA (10 ECTS)** City in Transition (16 ECTS)
School of Business / Organizations and Management	Corporate Responsibility in Global Economy (6 ECTS) Sustainability Politics and CSR, reading seminar (6 ECTS) How to Change the World: Innovation toward Sustainability (6 ECTS) Business Ethics (6 ECTS) Responsibility Management, book exam (6 ECTS) Sustainable Business and Consumption (6 ECTS) Capstone [project] in Creative Sustainability (6 ECTS)***
School of Engineering / Real Estate, Planning and Geoinformatics	Corporate Real Estate Management (5 ECTS) Real Estate Development (5 ECTS) Real Estate in Theory and Practice (5 ECTS) Sustainable Real Estate Business (5 ECTS) International Land Management (6 ECTS) Game in Urban Planning and Development (4–6 ECTS)
School of Engineering / Civil and Environmental Engineering	State of the World and Development (2 ECTS) Sustainable Communication (2 ECTS) Sustainable Global Technologies; Changing Course (6 ECTS) Sustainable Technologies Studio: Facing Local and Global Challenges (10 ECTS)

* Design for Government was a new elective module from the Department of Design.
** The course was developed from Sustainable Landscape Planning to strengthen the emphasis on environmental impact assessment (EIA). | *** By 2016–2017, the Capstone project course was made mandatory for CS students in both Design and Business.

CS applicants and intake

In the 2010–2014 intakes (see Table 24), the CS applicants applied to the program through four different degree programs, in design (Master of Arts degree), architecture (MSc), real estate (MSc), and business (MBA). Among CS applicants, CS Design has been the most popular degree program from the beginning of CS: there seems to have been a clear demand for such content in design. Each year, the number of applications has been three or four times the number of available positions. Of the participating programs, CS Business has had most difficulties in filling the student quota each year.

Table 24. *CS applicants, 2010–2014 (applications/accepted [available positions]).*

Degree program	2010	2011	2012	2013	2014
Design	41 / 12 [12]	50 / 12 [12]	41 / 12 [12]	47 / 12 [12]	52 / 12 [12]
Architecture	22* / 13 [14]**	51* / 15 [14]**	35* / 12 [14]**	31* / 9 [14]**	53* / 10 [17]**
Real Estate			21* / 6 [14]**	37* / 7 [14]**	37* / 7 [17]**
Business	17*/ 5 [12]	5 / 2 [12]	63 / 12 [12]	30 / 7 [16]	13 / 8 [16]

* Includes both 1st and 2nd priority in applying. | ** Intake quota of Architecture and Technology combined: 10 for CS Architecture and 4 (7 in 2014) for CS Real Estate.

In CS Business, the low number of applicants during the first years resulted partially from failures in advertising and marketing the degree, and communicating its contents clearly; the variation during the following years is also marked by variation in reputation and student perceptions that are nowadays so easily shared on social media or over the internet. Despite a sufficient number of applications in 2012–2013, similar difficulties in fulfilling the applicant quota have persisted.

The number of positions for CS Architecture students was significant. In the Department of Architecture, there were annually around ten positions for CS Architecture students. However, students of architecture are also often very busy and are drawn into professional life before graduation. From the perspective of CS Design, they were not the most visible CS partner. For CS Real Estate, there were only a few students at the start.

Table 25. *CS applicants, CS Design, 2010–2014 intakes.*

Year	Applicants/accepted/started	Male/female*	Finnish/abroad*
2010	41 / 12 / 12	6 / 6	5 / 7
2011	50 / 12 / 12	6 / 6	4 / 8
2012	41 / 12 / 11	– / 11	7 / 4
2013	47 / 12 / 11	2 / 9	4 / 7
2014	52 / 12 / 12	2 / 10	7 / 5

* Of the accepted students who started their studies.

In summary, throughout the CS program, CS Design remained rather popular and has dominated the CS student base. Overall, in looking at CS Design students as a group (see Table 25), it is clear that the students' have varied cultural backgrounds: of the CS Design students between 2010 and 2014, a slight majority has been from abroad (except in 2012 and 2014). Furthermore, there has been a female dominance (in both applicants and intake), despite the fact that male applicants have been preferred slightly in the application process for that very reason.

CS Design credit accumulation and graduation

CS student information, accompanied by statistical data, is regularly gathered by the program and is assessed in this research from five academic terms, between 2010 and 2015. The focus is, however, on CS Design students from the 2010–2012 intakes, and on students' credit and graduation statistics, along with some thesis topics. While the graduation times at the beginning of CS were not that fast, most CS Design students have performed their studies intensively and have often accumulated more credits than are necessary degree-wise.

After the first years of CS, some problems in graduation speed were identified and additional teaching content for the Master's thesis was initiated in 2013 (see section 4.2.1). After the 2015 Spring term, and the end of the period of data gathering, more CS Design students finalized their theses, with four graduates immediately after summer break and six more before the end of the year. As a result, although after five years of the program as a major only 14 had graduated from CS Design, by the end of the 2015 there were 24 graduates. Such a bump in graduations is visible only in CS Design (see Table 26). However, in 2016, there were again only six graduates.

Table 26. *CS graduates (theses published before the end of 2015).*

Degree program	2012	2013	2014	2015
Degree in Design (MA)	–	5	4	5+10 (Spring+Fall)
Degree in Architecture (MSc)	–	–	4	4 (whole year)
Degree in Technology (Real Estate) (MSc)	1	1	3	4 (whole year)
Degree in Business (MBA)	1	5	5	5 (whole year)

Of the 2010–2013 CS Design student intakes, the students who graduated had performed a lot of additional studies and many had participated in advanced study that had not been necessary from the perspective of credit accumulation, but rather based on genuine interest. However, despite this eagerness to participate in various studies, graduation was not always easy. Of the 2010–2013 CS Design student intake, only three of the students had graduated by Summer 2015 despite having taken part in all the necessary study, or more.

For example, of the 2012 intake, while only one had graduated by 2015 Summer, all except one (10/11; one with only 40 ECTS) had plenty of study credits, averaging 106 of the 80 credits needed. Even of the 2013 intake, only one had acquired fewer than 80 credits by Summer 2015. All of the graduates also had a substantial number of additional credits, even more than the other, not-yet-graduated group (see Table 27). Despite the obvious motivation of CS Design students, and their ability and skill in relation to projects, networking, and in developing activities, taking the learning to a thesis proved difficult.

Table 27. *Study points acquired by CS Design students by Summer 2015.*

Students' enrolment year	Average credits points acquired (by Summer 2015)		
	Graduated students (average credits)	Ungraduated students (average credits)	
		More than 80 ECTS	*Fewer than 80 ECTS*
2010	8 (150 ECTS)	4 (94 ECTS)	–
2011	5 (139 ECTS)	6 (103 ECTS)	1 (17 ECTS)
2012	1 (135 ECTS)	9 (106 ECTS)	1 (40 ECTS)
2013	–	9 (96 ECTS)	1 (76 ECTS)

By 2015, the CS program had produced several CS graduates through all of its participating degree programs. The first CS student graduated from CS Real Estate in 2012, the second from CS Business. By 2013, the first CS Design students started graduating. However, only a minority of the 2010–2011 students were able to graduate within four years of study, by the end of the 2014 or 2015 Spring term, respectively (see Table 28).

Table 28. *CS Design Master of Arts degrees granted by Summer 2015.*

Students' enrolment year	Amount of students graduated			
	2013	2014	2015 (by Summer)	Total graduates (by Summer 2015)
2010	3	2	3	8/12
2011	2	1	2	5/12
2012	–	1	–	1/11

Of the six CS Design students interviewed, active in developing CS student community activities and outreach, four had graduated by the end of 2015. While they were not amongst the first CS Design graduates, some of the first graduates were also active in this respect. In the end, there is no correlation visible here. However, three of the first theses were connected with research projects, potentially resulting in more tutoring from superior colleagues (professors and researchers).[90]

[90] The topics of CS Design theses — besides sustainability as a context of activity and research — have been varied, but many of them connect to project work initiated during earlier studies and experiences. Many also connect to the community as a focus of interest and involve the facilitation of collaborative design activity (e.g., in co-design workshops). For more details on CS Design theses, see http://acs.aalto.fi/thesis-works-cs-design/

3.3.3. Supplementary research publications

During the course of this doctoral research project, some contributions from it have been published as conference papers or other materials (such as Marttila & Kohtala, 2010; Marttila, 2011a, 2012; see also Marttila & Kohtala, 2014). In connection to student perceptions of the program, two other earlier conference contributions are worth mentioning, as they can be perceived to be important in developing the assessment itself.

Course questionnaires on interprofessional collaboration (2010–2012)

During the running of two advanced study modules, Sustainable Product and Service Design and Sustainable Urban Design in 2010–2012 (see section 4.3.1), the students' approaches to interprofessional work were studied through short surveys. The analysis was presented in a conference paper (Marttila, 2011a) focusing on students' preferences for tools and processes of design in relation to their disciplinary focus (students were mostly from design and architecture, with some from business). The surveys were conducted to test initial hypotheses about disciplinary preferences and profiles.

Based on the findings from the surveys (Marttila, 2011a; see Appendix 4), the majority view was that in interprofessional design collaboration, the understanding of the problem must be shared. However, in approaching the choice of tools and the process, two fairly equal groups of students were identified in the survey, one promoting a shared process of design (and learning), the other emphasizing a discipline-specific process. This also correlated with the preference in relation to sharing tools across disciplines: those "emphasizing the importance of shared tools" also "emphasize the shared process" (Marttila, 2011a , p. 8).

Another finding in Marttila (2011a) relates to how these preferences develop. In following the respondents from one survey to another, from a course in CS Design to a course in CS Architecture (the surveys were not anonymous), the students' perceptions had evolved, some of them significantly. In this sense, it seems that the disciplinary context of studies affects the students' perceptions perhaps even more than the degree program in the background. While approaches toward the process vary, these approaches are not necessarily dictated by the participant's professional or personal characteristics, but seem to be rather "learned through experience in earlier projects and work" (Marttila, 2011a, p. 10).

Despite its challenges, the interprofessional setting ("multi-professional" in this conference paper) "was perceived beneficial, and even the conflicts were perceived to benefit the participants" (Marttila, 2011a, p. 9). To improve the process, the emphasis has to be on "how the collaborative design process is managed, and how time and resources are shared between the participants" (Marttila, 2011a, p. 10). From 2011 onward, this notion on teaching from the perspective of one's professional practice also contributed to the refined inquiry in the teacher interviews and overall analysis.

Assessing written student feedback (2011–2012)

During 2012 (the second year of the CS major), general feedback was gathered from CS Design students in their second year of study. The survey topics ranged from specific, course-related feedback to overall feedback on motivations and learning. The main findings from this survey are described in an earlier conference paper (Marttila, 2012), but they also complement some findings in this research and shed light on the development of the inquiry.

In the feedback (as in Marttila, 2012), of the thirteen respondents almost all (10/13) mentioned the context of sustainability as one of their main motivations to apply in the first place, but quite a few had an interest in multidisciplinarity as well (7/13). Many of the open answers also seemed to relate to the students' personal or educational history. Interprofessional collaboration was perceived as a rather positive thing in general (8/13). However, the few disagreeing (2/13) had the opposite perception.

At the time, elements from the CHAT lens were also integrated into the research. As such, the paper sought to structure findings from the feedback as conflicts in interaction, looking at the emerging contradictions in relation to the concepts of interest arising from activity theory (see Table 29).

Table 29. *Identified contradictions and areas for development in student feedback.*[91]

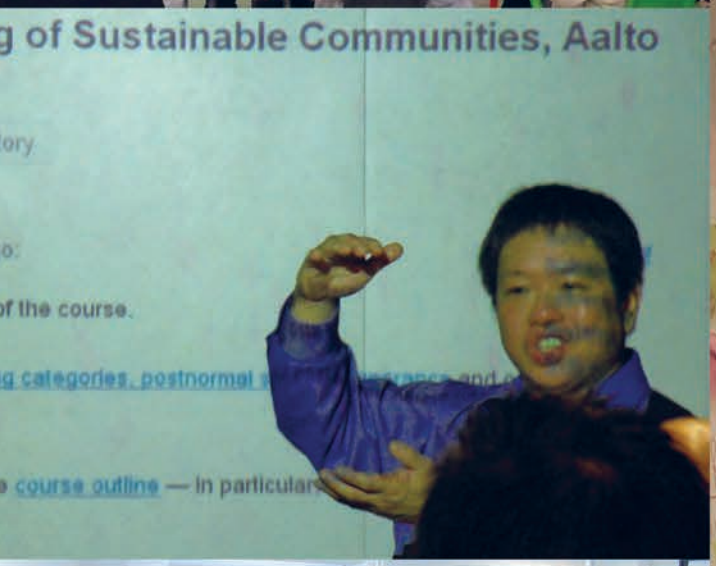
Conflicts in interaction	Example excerpt from the feedback data	Suggestions for development
Contradictions emerging from the shared understanding of the object of action	*"Initially frustrating"* *"Big differences even within the same field"* *"Learning to appreciate different points of views"*	• Starting co-creation activities quickly, to gather experience • To discuss problem setting sharing of tools, values, definitions, and language are needed
Contradictions emerging from the choice of instruments and tools	*"Communicating ideas has become more evident"* *"Discussions have increased the critical thinking skills"*	• Emphasis on skills for co-operation, skills for analyzing and synthesizing • Including systemic approach
Contradictions emerging from the division of labor, rules, and community	*"Not discussing different working methods of different fields"* *"Not enough administrative resources to manage the rich content"*	• Increasing transparency to manage collaboration better

Source: Marttila, 2012

[91] A second phase of the analysis in the paper (Marttila, 2012) was to identify themes for emerging contradictions within the activities, based on CHAT as a methodological framework. As such, it also presented the first ideas of activity theory as the methodological lens in approaching data.

In gathering the feedback, the students were also asked to identify "meaningful learning moments" during their first year in CS (Marttila, 2012). Shared introductory courses were perceived as the most meaningful (8/13). These courses were the ones enabling a systemic perspective and the emergence of a shared problem space (as language and tools to start to adjust), also relating to the choice of tools, outcomes sought, and the management of processes within teamwork.

Overall, as discussed in the next two chapters, the students' experiences created an understanding of important elements in CS interaction. Together with the initiator interviews and the accumulating experiences from encounters with teaching staff, a picture gradually formed of CS as a community of interprofessional interaction, jointly oriented to build knowledge for sustainability action and transformation.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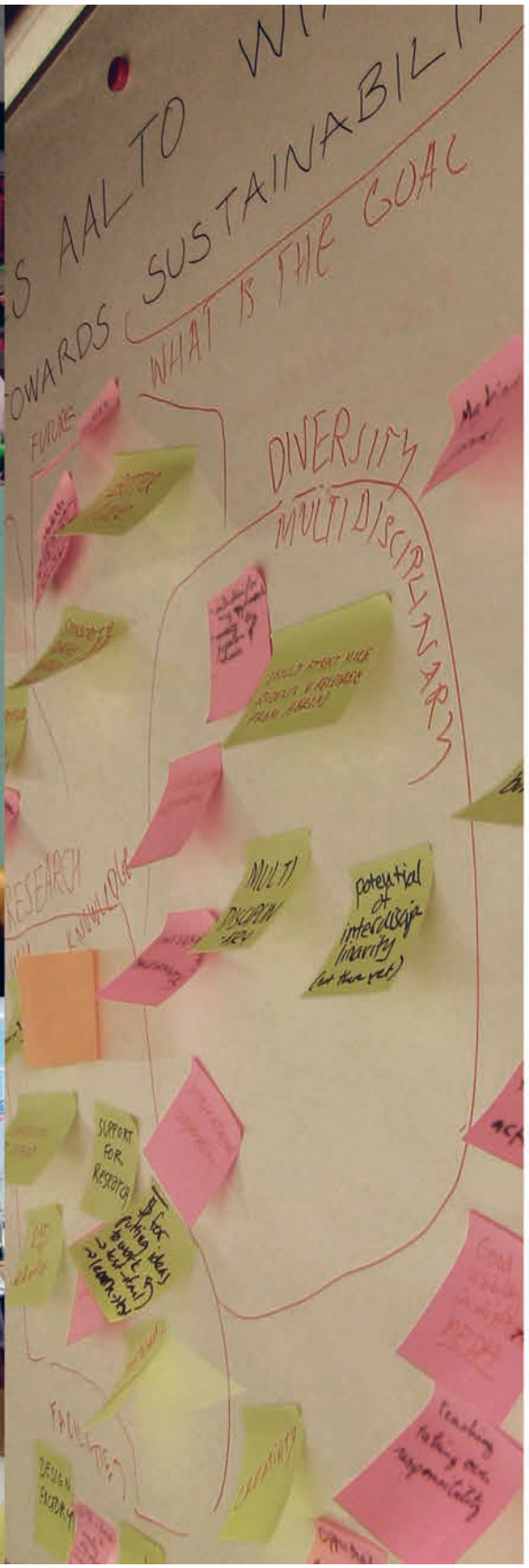
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WHAT IS THE GOAL
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potential of interaction
SUPPORT FOR Research


WHOSE*
ISSUES
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NOBODY'S, HIS'

Photos on previous spread (from left to right):

1. CS kickoff in 2010 with Aalto Sustainability Officer Meri Löyttyniemi
2. Systems Thinking (2010) with David Ing
3. Creative Teamwork (2011) with Cindy Kohtala
4. Notes from the CS meets PDP workshop (2011)
5. CS students in Aalto Design Factory lounge (2011)
6. Whose Issues preparations in Narinkkatori (2012) (Credit: Glen Forde)
7. Whose Issues in WDC Pavilion (2012) (Credit: Whose Issues Tumblr blog)
8. CS development workshop in 2013 (Credit: Seungho Lee)

4. PRIMING, IMPLEMENTING, AND EXPERIENCING CREATIVE SUSTAINABILITY

This chapter discusses the interview data that were gathered and focuses on the analysis approached through three groups on actors in three broad (and overlapping) phases of interaction. Thematic analysis and reflection are first performed independently for each interview set. At the chapter's end, the findings are structured as integrated thematic categories that are perceived by the interviewees as important in CS interaction and in interprofessional learning for sustainability in general. In the next chapter, these integrated categories are assessed through the theoretical framework described in the previous chapter (CHAT view on collaborative meaning-making; see section 3.2.2), based on which suggestions for development can be offered.

Besides the contextual background analysis, in structuring the assessment there are then three stages. The first and second stages were explained in Chapter 3 when the case and the data were presented. This chapter presents the second stage, focusing on the interviews, connecting with topics emerging from theory excursions and context, and then articulating and integrating key elements in CS interaction. The last stage of the analysis is presented in Chapter 5 through a CHAT-driven framework to assess the development in collaboration and its temporal interplay from an organizational perspective.

The three groups that were interviewed represent the three roles in interaction in the CS program, involved in priming the teaching in CS (initiators), and then in implementing (educators) and experiencing it (students). The interviews' contents can be seen in the interview forms (see Appendices 1–3). As discussed, besides the academic roles, the findings also connect to the temporal aspects of academic planning. In this respect, the emerging themes can also be perceived and assessed in relation to the aforementioned three phases of activity.

The temporal span of the interviews was rather long (see Figure 17): overall, the data gathering spanned more than five years. Furthermore, besides the researcher role, there was also continuous personal involvement as a teacher and collaborator in CS development, affecting the development of the inquiry (as elaborated in section 3.2.1). As a result, the themes that are identified were refined throughout the evolving inquiry, developed in connection with theoretical excursions, and conceptualized to provide glimpses of the ongoing complexity in the CS interaction.

4.1. Priming: Setting the Stage for CS

In the first set of interviews (in 2010), four academics involved in the development of CS were interviewed (as described in section 3.3.1). The interviews focused on understanding different professional approaches to urban sustainability and approaches to interdisciplinary collaboration, important theoretic and methodological frameworks, and the future of CS.

The first set of interviews was supported by a survey (see Appendix 1) with Likert-type scaling,[92] questioning different disciplinary emphases on sustainability (with an asymmetrical scale from 1–10). The survey questions were focused on sustainability in design and management processes, addressing the connections between dimensions of sustainability (e.g., "which dimensions of sustainability should be emphasized over another [...] in an urban context?") and professional areas (e.g., "how do you perceive the importance of different dimensions of sustainability in industrial management?"). After five questions related to professional roles, three additional, more open questions were discussed, these latter questions focusing on interprofessional interplay and the future for CS.[93]

The disciplinary groups were taken from the CS program website. Following the program slogan at the time — "rearranging thinking in business management, industrial management, and in design and architecture" — these groupings were selected and discussed. In the interviews, the boundaries between these professional practices were on several occasions perceived as problematic and were partially challenged. However, while in comparing the individual survey results the findings remained a bit controversial, some differences in average results were also visible (see Figure 19).

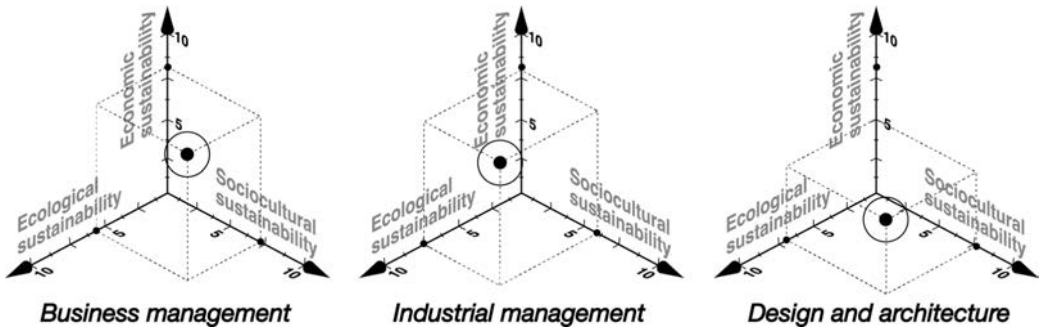

Figure 19. *Sustainability emphases on specific professional areas, based on CS initiator interviews (n=4).*

Source: Marttila & Kohtala (2010)[93]

[92] A Likert scale (Likert, 1932) is a psychometric scale commonly involved in research that employs questionnaires. It is one of the most widely used approaches to scaling responses in survey research.

[93] The research questionnaire results are covered in full in a conference paper (Marttila & Kohtala, 2010). In this analysis, the focus is on the thematic findings from the actual discussions rather than the questionnaire statistics.

When discussing differences between professional approaches and their areas of sustainability interest, the interviewees underlined the variety of the ways to perceive selected professional areas and their connections to dimensions of sustainability. At the same time, however, they built their understanding of sustainability on their professional and disciplinary perspectives.

4.1.1. Building sustainability on existing disciplinary frameworks

Endeavors to promote sustainability are varied in type and context. In relation to industrial production and design, sustainability entails sustainable production and products that have the *"lifecycle* [design] *as a cornerstone"* [#3, #4]. In business, it connects to innovations made in the industrial and material value chains [#1, #2]. Sustainability is, however, *"also something* [that] *is very close to the satisfaction or happiness of human life"* [#4]. Thus, sustainability is a *"relative concept"* [#3] and has different meanings in relation to different issues of interest.

While for some of the interviewees sustainability connects more to overall societal management [#1, #2], building from basic needs and equality [#1], at the same time for others it connects more to industrial engineering, consumption behavior, and fashion [#3, #4]. The Brundtland Commission's report "Our Common Future" (1987) is mentioned as something that *"each applies as one prefers,"* and yet its strength can be perceived in promoting the three different *"positions"* (dimensions of SD) and the need to balance them [#3]. In all the interviews, progress in sustainability connects with understanding timeframes and scales of focus. Ecological sustainability is *"fundamentally* [about] *being able to sustain something on a long, long term basis"* [#1] or *"has a very long time dimension* [...] *relating to fifty years"* [#2]. Sociocultural sustainability can be understood *"in terms of generations, for instance* [...] *talking about twenty years or twenty-five years or so"* [#2]. At the same time, investors might be looking *"to get* [their] *money in a short period"* [#4, also #3].

The time perspective of assessment plays a crucial role in relation to both material products and infrastructure, and changing businesses and markets (cf. temporal scales in section 2.1). There are *"optimal lifespans"* [#3] for certain solutions, and *"we have to find those kinds of solution which will last for a longer time"* [#4]. Cultural development and sustainability also connect together, but changing culture takes time. In the end, *"the way people change their behavior, their consumption habits and so on* [...] *changes rather slowly"* [#2], and to address the *"long, long term basis"* of thinking that ecological sustainability calls for, *"material systems and security"* are required in the shorter term [#1].

The role of collaboration between different professionals is emphasized strongly, but this *"does not mean that the students in different* [...] *schools get an even understanding of each other's professional kind of competences"* [#2]. Instead, there *"has to be some parts of the education, which are interdisciplinary"* [#4], but a *"disciplinary core"* is still required [#1]. There is *"a kind of setting that is professionally developed in each profession"* and *"bringing new people* [...] *making questions about why do things so, what is the basic understanding behind this, and, and so on"*: it is not about giving up the *"basic professional understanding,"* but

rather *"communicat*[ing] *what they understand and then try*[ing] *to get common understanding from that point of view"* [#2]. In connecting together independent degree programs from various fields with their in-depth professional studies, this requires *"common courses* [...] *that all CS students have to take"* [#1].

4.1.2. Developing competences for interprofessional sustainability

Overall, the core competence areas at this point had been defined for the program's application document. These focused on project and business management, design in a broad sense and in connection with innovations, business and urbanism, and cross-disciplinary skills and system design knowledge (see Table 30). In the interviews, certain aspects are also identified and addressed as crucial for interprofessional collaboration in the context of sustainability, and communicative and social skills are at the core of this shared toolbox. There are *"specific communication skills"* and *"interacting skills for getting* [and] *giving space"* for professional expertise, while still *"processing the emerging ideas further through networks"* [#2]. Professional skills like *"life-cycle design"* for designers [#2, #3] or *"critical thinking"* from *"organization and management studies"* [#1] in business are needed, too. Hence, the potential graduate skills of an interprofessional educational program include the abilities to take *"others* [professionals] *into account"* and manage differences in opinions with confidence, and to create *"a kind of knowledge background for the decisions then by interviewing and processing ideas from different professions"* [#2]. Understanding such activity in the interprofessional and contextual setting of sustainability becomes a skill of its own.

Table 30. *CS core competence areas.*

Project management skills: The graduates will enhance their capabilities in multi-disciplinary team leadership, which is required for demanding projects in industrial and urban business environments, for sustainable development.
Design skills: The graduates will enhance their capabilities in understanding complex ecological, urban and industrial systems and their interactions, as well as their main requirements for sustainable development. Creative thinking in architecture and design, combined with business knowledge and new technologies, will become, for the graduates, a basis for producing new innovations, new service businesses, new consumption patterns and revolutionary new urbanism.
Cross-disciplinary skills: The graduates will develop their capabilities in adapting knowledge, skills, and new approaches from other fields of expertise, relevant for their future work.
System design for sustainability: The graduates will enhance their knowledge and develop new skills and thinking in architecture and design, for designing more sustainable urban and industrial infrastructures, living patterns, buildings, products and services.
Business management: The graduates will develop new approaches and skills for the development of new, innovative, sustainable business models and improvement of business ethics and responsibility.

Source: CS Master's degree program application, December 2009

According to the initiators, from a *"learning point of view, there are no textbooks available that are so multidisciplinary as this program as a whole";* for the future professionals, *"the only way to start developing that type of multidisciplinary field is to in a way create this dialogue"* [#2]. And challenges still exist *"in communication to understand each other's purposes and means,"* being *"blind to see"* what the other party is trying to achieve [#4]. The resulting understanding of *"how differently people with ambitions in specific professions deal with the issues* [however] *creates human resources, competences, for all of the people"* [#2]. While challenging in professional life, such an open and interprofessional approach is considered possible as a *"learning context"* and can help *"people to socialize into new roles in their working life later on"* [#2].

Sustainability in general calls for *"shared discussions about what life should be about."* What becomes crucial *"from the sustainability point of view in general"* is the question of *"whether or not we are able to maintain such discussions that* [...] *bring in people to talk about* [...] *how should we organize the society and how should we think about future generations"* [#1]. To pursue both progress in addressing higher level sustainability considerations (e.g., environment in its abstract sense, consumption culture, economic growth versus social sustainability) and the ability to participate in discussions that concern such issues, certain factors call our attention. Summing up, *"this requires a lot of political capability"* that is perhaps *"not so obvious from those dimensions or from this, our three-pillar model* [of SD]" [#1]. Such a critical approach to capacity-building is also needed for sustainable design.

4.1.3. Challenging conventional learning

In all of the talks, practical inquiries into sustainability were emphasized. After all, in approaching sustainability, the *"system of activity as well as the roles of professionals must be defined"* [#3] and this can only be done in testing out different processes in different settings. Also, *"bringing the real case approach into the teaching by being part of* [university research] *projects"* [#2] supports such interprofessional work, and *"case studies on sustainable business"* [#3] help to build understanding of possibilities. In interprofessional collaboration, by just *"discussing and listening, you can find new aspects* [...] *how to think about the whole case"* [#4]. In summary, this results in possibilities to utilize disciplinary knowledge, but also to learn and develop interprofessional collaboration in practice.

For Aalto University, CS acted not only as a test-bed for new educational interaction, but also as an initiative to answer the call for interprofessional sustainability. As a *"brand for this type of Master's program, it's a big, big opportunity... and a possibility"* [#2]. By *"starting research projects, where all these elements are combined"* and *"workshops and outputs from them,"* it is possible to *"in a way create that type of intellectual climate"* [#2] that emancipates such understanding on interprofessional collaboration and sustainability.

The new openings that it was hoped would emerge from the interplay of the disciplinary views were considered important to take these agendas further: *"For this type of Master's program, where students* [...] *learn more about the practices* [...] *through joined projects,"* they will become *"believers in* [...] *sustainability"* [#2]. This can be supported by making *"this program so attractive* [that] *curious people want to join"* [#4], so bringing together *"students coming from different worlds"* [#2].

This open call for new interaction, however, was also acknowledged as a potential risk. In this respect, CS can be perceived as *"a kind of platform for* [...] *challenging the current practices"* [#2] and with this type of *"open approach* [...] *it's very difficult to predict what comes out"* [#2]. Such emphasis in collaborative mediation might also arrive with some trade-offs, as *"people don't, for instance, get a kind of doctoral studies competences during their Master's studies"* [#2]. While the learning of disciplinary skills is crucial in this process, academic skills might not be equally important.

4.1.4. Summarizing emerging themes from the priming phase for CS

Overall, the initiator interviews addressed sustainability in urban planning and design — and the interplay of professions — through notions of CS initiation. Such aspects become crucial in priming interprofessional collaboration and learning in the context of sustainability. In looking at the overall themes, the following five emerge through topics in discussions (see Table 31).

Controversial sustainability

The challenges inherent in the broad spectrum of meanings that the concept of sustainability encompasses became evident in the discussions. According to the initiator interviews, sustainability can be approached from various different angles: the question is what is considered valuable. One of the emerging themes of the interviews is the tension between economic growth and environmental sustainability. Financial value is perceived as the most common motivator in approaching contemporary activities of design and planning. Sustainability, however, has very different meanings in its three different dimensions and in relation to different time scales of assessment — for example, the short-term view on product design in comparison with building design, or doing business with sustainability and economic progress for societal development. Moreover, these dimensions and scales can have conflicts between them. While economic growth is to promote global wellbeing and equality, it is often in conflict with sustainability interests. As a result, economic and environmental considerations can often clash. Similarly, questions on social progress and sociocultural sustainability put stress on environmental sustainability that is already compromised according to the wide scientific community.

Building capacity for sustainability dialogues

Shared dialogues for sustainability between laypeople and professionals can take place in various contexts. In CS, the idea was to promote professional dialogues between future experts, to contribute to new understanding on sustainability, and to develop professional practice. Critical thinking and the ability to involve oneself in dialogues and collaboration around sustainability were identified as crucial components. However, for any professional, skill and knowledge are also necessary to be able to contribute to a sustainability inquiry [#2]. Also, amongst laypeople and globally, the ability to understand sustainability is seen as an outcome of certain conditions and capabilities, as *"you will need the bread, you will need the security, you will need the* [...] *living environments and all that before you can really start to talk about ecological sustainability"* [#1]. As a result, a potential mistake in sustainable design and planning can also be made when things are considered *"too broadly"* without *"knowing the sociocultural context"* [#3]. For a designer facilitating collaborative dialogues on sustainability, ensuring that there are sufficient resources of both knowledge and ability is crucial.

Staging of context, setting the stage

In many ways, the initiators are setting the stage for the forthcoming CS studies in introducing various actors and content to the program preparations. These components are related to various people and projects that already existed, some reworked into new forms in CS. For the initiators, CS as a pilot for interprofessional interaction was approached as a project in itself. From the beginning, the idea was also to emphasize such projects and encounters in CS teaching, sharing experiences and skills across the departments. On this basis, new ideas and solutions for sustainability would then emerge. However, in approaching meeting points between different professions, there are outsiders and insiders, and in approaching interprofessional sustainability. What becomes important in this process is open, reflective iteration, as it is also about *"bringing the feedback to the, kind of, multi-professional context"* and then *"keep*[ing] *the process going on through new types of input depending on the kind of solutions that are emerging"* [#2].

Expanding disciplinary perceptions for learning and practice

Despite the emphasis on interprofessional collaboration, the focus remains on building professional and disciplinary competence. The available skills and knowledge are what make any collaborator valuable, and for professionals this is also measured in disciplinary expertise. However, interprofessional interaction also requires understanding other disciplines and stepping outside the comfort zone. Expansive approach into collaborative inquiry is needed. In CS, collaboration in real-world projects connects various professionals in a shared practice. In approaching complex challenges of sustainability, being able to compare things, issues, and processes, and to understand different competences within the larger context, becomes crucial.

Critical, professional perceptions on sustainability

Critical thinking is mentioned as a key component in sustainability assessment and transformation [#2], but in the contemporary design practices there is a lack of it [#4]. There is an imbalance in approaching the challenges of sustainability and the way contemporary economy works. In essence, according to the discussions, both ecological and sociocultural sustainability seem to take place under economic imperatives. One can infer that if our entire social system is existing increasingly in the context of the global economy, the concept of sustainability and its three dimensions also become nested in it and understood under its terms. Critical perceptions and discussions on sustainability are needed to challenge such assumptions [#1, #2]. Again, this can be done by introducing more perspectives to the shared inquiry, expanding the understanding further. Through interprofessional design collaboration, such perceptions can be brought forward.

Overall, in this phase, the materials in the form of disciplinary frameworks and theoretical approaches are introduced to the interaction. Based on the interviews, sustainability as a topic and context of action can be perceived in many ways as controversial, and there are many ways that different professionals approach it. Interprofessional collaboration and knowledge-building is then identified as a key area where such a controversial and yet scientifically robust topic can be discussed. In approaching CS, the program is perceived as a platform where future professionals and experts are invited to develop new understanding on sustainability.

A clear need for CS in general is identified, as well as its potential for Aalto University. For the interviewees as initiators of CS, the program is also portrayed as a playground, where encounters under the grand theme of sustainability can take place and new ways of working can be tried out. In CS, this becomes evident in staging the collaboration while not quite knowing what will happen and what will students become.

Table 31. *Identified themes of interest in interviews I: initiators.*

Theme	Description	Example instance(s)
Controversial sustainability	Sustainability has different meanings and temporal scales in different contexts and for different people.	*"different professions perceive sustainability differently"* [#3] *"ecological sustainability has a very long time dimension, so when we are talking about it we probably refer to something relating to fifty years* [...] *for economic sustainability, we could be thinking about business cycles in terms of* [...] *seven to ten years"* [#2]
Building capacity for sustainability dialogues	Dialogues on sustainability require abilities for collaboration, but also some (professional or layperson) input to the inquiry. Furthermore, if there is no certainty of tomorrow, it is difficult to discuss things in the longer term.	*"it's about security, and sharing of resources, education* [...] *the ability to kind of engage with the shared discussions about what life should be about, and the kind of... political capabilities"* [#1] *"you also have to have an understanding of the real processes that are in use currently, and that are in the opportunity space that can be created... through the combination of professions"* [#2]
Staging of context, setting the stage	In CS, the idea has in many ways been simply to set the stage for academic collaborators to join in and for future students to pick according to what they perceive as important.	*"bring in new people, and then let them start asking questions about why do things so, what is the basic understanding behind this* [...] *starting research projects, where all these elements are combined by bringing international, global perspectives into the picture through exchange students and specialists* [...] *producing workshops and outputs"* [#2]
Expanding disciplinary perceptions for learning and practice	One main theme is also in expanding the disciplinary perceptions and practice, to develop a new, interprofessional platform for sustainability inquiries and learning.	*"recognizing how differently people with ambitions in specific professions ... deal with the issues, then, that create human resources, competences, for all of the people"* [#2] *"there are no textbooks available that are so multidisciplinary as this program as a whole"* [#2]
Critical, professional perceptions on sustainability	Critical, professional approach is needed to developing sustainable design and business.	*"the kind of short termism... in national economics in global regulation... is the kind of problem that is most urgent"* [#2] *"criticism is somehow, like, built into the designer mindset, that they think that they can listen, like all sorts of experts"* [#4]

4.2. Implementing: Making the Most of the Interprofessional Context

The second set of interviews was focused on the CS educators and conducted with six teachers and two assistant teachers (with two follow-ups; see section 3.3.1) involved in implementing the shared CS introductory studies between 2011 and 2013. Two of the interviewees were also specifically chosen as they were connected to study content introduced to the CS program only after its few first years of action. Overall, the interviews first addressed the development of the teaching content and the professional history of the interviewee, and then more general themes around teaching practice, course implementation, expectations and outcomes, and sustainability and interdisciplinarity as a general context for collaboration and learning (see Appendix 2). The idea was to create a comprehensive understanding of the shared tools, activities, and frameworks that connect students from various backgrounds in a shared process of learning.

4.2.1. CS as a context for teaching

From its beginning, the CS program has acted as a rather open arena for discussions on how interprofessional sustainability should be understood, approached, developed, criticized, applied, and evaluated. These concepts as keywords have also invited collaborators in. In respect of professional identity, the CS staff and students can be perceived as *"a bit different than the average in their department"* [#9a]; according to the teacher interviews, they also proved to be very motivated in their work.

Sustainability challenges are perceived to be complex [#5, #7, #8, #10] or *"wicked"* [#6a], beginning with a broad context and overarching inquiries. To approach such a context, collaboration becomes a crucial component of the process, as *"without having some kind of multidisciplinary or interdisciplinary* [...] *or interprofessional"* process, *"environmental problem solving"* is considered impossible [#6a]. Expertise to tackle sustainability cannot be found in *"a single person's character, but it's in between persons... it's in networks"* [#5], and each collaborator must bring in their professional contribution and *"their own experience and interest, which is the most important part of sustainability"* [#9b]. Such complexity calls for collaboration on several levels in order to agree on and implement actions. Naturally, when discussing sustainability as a context for action, the origins of the concept in Brundtland's Report are mentioned [#7] and the three dimensions of SD are widely acknowledged by all teachers, agreeing that the three-pillar model, despite the criticism of it, is *"still a useful way to think of sustainability"* [#6a].

According to the CS educators, interprofessional activities are nothing new: *"it has always been* [that] *when you do something, there are people from different, various backgrounds"* [#10]. Some contexts are, however, more suitable for interprofessional assessment, as general understanding and experience of the phenomenon is a benefit. For example, the city as a shared space can act as a *"template for this kind of multidisciplinary work because it's such a complex system and requires so many inputs"* [#9a] (from many *"social systems"* as in interview #1). Hence, an interprofessional approach is needed when *"we deal with complex problems"* [#5] or *"wicked problems"* [#6a] that *"a single person cannot solve"* [#5]. Instead*, "you need to have different types of expertise in the* [...] *process"* [#6a].

Sustainability as a context is identified as *"value-driven or value-rich"* [#10]. In CS, however, to prepare for real-life challenges, people must *"try also to work with people who have different values"* [#10]. Sharing information in *"social networks"* is also important, as there is often *"a correlation between wide network and achievements"* [#5] and new actors can then more easily join in. Collaborative meaning-making for sustainability remains one main focus of action; and yet, in CS, this goal becomes contested, expanded, and iterated from various different perspectives.

Challenges in defining CS study content

The shared courses acted as the main joint course content that all CS students took. In this respect, for students they also acted as crucial entry points to the program interaction in general. In brief, the shared courses were also the main content to address the shared competences that the program was to develop, as described in the priming phase (see section 4.1.2). This content was also genuinely novel, as it was created for the program only, mainly based on initial developments during the piloting phase as a minor, or even earlier (see section 3.1.3).

Overall, although there were developments in the course offerings and content, the official, accessible (i.e., online) course information often remained rather thin and sometimes was not refined even when the content evolved and staff changed. Often the content was described in only a few sentences with no information on specific topics, theories, or methods that would be used (see Table 32). Although the written course specifications were not the only repositories of knowledge in regard to course content, it is somewhat evident that in developing the course content the majority of the knowledge utilized was introduced and carried on by the educators themselves.

Table 32. *Examples of course descriptions (2012).*

Creative Teamwork (and Project Management) The course familiarizes students with several competencies like the multidisciplinary approach and design thinking. Students learn about various concepts related to sustainability. Students experience the communication and practices of multidisciplinary group work in the context of cultural sustainability. Students will adapt design thinking as a problem-solving method.
Systems Thinking I & II (I) Understanding of what systems thinking means in creating sustainable urban communities; (II) Knowledge about concepts usable for planners and designers in creating sustainable communities.
Creating the Mindset of Sustainable Societies To create the common ground of sustainability studies and to learn to deal with different aspects of the sustainability concept.
Continuous Transformation To learn the mechanisms of human decision-making, innovation, and social change; to promote further novelties in the field of sustainability.

Source: Official online course description documents

In this respect, a lot of the information and competence in course implementation was tacit and intangible, embodied in the actual teaching activity. While for the program management perspective this was not a crucial issue, as the program director interacted with teachers, who were professionals with their topics, from the student perspective the vague descriptions caused some confusion, as elaborated later on in the student interviews (see section 4.3.3).

Development of new CS study contents

As described earlier, many courses were reorganized various times between the years 2010 and 2015 (see section 3.3.3). From the academic term 2013–2014 onward, new shared study content was also introduced into the program. As a result of identifying a student need for facilitation skills, two new elective courses were initiated. Also, as the graduation times in CS had proved somewhat long, and students had indicated a need for better support in thesis work (in addition to compulsory thesis workshops in their own degree programs), new content was introduced to support thesis-making (see Table 33).

Table 33. *New elective studies in CS, academic terms 2013–2015.*

Course name	Study period	Responsible teacher(s)/ school	Credits (ECTS)
Participatory Methods and Facilitation Skills	III	Paula Siitonen / ENG/ARTS*	2
Creative Cooperation Methods and Skills	IV	Paula Siitonen / ENG/ARTS	2
CS Thesis Development Workshop	I–IV	Laura Delaney-Ruskeepää / ARTS (with support from other selected teachers)	3–5

* Paula Siitonen started to work for ARTS, too, in 2012, by which her CS courses are organized.

The Participatory Methods course was initiated after it had been evident in student and teacher feedback that some more extensive content on collaboration and facilitation methods would be beneficial. The CS students themselves had had encounters with an expert on such content in Aalto University School of Engineering during an optional course in the sustainable global technologies (SGT) minor study program (in particular the 'Sustainable Communication' course; see section 4.3.1); after some conversations with the CS program director, this expert was invited to work in CS, too. Her first teaching events in Summer 2012 in the CS program were structured around preparations for the student-initiated World Design Capital (WDC) Pavilion CS activities (see section 4.3.1), and in parallel with the WDC project, in Spring 2012 a short, intensive course was held with the title "From Conflicts to Creative Cooperation," focusing on conflict resolution. From Fall onward during the 2012–2013 academic term, the teacher also continued to contribute to the program in the Creative Teamwork course.

The CS Thesis Development Workshop was based on meetings that started in 2011. It began as an official course in 2012 after it had become somewhat evident that several students struggled with their thesis process. While all the CS students already participated in thesis seminar processes in their respective degree programs, there had been inquiries from students to help them better connect the various thesis processes across the CS program. The workshop consisted mainly of students from CS Design, and some from CS Architecture and CS Real Estate. CS Business students had their own seminar series at degree program level (which was perceived as functional by the students) and they were mostly absent from these workshop sessions. Some specific sessions, however, were organized to introduce the topics between the groups. The course attendance was not graded — students just passed or failed — and the course was optional throughout its existence until Spring 2015.

In general, this new content pointed out how program management was able rapidly to respond to identified needs for new teaching content in CS as a whole. At the same time, it was very much based on student initiative that gradually grew stronger in the program as the students' expertise grew (see section 4.3).

4.2.2. Role of theory and traces of disciplines

Learning in the context of CS involves an introduction to various theories and practices. Such context combines several perspectives and approaches to making, as *"there are theories, and a toolbox of methods, and skills, and processes"* [#10]. Although the focus in CS was also on real-world problems and action, the study consisted of a lot of theory (e.g., from systems science, behavioral studies, engineering, etc.). In such a setting, the role of theory also becomes a justification to pursue a certain approach, to understand *"why you do something"* [#10].

Tools and methods used in teaching and learning are discussed and utilized at various levels in CS activities. Some of them are methods used in teaching; others may be tools for professional practice. Some are important for program development and to improve education in academia in general, and some are important particularly for interprofessional collaboration in the context of sustainability. While the synthesizing tools are an essential part of the collaborative skills-set for interprofessional work, professional tools from various disciplines are also introduced. In advanced study modules, such tools are introduced and used in different phases of the work. Some examples are different conceptual tools to manage knowledge-building in respect of a particular professional interest (for example, different matrix assessment tools in business management or ecodesign), tools to manage qualitative information (e.g., benchmarking, mapping, etc.), or quantitative tools for assessing financial or material flows and impacts (e.g., LCA tools; see section 1.2.2).[94]

The components of interprofessional collaboration and learning

From the very beginning of studies in CS, the emphasis was on independent teamwork and on building relations across disciplines and topics, in studio work, projects, and self-initiated activities, to support peer learning in the CS community. Peer-to-peer learning can happen in discussing theories and exercises or *"just in the form of* [sharing] *presentations"* and feedback [#10]. Often in peer learning, however, heterogenous groups work better, and CS groups were often organized *"to get people from different study programs"* [#8] into each group.

In an interprofessional setting, the emphasis on communication and participation is necessary right at the beginning, not depending on disciplinary background or level of professionalism: it is a way to show *"that this is a studying culture and working culture in here"* [#10]. Skills for *"intra-personal"* assessment are needed to *"reflect on your own motivations and your own emotions and your own actions,"* and *"skills and knowledge and attitudes"* [#5]. *"Inter-personal"* skills, on the other hand, help students to become aware of *"how your own behavior affects the situation,"* introducing *"social intelligence"* to interaction between people [#5]. These *"inter-"* and *"intra-personal"* skills must be approached in an interplay, as *"intertwined with other"* [#5], and this can be supported with small group exercises where theory is

[94] From 2013 onward, a full-scale LCA assessment tool for materials and products, Granta Design's CES EduPack, has also been in use in CS Design teaching (see www.grantadesign.com/education/edupack/).

introduced before or after the collaborative reflection, under different professional perspectives [#5, #10]. In such collaboration, it is not sufficient to *"just participate yourself, but also think how you yourself involve the other ones"*: this *"could be used* [as a kind of] *hidden agenda, to create the culture"* for the whole program as well [#10]. As a result, the teaching methods in CS were somewhat unconventional in relation to more traditional academic lecturing, involving more small group activities and practical exercises. *"Learning by doing"* is mentioned as the only way *"to learn* [to] *collaborate"* [#5], and is understood as the main pedagogical approach in the program. And yet, teaching on relatively short introductory courses often *"cannot go to methodology"* [#8] or deeper into theory and is *"more about developing thinking... and modifying thinking"* [#8] for further collaborations.

While some of the shared CS content was simply series of lectures, most was structured as workshop-like full-day sessions with independent and/or group work. The daily topics and tasks were also often connected to a bigger case inquiry, as in Systems Thinking and Creative Teamwork (2011, 2014 onward) courses. The reflection between roles in collaboration and professional knowledge in relation to different phases of work seemed to be a key element in learning interprofessional collaboration. Consequently, besides synthesizing exercises, tools for managing collaboration also became crucial (as in Table 34).

Table 34. *Examples of tools for synthesizing and collaborating in CS shared introductory studies.*

Type of tool or exercise	Description of the tool or exercise
Examples of tools and exercises for managing collaboration	*"group dynamics" exercises* [#9a] *"basic concepts concerning team building and project management"* [#5] *"mini competence mapping exercise"* [#6a] *"work breakdown structure"* in concept creation process* [#5] *various online "social" tools* [#5] *and online information***
Examples of synthesizing tools and exercises	*Reflective writing (essays, learning diaries)* *"verbal, visual metaphor" creation* [#5] *Assessing, analyzing, and synthesizing "dichotomies"* [#7, #8] *"sketching and drawing [...] not limited to designers"* [#6a] *"scenario building"* [#5] *"design games" (like Play Rethink*** in 2011)* [#5, #6a]

* A work breakdown structure (WBS) is a concept familiar from project management and systems engineering acting as a decomposition of project work. | ** Students and teachers utilize various online programs and apps to communicate (e.g., Facebook), to co-create materials and manage collaboration (e.g., Google tools), and to manage course information on CS web pages (http://acs.aalto.fi) and online course platforms offered by the University (e.g., Moodle, MyCourses). | *** Play Rethink is an eco-design game by London-based Rethink Games.

The differences between cross-, multi-, and interdisciplinarity are discussed, but in general the interviewees have various ways of utilizing the terms, and some also acknowledge this variety (e.g., #8). For one, in interdisciplinarity *"people are meeting in between their fields,"* while in multidisciplinarity *"everybody is more democratically coming together for one common goal"* [#9a]. Another view is to think (as in this work in general) that in interdisciplinarity the collaboration deepens further, and in transdisciplinarity new actors are introduced to collaboration [#5]. In general, the beauty of an interprofessional approach is perceived in various skills and competences being able to support each other in a collaborative, shared process.

The role of theory building

Theory is involved in all shared CS study content and it remains important in understanding why something is done [#10]. Theoretical literature is introduced in class or lectures, or as readings and reflection, or in personal encounters. Theories such as social constructivism are mentioned as overarching principles, to emphasize *"that knowledge is built in a social context"* [#5]. Several other theoretic bodies are also addressed. For example, in the Creative Teamwork course, the collaborative process is approached *"from psychology or sociology"* but *"also project management"* [#5], whereas the Systems Thinking course introduces more emphasis on applications of *"systems science," "networks,"* and *"complex systems"* science [#7, #8]. Also the Continuous Transformation and Creating the Mindset courses include a lot of academic reading and writing. A lot of the theory on the background to the CS approach to studying and working involves *"communication theory"* and *"systems theory"* [#10], present in both Systems Thinking courses, as well as in Creative Cooperation and Participatory Methods courses. Also, theories on team building[95] [#5] and *"group dynamics"* [#9a] are present, perceived as most beneficial when introduced early into the studies [e.g., #10].

Lastly, quite naturally for academic education, a lot of CS teaching utilizes written materials — various types of literature and articles, or reflective production of essays and learning diaries. Producing academic text is considered important in all of the courses, but there is *"a vast difference"* [#8] in students' academic writing skills, and experiences regarding it vary a lot. For example, while the teachers of Systems Thinking course both address the challenges of producing academic quality text, at the same time the teacher in the Participatory Methods course considers the students' skills rather good [#10]. Some teachers connect this to the student's disciplinary background [#8, #9a], while they also underline that *"there can equally be an engineer, architect, or industrial designer who has done the top paper"* [#8].

[95] The interviewee refers to a model of group development as proposed by Bruce Tuckman and Mary Ann Jensen (1977) consisting of "forming-storming-norming-performing," further expanded with "adjourning" as the fifth level (see http://www.pmhut.com/the-five-stages-of-project-team-development).

4.2.3. Design and creative sustainability

According to the interviewees, in CS, the problems of sustainability are perceived as *"not theoretical problems so much,"* but instead *"mainly practical problems"* or *"design problems,"* meaning *"that there are actions to be taken"* [#5]. Design competence entails *"iteration cycles, the prototyping, the testing,"* being *"ready to experiment and try things, and then repeat them until something works a little bit better"* [#6a]. Utilizing rapidly produced reflective artifacts, such as drawings and visualizations, helps to *"bring more of your embodied knowledge into the process"* [#5]. In comparison with writing, *"you bring more emotions* [and] *more intuition"* to the process of knowledge-building [#5]. Design thinking is also strongly connected to visual processing and *"quick and dirty visualizing of ideas"* [#5].

Creativity connects to *"creative problem solving"* [#8], suggesting that problem assessment does not always require well defined or well structured boundaries at its beginning. Creativity is something that can be understood to take place when such new understanding is created. In this respect, many practical skills, such as project management skills, should be understood as a *"supportive component"* instead of *"the killer of creativity"* [#5]. Creativity in the name of the CS program also entails being *"creative in how we use the tools, and develop the tools"* [#9a] in teaching sustainable design.

Utilizing such smaller, theory-driven tasks and exercises may also act as *"one learning objective,"* as *"it's good to work with a sort of quick and dirty manner* [...] *because, in these fuzzy situations... you have to go through several scenarios"* [#5] to find analogies and synthesize. Reflection in small design tasks — *"drawing and making mind maps and things"* [#6a] — can also help in overcoming conflicts from clashing perspectives on work and content. Visual processing with flip boards, markers, and post-it stickers is often used in various exercises. Furthermore, when considering different "what if" ideas and scenarios on a conceptual level, the reasoning can be supported with visual cues. As such, the collaborative meaning-making processes in design also connect to the identification of *"possible paths to desirable future"* [#5]. In seeking transformation for sustainability, the proactive stance of the design-led process can help to proceed through the complexities in the context.

Learning by doing, which is needed in approaching sustainability as a context, resembles *"learn*[ing] *design thinking"* not as a theory but through *"the act of* [...] *designing collaboratively something"* [#5]. In this sense, *"sustainability is a very, very natural context for design collaboration,"* as *"design traditionally has already dealt with different approaches,"* questioning viewpoints ranging from *"material"* to *"production technology"* and from *"end-users"* to *"other stakeholders like the case-owners, the business, business people"* [#5].

However, sustainability as a context also remains challenging to designers in an interprofessional team: *"if designers and the creative process in general is meant to be divergent and exploratory,"* it might be challenging with the constraints that *"sustainability as the context brings in"* [#6a], and some other professionals in the team might *"want to deal in a convergent way"* from the beginning.

Assessing challenges, findings, and ideas as a part of a shared system of inquiry becomes crucial, and to proceed there has to be systemic understanding of components and relations that play a part in the interaction. For a design team, this means finding out *"what are the containing structures, containing systems"* in relation to the *"larger structure"* [#8] and having the ability to build arguments on this basis. In relation to sustainability, CS can be perceived as a platform to challenge existing agendas and suggest new ones. As a result, CS is also perceived as *"an opportunity for Aalto* [University] *to really develop something new"* [#9b]. Spearheading interprofessional education for sustainability is easy to perceive as a positive component in university communication, and branding on a larger scale.

4.2.4. Summarizing emerging themes from the implementation phase of CS studies

In brief, the shared CS introductory studies seem to have aimed at creating a basis for interprofessional design collaboration and sustainability dialogues. The fundamental idea for the joint content is to prime students from several fields to work together around a shared problem, involving value dialogues on sustainability along the way. The actual collaboration is then taken toward a real-world setting in project-based study modules introduced by each participating department.

Like the initiator data, the interview material from the second interview set was first coded and analyzed independently. However, after writing the analysis up as a story, the themes were re-evaluated and restructured. In this sense, the themes here continue the rationale that was set up in the initiator analysis. The following five general themes are elaborated from teacher interviews (see Table 35).

Tackling novelty and complexity

In CS, many components of the shared introductory courses were newly planned for the program, with a special emphasis on sustainability as a context for action. The challenges of sustainability are identified as wicked — *"there are complex, dynamic systems involved"* [#7] — and interprofessional collaboration is identified as the main solution in tackling them. New study content, however, calls for the evaluation and assessment of the outcomes. In CS, *"we're kind of learning by doing and it's a very experimental program,"* but after a certain amount of time *"we have the responsibility to then produce results on how we are doing things, what are our tools and methods, and how do they work"* [#9b]. In general, the constant evolution of content calls for a flexible and reflective approach to teaching. New content was revisited in various projects, some of which eventually became more established.

As in the initiator interviews, the idea was *"just go and do it and see what happens,"* and this is perceived fitting *"if you think about the name of the program, Creative Sustainability"* [#10]. As the challenges in focus were *"about multidisciplinary and rather new issues in sustainability"* there was not a clearly *"established path for each profession"*: instead it was *"something students need to develop themselves"* [#9a].

Expanding processes of learning

In general, the idea was to expand the professional views on sustainability along with the understanding on which CS as a study program operated. Teachers also eagerly connected their other encounters with CS content and teaching. Eventually, the CS students went *"outside of the university with their projects,"* resulting in *"their professional development and personal development"* [#9b] and an increased awareness of CS outside the program. Such expansive and transdisciplinary activities of outreach were also supported by the program director.

Projects on courses and in advanced core study modules acted as platforms to expand collaboration toward new collaborators. In the context of interprofessional sustainability, there is a constant need to expand dialogues outside the like-minded — whether in relation to one's profession or values — *"to really explain your ideas to somebody who's completely on the outside and argue those ideas, why they are valid"* [#9a]. Facilitating collaboration, however, does not always mean learning. Instead, one has to structure *"the act of learning"* [#5] with *"very cleverly designed tasks to learn."* The theories and activities utilized *"must support the learning objectives,"* which are well described [#5]. Building from well prepared learning objectives may help to *"come backwards to the tasks, to the theories, to the practices,"* to "support the learning processes" [#5].

Sharing initiative

CS students and the contributing teaching staff were often very motivated. Various types of peer learning and expansive capacity-building for sustainability dialogues took place between staff, but also with and within the student community. This proactive approach was often strongly supported by the teaching staff and program management, as *"when students are developing ideas,"* these should be communicated *"all over the world* [...] *to develop their own ideas but also to develop themselves personally"* [#9b]. In a sense, giving students experiences of such leadership also means capacity-building for the program.

Much of the early content of CS was built on discussions held within the preparations board and through the group members' contacts. Still, in developing the pilot content, some participants became collaborators in teaching (as in both Systems Thinking and Creative Teamwork courses, for example), and several outside contacts were supported in various project collaborations. Later on, student initiatives and activities led to full-scale projects and to the implementation of new course content. Such an approach to initiating studies and activities in fluid collaboration with the program leadership was often the case when introducing new content, projects, student and staff activities, or other novel interactions.

Institutional constraints and challenges

The core CS teaching staff were in general motivated to develop the CS community and content. However, there were also several constraints to the development of content, and even continuation. The biggest constraint addressed in all the interview material was the scarcity of time. While amongst the core CS staff *"people are pretty invested in the program and generally it's possible to find time amongst the teaching community"* [#9b], there are also *"some professors or teachers that we don't really get a chance to discuss topics in the program with because they simply don't have the time"* [#9b].

Institutional constraints and the resulting challenges were also visible in the changes of personnel, based on the availability of doctoral students as assistants, or visiting teachers and hourly-paid lecturers, or researchers tied to specific project funding. The differences in academic schedules, and the practices of decision-making and development of study content can also cause problems. In CS, these have often been different in different schools and departments, although through the Aalto merger they have started to conform. Furthermore, the overall structure of studies in academic terms and annual courses creates a natural sequence for developmental activity.

Developing one's own (teaching) profession

While the educators are aware of the potential of interprofessional collaboration, they still approach the emphases in teaching content mainly on a professional basis, based on their disciplinary experiences and perspective. Personal interests are connected to the CS program topics, and the broadness of the program and its activities makes this easily possible. In approaching these interests, students are also perceived as resources performing the learning on courses to serve the professional development of the teacher.

Based on the interviews, however, the teachers are often also rather unaware of what teaching takes place on other courses. Also, in relation to institutional constraints, there is little time to contribute to the overall development of CS content. Instead, encounters with CS students become limited to only a few course sessions, and a more comprehensive understanding of the learning in CS overall is difficult to form. In the end, only a few of the several teachers were involved in CS teaching (shared introductory studies or advanced studies), and most of them were operating mainly in their own schools and departments, with only occasional encounters with CS students and other CS teachers.

Overall, the materials and interviews with teachers identify the implementation of CS studies as a journey into the unknown, but with confidence that such an approach, supported by interprofessional mediation, can result in a new understanding and professionalism. The initiative to develop the content and approach was also extended to the students themselves.

Table 35. *Identified themes of interest in interviews II: educators.*

Theme	Description	Example instance(s)
Tackling novelty and complexity	Sustainability challenges call for new approaches to deal with the complexity, and combining professional expertise from various sources helps.	*"in today's complex world, we deal with complex problems, and it's quite clear that a single person cannot solve these"* [#5] *"they're wicked problems, they're complex problems, and I think it simply needs…you need to have different types of expertise in the process"* [#6a]
Expanding processes of learning	In teaching, the idea was to expand the students' disciplinary perceptions of sustainability, supported by interprofessional peer learning and project-type teamwork-based learning, to gradually expand understanding.	*"it's important to somehow validate outside one's own path of thinking that the framework actually makes sense"* [#9a] *"different people can approach the same problem* [...] *but for different people it's still different... It simulates well some real-world situation"* [#7] *"there are so many theories and models that perhaps cannot be adopted immediately so that they could be discussed* [...] *it belongs to the learning process"* [#7]
Sharing initiative	Overall, the initiative for developing content and introducing new content was welcomed by the teachers of shared introductory studies, and especially the program director.	*"the support for teaching has been really great* [...] *it's also really open to new ideas, so that teachers who have ideas for courses can easily go to her and discuss and establish a course"* [#9b] [The program director] *"offers many opportunities for students or teachers to run workshops and the issues that they see as important"* [#9a]
Institutional constraints and challenges	Institutional challenges relate to schedules, roles, and resources in academia, mainly the lack of time and ability to contribute to activities of program development alongside the other duties in teaching and research.	*"the practical issues in organizing the course, and in schedules, and. the whole annual rhythm, and then in weekly timetables... that isn't easy"* [#8] *"teachers are really burdened with, for example, funding* [...] *the professors are burdened with administrative work, when it comes to deciding on budgets and things like that. In the end, I don't know if that's what either category of people is really hired to do"* [#9b]
Developing one's own (teaching) profession	Despite the promotional approach toward interprofessional collaboration, the teachers nevertheless act mainly on a professional basis, based on their disciplinary experience and perspective.	*"I think we've managed to introduce something new, like, thinking. I'm confident that we've succeeded in that* [...] *But then have we got them* [students] *inspired — as I always consider that important — there are probably some big differences"* [#8] *"each professional probably has a different idea of what success is. So, they're going to set their goals differently"* [#6a]

4.3. Experiencing: Developing Interprofessional Competence

From the beginning of the research, the idea was to interview students in CS Design. Initially, the idea was to interview students after their graduation; eventually, however, as their studies in CS extended (the first graduates were in 2013) and students had already begun to initiate various student-driven activities, the students involved in organizing such activities were invited to take part in more detailed interviews (see section 3.3.2). In this sense, only students that were more active in the CS community were interviewed (see Appendix 3). This shortcoming, however, is addressed when reflecting on the results and in comparing the findings with general program feedback from the students. Overall, this phase brought to light the new type of professional that was emerging, as well as the shortcomings in connecting this new understanding to meaningful action.

4.3.1. From projects and courses to student-initiated action

In the teacher interviews, several projects (mainly from various CS courses) were mentioned to connect students and teaching staff with interesting content. In the student interviews, too, various project encounters were mentioned as essential in developing further collaboration. In CS, more in-depth project content was often connected with advanced study modules offered by the participating degree programs, but also with more ad-hoc CS projects that were built along emerging interests and interaction.

More long-term interaction — for example, in project-type collaboration — is necessary to develop a shared orientation and trust to develop further activity. In CS Design, between 2010 and 2013 the influential advanced study content were the mandatory Sustainable Product and Service Design (SPSD) module (15–10 ECTS depending on year) and Design Ethics (15–12 ECTS), with its alternative, Values in Design, since 2013. All these modules involved a project element. Other popular advanced CS content that involved team-based project work included various courses from the different CS degree programs (see Table 36). More temporary CS projects also included a range of content: examples of such projects included smaller cases addressed in the shorter introductory courses, client-related assignments, and projects connecting to national or EU-funded research ongoing at the university. Each year in the CS Design SPSD module, one of the cases was also connected with sustainability development at Aalto University campus.

Much of the project content was also related to bigger research projects on university or school level. The research-related projects created possibilities for continuation: several course assignments connected with the same overall topic. For example, in 2012 the metropolitan area of Helsinki (and the city of Lahti) acted as the World Design Capital (WDC). During the preparations for the year, funding was targeted to projects improving wellbeing in the city with design. The 365 Wellbeing projects (see Keinonen et al., 2013) were part of the Helsinki WDC 2012 program and acted as Aalto University's flagship programs during Helsinki's

WDC year.[96] This also created possibilities for several additional course projects, connecting well with sustainability and CS Design.

Table 36. *CS Design students' (2010–2013) participation to advanced study modules with a project component (by Summer 2015).*

Advanced study modules with a project component		**CS Design students' course participation per year of intake**			
		2010	**2011**	**2012**	**2013**
Mandatory CS Design study modules	Sustainable Product and Service Design* (ARTS/Design)	12	11	10	11
	Design Ethics (project part) (ARTS/Design)	11	11	4	6
	Values in Design (ARTS/Design; an alternative to Design Ethics since 2012)			5	1
Other advanced CS study modules	Sustainable Urban Design (ARTS/Architecture)**	6	4	2	3
	Sustainable Building Design (ARTS/Architecture)	5	2	2	2
	City in Transition*** (ARTS/Architecture)	1	-	3	-
	Sustainable Landscape Planning (ARTS/Architecture)	-	1	-	-
	How to Change the World (project part) (BIZ)	3	3	3	7
	Other CS projects*****	9 (by 6 different students)	6	2	4
	Design for Government (ARTS/Design; since 2014)	-	-	4	5
Optional non-CS studies	SGT program project courses (ENG)****	1	2	2	2

* In 2010, titled "Sustainable Product Design," and then "Sustainable Product and Service Design." | ** Before 2012, a part of the School of ENG. | *** Titled "Cities in Crisis" before 2012; arranged bi-annually. | **** Not in core CS offerings. | ***** Optional content was listed under CS projects, as well as various academic output and outreach contributions, but only project-type work worth 5 ECTS or above is considered here. Some students took part in several projects (number of students in brackets).

[96] WDC Helsinki 2012 promoted design with 550 projects and 2,800 events. The annual program was implemented by a network of 290 organizations in Finland and abroad, and the events and sites attracted 2.5 million visitors (http://www.hel.fi/static/liitteet/kanslia/blogit/WDCperin-toen1.pdf).

The encounters and collaboration during various projects acted as an important mechanism connecting students in the CS community. In general, collaborating with a shared goal in a project-type setting seems to weld people together. As one of the interviewees [#17] describes it, people are met *"more randomly"* initially, but then encounters in projects strengthen the relationships. Many of the projects also evolved into thesis works for students, and activities organized in relation to these also contributed to the community — for example, CS space development workshops.

Development of student-initiated activities

During the first CS Design term (2010–2011), there were several students connecting together, but mainly in sustainability events and activities outside campus [as in #15]. At that time, there was only few students in CS to begin with, and CS did not have a designated space in Arabia campus either. Already in 2010, however, a student commune with a central location shared by three CS Design students acted as a location for several student get-togethers. And in 2011, as CS Design got access to spaces in Aalto Media Factory (AMF) in Arabia, this served as a location for various CS student activities, ranging from movies to talks, and to workshops to cooking.

In comparison with the students' earlier, undergraduate university encounters (abroad), Aalto University was described as a place promoting student initiated activities [#14, #17]. This setting, and the flexible spaces in AMF that CS Design acquired, helped *"to organise the things in a very easy way"* [#14]. Various CS student activities were organized in AMF spaces between 2011–2013. As one active student himself described it, during that time *"there* [was] *always something happening"* [#14]. Besides the more student focused activities, CS students were also involved in initiating various content for the program, ranging from self-organized workshops to projects, also creating new collaborations across schools and departments. Eventually the various collaboration and activities led to developing a more established CS student community, and also talks on sustainability interest inside and outside the university emerged (see Table 37).

Table 37. *Examples of student-driven activities in CS between 2011–2015.*

Type	Name (years)	Description
Examples of student-initiated CS activities	CS Movies (2012–2014)	CS Movies, one of the first activities organized by the CS student community, continued in various forms between 2012 and 2014. It was originally initiated by one active student based on a personal interest, and later continued by fellow CS students.
	CS Meets (2012–2015)	Organized initially by the initiator of CS Movies in 2012, in CS Meets (or CS Talks), the format was to have "*first the guest lecturer* [making a] *short presentation about the work he does and then just discuss* [...] *with some cookies and tea and so on"* [#14]. This activity also led to new topics emerging from the sheer student interest.

Table 37. *(continued...)*

Type	Name (years)	Description
Examples of student-initiated CS activities	CS Breakfasts (2012–2015)	CS Breakfasts began in 2013 as a continuation of CS Meets, but with more formal support from the CS program and its director, and with a change in schedule from evening to morning. CS Breakfasts gradually developed into a formal structure, led content-wise by the program director, while still addressing topics emerging from the students. As such, the activity continued until the end of this research.
	Yoga and Drawing (2012–2013)	CS Design students also organized some even more informal activities to support their own (and fellow students') interests. Organized by the initiator of CS Movies, a series (seven sessions) of drawing sessions is one example; another is a series of student-led yoga sessions initiated by another student. These activities, however, were open not just to CS students but to anyone interested who wanted to get involved.
Examples of student-initiated learning content	Microwaves (2011)	The Microwaves workshop series evolved from CS Design students encountering the Global Sustainability Jam (a 24-hour hackathon for sustainability), resulting in *"the idea to develop our own 12-hour or 24-hour workshop, in which we'd go forth to develop the kind of topics… that interest us"* [#18]. In these semi-structured sessions, there was self-facilitated teamwork and *"collaborative cooking and so forth"* [#18], with various topics, the CS WDC contribution amongst them.
	CS in WDC Pavilion: Whose Issues? (2011–2012)	In 2012, the metropolitan cities in Finland (Helsinki, Espoo, Kauniainen, Vantaa), together with Lahti, were acting as the World Design Capital cities. As one CS student was working as a trainee in the Demos Helsinki,[97] which had the responsibility of organizing activities for the WDC Pavilion in Helsinki center, the CS program was offered a possibility to organize something for one day. This workshop session in WDC Pavilion was eventually called "Whose Issues?" for which CS students created the content themselves, although several CS teaching staff were invited in as experts to support the interaction.

[97] Demos Helsinki is a Helsinki-based think tank that acts as a consultancy and an intermediary in various national and EU-funded research projects addressing sustainability.

Table 37. *(continued...)*

Type	Name (years)	Description
Examples of student-initiated learning content	PdP collaboration (2012)	The Product Development Project (PdP) is a famous project-based course in ADF. In PdP, a multidisciplinary student team tackles real-world cases given by clients over the whole academic term.[98] In Spring 2012, an event titled "CS Meets PdP Workshop," was organized, in which the CS students facilitated priming exercises and then coached each participating PdP project team on sustainability topics. For CS students, the idea was "to learn from experiences of PdP teams and challenging ourselves" [workshop description].
Examples of students reaching out from CS program	Big Plans Bakery Co-op (2012–)	The Big Plans Bakery (BPB) is a CS student-established "interdisciplinary" cooperative fitting "somewhere between a think tank and a design consultancy" — a reason for it being called "a think/do tank" (http://www.bigplansbakery.com/). Big Plans Bakery was ultimately involved in implementing CS studies in both shared courses and projects (e.g., in School of BIZ), and then in arranging two teachers for the 'Creative Teamwork' course between the 2012 and 2014 terms.
	Aalto Sustainable Community (ASC ry.*) (2014–)	Initially, talks around a CS student association emerged amongst CS Design students, and the program director was supportive. However, while there were discussions on such a need since 2011, only after students of the second and third year were involved in activities did the official talks begin. Eventually, in the discussed form, the association was registered in Fall 2014, with the name Aalto Sustainable Community (ASC). However, since its initial active start, ASC has not been very active and has kind of been on hold.

* The acronym "ry." refers to a registered association in Finnish.

4.3.2. Perceptions on being a student in CS

Besides courses and projects, sharing spaces also created encounters between students. However, spatial locations of CS program activities and studies kept changing. During its first years, CS Design in the School of ARTS was located in various places, ranging from spaces shared with other actors (as in AMF) to, finally, a designated CS space in 2014. Between 2010 and 2011, the program functioned in spaces designated to the Department of Design in general without any specific designated space. These spaces were also spaces for already established degree programs, and CS was often a sort of guest. Furthermore, the

[98] On the PdP course, since 1997 there have 201 projects and 1,917 students involved. Students arrived from various schools or universities before the Aalto merger, with students mainly from design, business, and engineering. A new set of 13–15 projects is initiated every academic year (see http://pdp.fi).

Aalto University merger resulted in changes in campus structure, still affecting the university operations today.[99]

While between 2010 and 2015 the basic CS Design and introductory studies were arranged mainly in Arabia, several CS workshop and teaching sessions (e.g., project presentations) were also organized in the Aalto Design Factory (ADF) on Otaniemi campus.[100] ADF is also mentioned as a reference point for CS students, with its "informal activities and interaction perceived as crucial success factors" and "open sharing within the community" (Björklund et al., 2011, p. ii). As a working space, ADF is mentioned as a place that *"everybody has been"* [#16]. For the CS students, however, ADF was not always felt to be open to all collaborators, and it had a strong spirit of its own [#16]. Furthermore, the ADF location was difficult. In this respect, having a space on Arabia campus was essential in facilitating various activities.

The Aalto Media Factory (AMF) in Arabia, however, was considered by CS students (except for the first batch) as their home base, at least in CS Design. As one 2010 CS Design student describes it, *"the second year students, the third year students, they said that that was their place," "a space for them to be, and… where they went whenever they felt like they wanted to meet some people"* [#16]. While AMF was not *"officially CS,"* it was open to new actors and *"they opened the doors, and people went in"* [#16]. By 2013, however, space issues were again encountered, as the use of AMF spaces was increasing and new agendas of interest evolved there. Furthermore, indoor air quality issues played a major role and prevented the plans for building a designated space in 2012. Many spaces were found to be problematic in this respect, caused mostly by the fact that the School of ARTS was mainly based in a renovated factory, with problematic building structures to begin with. Finally, after being more or less *"nomadic"* for several years [#17], in Fall 2014 a new designated CS space was opened in Aalto Arabia Campus on the second floor, next to the main entrance lobby.

In developing student activities at the beginning of the program, *"first everyone was really active"* [#15], perhaps partly resulting from the fact that *"everything was brand new"* [#15]. Gradually, after initial challenges resulting simply from the small number of students, by 2011–2012 the CS Design community started to be established with the CS community on a larger scale, and various student activities started to emerge. These activities were initiated by a rather small group of students and were often motivated by their personal interests, but were nevertheless supported by the program management in CS and in CS Design.

[99] After the 2010 Aalto merger (as described in detail in section 4.1.1), there was a decision gradually to move all school of ARTS teaching activities to the Otaniemi campus area, some 10 km away from the campuses in Arabia district and in the city center. The move for the Department of Design in Aalto ARTS has, however, been postponed from the original 2014 to what is now considered to be 2018.

[100] ADF is a teaching, working, and prototyping space initiated during the establishment of Aalto University, being the first official building of the new university (http://designfactory.aalto.fi/). ADF is based on earlier research and teaching collaborations, aiming to be "a platform for integrative interdisciplinary education, research and industrial collaboration, as well as a catalyst for a culture of experimental and problem-based education to promote better learning outcomes" (Björklund et al., 2011, p. i).

Many of the students active in developing the CS student community were on the CS Design program, and some reasons are evident. First of all, *"at least the first few years, the design people were the majority"* [#15] (see statistics in section 3.3.2). It is easy to agree that, as the other CS schools had only a few students and a lot of the studying was still done in school-based degree programs, the other CS students were simply not that present on the Arabia campus. Furthermore, as one of the first students describes, amongst CS Design *"there has always been"* some very active students [#15]. Each year, the group of active students varied, but in 2011 the cohesion in the CS Design group was even stronger, as they seemed to *"do things together a lot, and spend time together"* [#17]. In the end, *"it comes down to the couple of active people arranging things, and then everyone else joining"* [#17].

In developing the CS student community, the different disciplines in CS *"mix quite well"* [#15]. While the group of active CS students always involved a variety of professions (although CS Design dominated) and cultural backgrounds (a minority was domestic), yet there existed a *"sort of collective decision-making"* amongst students, based on *"a sort of a spirit... and a general positivity among the group"* [#17]. In this sense, *"the program fosters some kind of sense of responsibility"* and *"a basic sense of, yeah, being good"* [#17].

The process of developing the CS student community involved various activities bringing people together. Besides possible personal interests, a common motivation in developing the CS program, its contents, and activities for students was simply serving the CS community. The CS students seem motivated to contribute to the community. As one student, who was involved in various activities, describes it, *"I just like, somehow, also to add some value to the group of people I'm studying or working with or doing something"* [#14]. The students themselves describe, how *"the majority* [of them] *think CS is more like family"* [#13] and at least *"more like a family* [when] *comparing with other programs"* [#14]. In this sense, the CS students often also *"stick with each other and support each other"* [#14]. Overall, there was an open approach to collaboration. The CS students interacted openly with other students from Aalto University and pursued collaboration outside the university.

In 2015, one of the CS graduates focused his thesis on CS as an example of "post-formal" education for social sustainability (Salovaara, 2015). To the graduate, the real learning in CS took place between the shared CS studies as "core studies" (Salovaara, 2015, p. 40), with advanced content from CS Design (SPSD, Design Ethics) and other departments, and the extracurricular activities, courses, workshops, and projects that were outside the formal agenda. Gradually, these extracurricular activities also progressed outward from the core of CS and even from the university (as in Whose Issues? event and eventually in BPB; see Table 37), eventually connecting back to the program in the form of involvement in course teaching. According to the argument in the work, the learning in CS needs to support both formal, "university-organized and -certified" education, as well as "non-formal" activities connecting to one's "passion" on some specific subject and activity (Salovaara, 2015, p. 126). If the interaction between the two

contents is well balanced (and managed), the interplay between the formal and non-formal education can lead to a "post-formal education" of the future (Salovaara, 2015, p. 126), from which the author gathered his expertise during his studies.

4.3.3. Students developing CS content and community

The official content of the CS program developed through various processes, from initial interaction in developing the CS minor to major preparations, and eventually to activities taking place during the first years of the program. In Fall 2012, when the official advisory board activities in CS began, the first formal CS development meetings on the school level were held and, more informally, amongst the student community. Overall, amongst the CS students, there were motivations to improve the CS program community and content, as being a CS student was perceived to be connected with a willingness to be involved in developing the teaching itself. As one interviewee put it, *"I really don't understand that some people study* [in] *Creative Sustainability but they don't care about* [improving] *education"* [#13]. Another student describes that as *"we have this experience,* [and] *we have tried out different things"* [#14], this also acts as a justification to listen to their views.

In Fall 2012, CS perceptions and feedback from students were gathered in a more comprehensive survey by one student (interviewee #15), commissioned by the CS program director. The online survey continued with a student workshop. According to the workshop results, the CS program remained "undefined" and "maybe should stay as such" (2012 workshop report), as it could then invite all sorts of input into interaction, supported by an "overall feeling of openness and chance to experiment." However, "people still rely on the discipline close to their school" and do not "feel like experts of creative sustainability" (2012 workshop report). In considering the contents of study, an "even more practical approach" would be appreciated (2012 workshop report). The survey also emphasized how student perceptions are rather neutral in balancing "theory" and "practice" (3.4/5 on a Likert-type of scale; see note 92) but positive in relation to content being "project-based" (4/5). Furthermore, according to the respondents, the things they have learned in CS have come rather equally from "extra activities" and the "official curriculum" (2.8/5).

In general, the students have very strong experiences of the study content, perhaps also strengthened by their motivation towards participation in the program to begin with; but these feelings are not always very visible in the courses or to the teachers. Often *"actually nobody complained in the class, but we were complaining a lot"* [#13]. On the other hand, the developments in the course content are difficult to see as a student, as students take courses only once. However, according to students involved in the formal developmental activities (#15, #17, being communications officer or having academic board duties), there was constant progress in developing and iterating the shared introductory study courses in CS. This was partially perceived as positive and as *"a response to student feedback,"* but sometimes also *"circumstantial,"* based on the availability of teachers and so on [#17].

As in relation to the Systems Thinking course, a student feedback video (discussed in interview #13) criticized the lack of time in terms of both planned content and how much students were able to contribute. This lack of invested "credits" and "time" (how much students are able to contribute in relation to their scheduling of studies) connect together and, according to the video, result in a lack of "motivation" and "productivity," hindering "knowledge" production. The video also addresses the roles of participants, suggesting not only peer learning but also peer teaching with students taking teacher roles, starting from practical room arrangements to how topics and papers are discussed and reflected on in the group (see Figure 20).

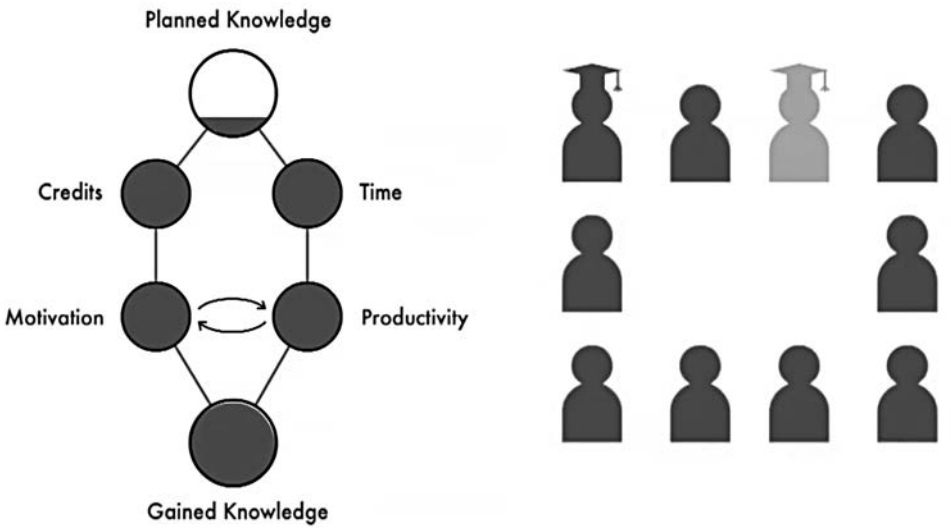

Figure 20. *Edited from screenshots from Systems Thinking course feedback video*
Source: Edited from the student video; courtesy of course students

The video also listed actual "ideas for motivation" to promote learning. Among these, were "more detailed feedback," sharing students' "own experiences," "innovative ways of presentation" (and "user-friendly web page"), and a better balance between "creative and academic assignments" and more "practical assignments." While this feedback was then discussed among teachers — it also led to structuring the phases of learning better in future teaching — the students felt that they got *"no feedback from the teachers,"* with only one teacher responding [#14]. Similar experiences of a lack of feedback (and follow-up on ideas) were encountered on other courses; and yet, also according to the students, in CS development, *"the student involvement* [...] *in more than just the feedback sense, but in some kind of co-creation sense is* [...] *important"* [#17].

In April 2013, a bigger workshop on CS program development was organized by CS Design, involving participants from all CS schools. More than 30 people participated, of whom roughly half were students from various years of intake, and the participating departments. In the workshop, identified as working well in CS were the "appreciation of values," "diversity," and CS as "learning platforms."

Identified as important areas of development were “practical project-based active learning,” “communication and networks,” “teachers’ collaboration,” and “pedagogical renewal,” amongst others (2013 workshop report).

The notion on improving communication related to the fact that “teachers share and learn from experience” and experiences of teaching and learning should be better shared, as well as to “telling what we do and hearing the voices of everyone” and “increasing awareness” (2013 workshop report). Pedagogical renewal was needed for “understanding all sides of knowledge” with a “dialogic approach”; and, as current thinking is “too top-down,” education should “listen to feedback” (2013 workshop report). Finally, practical and project-based “active learning” emphasized “learning by doing” to “test and prepare for future situations” and “to gain professional expertise” in “real life projects/problems” (2013 workshop report). In relation to the practical challenges in experiencing CS studies, teachers’ collaboration was also emphasized to avoid “overlap” and for “sharing workload,” and to give students “knowledge about teachers’ expertise” and an “overview of what is going on” (2013 workshop report). The workshop came up with ideas to proceed with, such as a “teacher exchange workshop,” a “blank module designed by the previous year’s students,” an “open conversation while developing ideas,” and good reporting of the ideas (2013 workshop report).

These developments were taken forward in various forms. Since the big workshop, teacher workshops (that had started on a school basis earlier) have been a regular annual event aimed at CS teaching staff. Previous years’ students were brought in to teach — for example, on the Creative Teamwork course — and communication online was already under development. In this sense, many of the issues had already been identified. However, several of the ideas that were discussed to involve previous students in teaching newer ones (for example, creating a project in which students would introduce some cases, or tutoring) have not really progressed. The formal follow-up, at least how it was experienced in terms of communication, remained thin.

In the end, CS students were perceived as slightly different from the “ordinary” student. CS students are perceived as taking *“things more seriously”* [#17] or being more critical in dialogues and thinking [#16]. Topics strange to others, such *as “toilet infrastructure in the third world, or some typical CS topic like that”* was no longer perceived as an *“unusual… strange topic,”* but for CS students a *“normal conversation* [...] *to have”* [#17]. Such an ability for a critical and dialogical approach toward any problem that is framed within the sustainability context can be considered as the key ability for collaborative analysis and synthesizing, as described when looking at interprofessional collaboration (as in sections 2.2.1 and 3.2.4). And yet, such an ability can help to connect with expert professional skills, too. As one interviewee analyzes, he is not sure if *“discussing tricky topics”* counts as expertise, but it comes down to *“being comfortable in the unknown”* [#17]. According to the same interviewee, sustainability and interdisciplinarity are in a sense *“the kind of two sides of the coin thing.”* According to him, from the CS perspective, *“the kind of discipline-based work that we're used to, the siloing of things, is one of the things that led to the problems that we have now”* [#17]. The

interprofessional approach is then perceived as *"maybe one way of... climb*[ing] *back, and getting to a point where sustainability, in whatever sense you mean it, is something that is working"* [#17].

Eventually, the first few batches of CS students' activities culminated in the initiation of a community on sustainability for the Aalto community as a whole. The idea behind this initiative was to *"serve the next ones"* [#17], and interested students at Aalto more broadly. In respect of communities interested in sustainability at Aalto University and amongst CS partners, a group around sustainability already existed in the School of Business, called the Sustainable Business Club (SBC) and consisting not only of students but also academic staff and a lot more people than just CS. This organization had an established history before CS, and it had been active in communicating events, as well as in organizing presentations, events, and regular reading sessions. As a result, a question emerged among CS Design: *"do we need that* [same thing] *at a design school?"* [#17]. The SBC events were, of course, open to all, but while participation in some events was shared, CS Design students also felt that a more open community was needed. Finally, after long discussions, the Aalto Sustainable Community (ASC) was registered in Fall 2014, with CS Business students leading its preparations and initiation. However, since its active start, ASC has been on hold.

4.3.4. Summarizing emerging themes from the experiencing phase in CS Design

In the student interviews, the topical structure focused on the activities of the students themselves, their motivations for being involved, and their perceptions of being a student in CS in general, also addressing topics of interdisciplinarity and sustainability, as well as the development of the CS community. The overall focus was on understanding how involvement in CS had been experienced, and to what type of profession it had led. At the beginning of the program, students were very motivated to be involved, driven by both their personal interest and the openness and novelty of the program. Looking at the study journey of the students, for many it lasted perhaps longer than expected, but was nevertheless perceived as successful.

According to the interviews, for many CS students, sustainability was *"like a mindset, more like a lifestyle, and the way you use things"* [#14]; for many others, however, it was just as an important aspect in future professional work. After graduation, the active student who was involved in producing the video feedback and in initiating various activities started a graphic design agency with a sustainability emphasis; another also eventually worked as CS communications officer before moving into the industrial design industry, following the other interviewee who worked in the position during research. Of the three remaining, two are now doctoral students, and the last one has moved back to her home country. Nevertheless, all of the interviewees still have a strong sustainability emphasis in their current work, and this is true for many other CS alumni as well (see afterword).

During the first few years of study — and through the involvement in various program (and self-initiated) activities — new professionalism and community started to emerge for students in CS Design. After experiencing the CS content and community, the students grew to know CS as their second family, and argued for a special type of approach to collaboration and learning based on open, iterative, and consensus-building interdisciplinarity, extending to transdisciplinary outreach between schools and outside actors. Overall, the following five themes were elaborated (see Table 38).

Learning to swim in complexity

The range of advanced studies in CS is rather broad, and many of the CS Design students have also participated in more content than necessary credit-wise. In many ways, the students have followed their path from one course to another based on other students' experiences and encounters with teaching staff. In students' words, CS just *"throws you into the chaos, and… waits for you to learn swim in it"* [#17]: "it's about stepping out from your comfort zone, and being comfortable beyond that." Such freedom of choice also relates to the nature of the subject of study — interprofessional collaboration — and the crossing of the boundaries of one's professional and personal knowledge.

Getting to know the complexity in studies themselves has pulled people together, and the interviewee describes how he and two other students even *"booked one of the meeting rooms* [to] *go through all the course options and figure out what's there we could take that might be interesting"* [#17]. However, as the interviewee describes it, for some people such freedom of choice can be debilitating. This freedom of choice *"probably has"* also affected the length of studies [#17]. Yet this is perceived as a positive thing, as "pressure to complete a certain set of courses" would *"prevent you from taking something else that you find interesting"* [#17]. For the CS students, the possibility of studying more than was required for the grade has been a common interest. On the way, they have also gained knowledge for their thesis projects, many of which describe CS as an important component in learning.

Access to and support from CS

Overall, there has been constant support from the program side to promote student activities and the various activities that could strengthen the student community. The CS program director, whose office was located on the Arabia campus, was always supportive according to talks with both staff and students. In part, it was also acknowledged that when students are active, they are often *"directly or indirectly promoting the program"* [#17]. Interaction in creating new content was supported, but at the same time students felt that their contribution to CS development was not always acknowledged. In approaching support from the student perspective, there are *"two types of support"* [#14]. One is material and financial support for student activities themselves, *"like just buying the food and beverages during those CS movies or open lectures"* [#14], or easy access to booking a room. The other type of support for activities is *"rewarding at some point"* those students who organize activities [#14]. Suggestions to get study

credits were identified, and some given, under CS projects; however, only participation in more formal events and projects was credited in the end.

Projects as stepping stones

For most of the students interviewed, encounters in various projects (in relation to shared courses, CS projects, or research) are described as crucial in developing relationships between fellow students and developing the active CS student community. Even conflicts that take place in project work (for example, in the SUD course in 2011) are mentioned as creating grounds for further collaboration and later *"laughed at together"* [#15]. In many ways, the student activities were also started as projects, tied to certain people for a certain period of time. Some student-initiated content developed into formal CS project content, and some was even made into official course content (such as the Design for Government course; see section 3.3.2). Project collaborations, however, connected students selectively, based on their year of intake, disciplinary background, and overall interest in being involved. For example, even the most active students admitted being completely unaware of some CS projects that others found very influential (e.g., in relation to the WDC 2012 projects; see section 4.3.1). In this sense, while participation in projects in advanced studies created new networks and knowledge for students, sometimes it was difficult to connect the learning back to the program or its future students.

Projects also act as stepping stones in developing professional skills and preparing ideas for the thesis works. However, projects can also feel a bit artificial with their study period-based schedules, and this does not prepare students *"for long-term project development"* [#15]. For students who contribute greatly in the teamwork, the lack of continuation can be experienced as a failure. In this sense, students also identify a need for some project content with *"an organic beginning and end"* [#15]; in some ways, they themselves develop such content by continuing the talks through the student association or other student interest in CS. From a student perspective, the CS studies themselves can be perceived as a project, connecting encounters and content in the development of professional practice.

Becoming a community change agent

During the first year of CS as a major (2010), the student base was small and the encounters more random, not around scheduled activities. However, in 2011, more students enrolled (some very active) and the ability to utilize AMF spaces as CS student space was granted. According to one interviewee, *"what makes us together"* in the CS community *"is that we have some events organized by students in CS"* [#13]. The active CS students were also active in their outreach toward other programs and even outside actors. For many, CS was perceived as another family. During the participation in collaborative activities and learning, the students had connected as a community. Many of the students were also interested in developing CS as a program. One of the interviewees mentions a "champion model" (see Crawford, 2001): *"you need a person, at least one person, that has passion for leading the work"* [#15]. These champions were found from

among both students and staff. According to the interviewee, *"it somehow feels ... that each year a group is kind of found* [amongst students] *that is more attached to the lifestyle"* of sustainability [#15]. These people were also interested in developing the CS content according to what they perceived as important.

However, not all students were active. Each year, some students took an active role in the community [#15, #17], and after a few sessions and events *"some people stay,"* with most leaving, and *"again after the second year batch, and third"* [#15], eventually forming a group of students continuing interaction within the student community from one year to the next. Being involved in such community activities is *"kind of like reciprocal outreach"* [#14]. The active students *"should kind of get something... back, and the same amount"* [#14]. In the end, student activities were partially supported through gaining credits, but this was not the primary motivation, as people often took part only in some phases, and only a few were getting credits in the end. For many, the involvement itself was sufficient motivation, and a chance to develop CS motivated further.

Building a community for interprofessional practice

The interviewed CS students also identify themselves as a bit of a *"special group"* in academia [#15], not only in the way they approach problems of sustainability and interprofessional collaboration, but also as experts on diversity around their topics. In student replies, it is also acknowledged, that *"only a few of our teachers have so diverse a background that is, like, offered to us"* [#15]. Not only is design skill needed, such as in media or graphics design, communication, and workshopping, but also skills for bringing in all perspectives. Often this means more critical discussions and a more open approach to collaboration with whoever wants to contribute. Generally, students seem to like interprofessional collaboration as it "broadens your way of thinking and you are in constant learning," although "it may be a long and stressful process" (Marttila, 2012, p. 1153). For many, this created frustration on the way, but was at the same time one main component in future professionalism.

This process continues toward a shared direction, and some people stick to it, eventually forming a community of active actors around various CS activities. Amongst such groups, there is at least partially a shared direction for activity, but many of them can also coexist around varied interests. As one interviewee puts it, the students involved in CS development have *"been pretty good, I guess, so far in... sort of collective decision-making, and whatever, without any problems"* [#17]. In the end, despite their heterogeneity, the CS students form a sort of collective approach.

Many of the CS students have been intentionally applying to a multidisciplinary program around sustainability (as in section 3.3.3). In this respect, they represent a group that is open to multidisciplinary or even transdisciplinary processes and practices, and already at the beginning sharing strong interests and motivations regarding sustainability. Overall, the interviewed students were all in some way motivated to develop the CS community and content, and perceived support from the program management.

Table 38. *Identified themes of interest in interviews III: students.*

Theme	Description	Example instance(s)
Learning to swim in complexity	CS study content is perceived to be exhaustively broad and sometimes vague, and yet this is perceived as the strong point in the program. Managing one's studies becomes an exercise on its own.	*"I booked one of the meeting rooms in the Media Factory for a couple of hours, so that we could sit down, with our laptops, and go through all the course options* [...] *And we did not get anywhere"* [#17] "*we also, in* [another city], *have like a pretty unclear* [degree] *program... in a sense that it gives so many possibilities... which I consider as a strength"* [#18] *"I guess it was good in a way, that I could get away without having a study plan, because then if a course popped up from nowhere, you could just pounce on it and take it"* [#17]
Access to and support from CS	Access to develop CS and support for various activities has been constant, and yet students perceive that their ideas are not always heard.	*"I was really glad to see that now, just as a student, I can do it here, and that Aalto and the Media Factory provide all these possibilities"* [for organizing student activities] [#14] [The student-driven activities] "*were self-initiated, but they were supported by the program as well"* [#13] [The program director] *"seems quite happy that students are active, and I suppose whether directly or indirectly promoting the program"* [#17] [however,] *"maybe it's going to take a few years to find out if that workshop actually fed into anything* [...] *at least it happened"* [#17]
Projects as stepping stones	Projects are identified as something that welds people together. They also connect to the developing professional ability. Various student activities were also approached in a project-based manner.	*"after the Whose Issues? project kicked off... and* [another student] *got interested in that... and he was working at the Pavilion, and made that connection* [...] *and then, we just happened to end up on the same project in France"* [#17] *"interest towards other's projects and also the, like, shared projects* [...] *people have found each other here, and... realized that they can compensate each other's know-ho, and create more collaboratively than would be possible alone"* [#18]

Table 38. *(continued...)*

Theme	Description	Example instance(s)
Becoming a community change agent	For many CS students, there has been a strong motivation to develop the CS community and content according to their sustainability interests.	[In CS,] *"the students are active. They are always going to help"* [#16] *"I don't know, maybe the program fosters some kind of sense of responsibility... to whoever the new students might be"* [#17] *"for me, it's like the priority, the education* [...] *can play a really visible role in awareness, caring about things that people usually don't care about"* [#13] *"everything that is done in the program is taking it in some direction... and everything that has been made, like, acts as a kind of resource ... for future development"* [#18]
Building a community for interprofessional (design) practice	Gradually, a new professionalism has emerged, focusing on interprofessional mediation and collaboration in design.	*"we are a special group... Only a few of our teachers have so diverse a background that is, like, offered to us"* [#15] *"our field is one of the central fields that represents some new design thinking"* [#18] *"I don't know if it's an expertise, though* [laughs] *unless that counts as an expertise, discussing tricky topics"* [#17]

4.4. Identifying Key Elements in CS Interaction

To better understand the main components in CS interaction, ranging from its priming to the implementation and experiencing by teachers and students, the thematic findings from the three sets of interviews are integrated into five cross-cutting main thematic categories, to be analyzed in relation to the three main phases in developing an inquiry for interprofessional interaction and learning. These main categories were developed in interplay with the emerging analytical framework, in line with the GTM-type process of analysis in which both the data and the theoretical insights encountered are utilized.

However, when moving the focus to the interaction between the actors and phases in the activity, additional focus still needs to be put on the academic context of operation. While CS was in many ways initiated as an open platform for collaboration, and while various components of the program have emerged on this basis, there is also the national and academic agenda that connects to the program development, which is not necessarily aligned in a similar manner. While the demand for such a program in relation to both sustainability and interprofessional collaboration was rather evident, there was uncertainty about the outcomes. Furthermore, under contemporary pressures, the new agendas can also be perceived as rivals.

For teachers, one difficulty was in contributing to the CS community in addition to their main activities in their home departments, and their contribution to CS as a whole was based more on course encounters only. Furthermore, as CS operated on three campuses, many part-time CS teachers (on short annual courses, projects, or advanced studies) were located outside the Arabia campus, where the program director, study coordinator, and CS Design students were mainly located.

4.4.1. Contextual challenges set by the university

In addition to the themes emerging from the interview materials, some themes can also be identified in revisiting the story of CS initiation (see Table 39), along with the overall development in the context of operation (e.g., funding and staff).

Academic structures as a challenge

The institutional structures in contemporary academia become visible in planning documents, development of content, and approaching roles in interaction. One main constraint is the fact that studies are often planned several months before they take place. In CS, the interplay between various degree programs in different schools has caused further difficulty, and the different degree structures and study schedules were difficult to combine. In CS, as many of the topics have been new or project-based, the teaching staff have also been more temporary, and there has been inconsistency. Furthermore, in creating CS content, teacher and student roles have also often been mixed. Overall, the academic structures have often hindered progress in developing new content. On the other hand, for the participating departments, CS has been an arena to try out new types of collaboration in pilot form and act outside the normal constraints.

Institutional (and national) motivations

In many ways, the initiation of the CS program as a cross-school major program was made possible by the Aalto merger and the demand for addressing sustainability in university teaching. Also, in connection with UN promotion of education for SD (as in section 1.2.3), the time was fitting to introduce such agendas to academia. Overall, in revisiting the National Innovation Strategy (as described in section 3.1.1), many components of CS content are also strongly connected to the expectations of future university teaching, bringing professionals together to innovate new solutions to improve national competitiveness. In this respect, CS is also driven by both national and institutional motivation to develop a new type of interprofessional learning for sustainability. In connection with these motivations, funding for the pilot was acquired, enabling a new opening such as CS.

Assessing success in academia

In approaching the success of CS as an educational program, the results remain mixed. The initiation of CS — albeit a complex process in its own — can be considered a success story of introducing new content to academia and seeking bold new critical interprofessional dialogues on sustainability. However, the effectiveness of studies in relation to the graduation times of students was not very high. However, cross-school encounters and networking and the breadth of study are not measured when assessing the success of education. Success in learning interprofessional sustainability is even more difficult to measure, as indicators for success are difficult to imagine. Yet the evolution of CS content, its continuously motivated student base, and the previous experiences and formalized activities developed on a community basis can also be considered as examples of success, as they have developed the academic content and structure in CS interaction.

Table 39. *Identified themes of interest in assessing the context of CS interplay.*

Theme	Description
Academic structures as a challenge	Academic structures ranging from the schedules to working positions caused extra difficulty for CS as a cross-school program.
Institutional (and national) motivations	The initiation of CS was fueled by national and institutional motivations, visible in the background materials and context.
Assessing success in education	Success in education is measured according to effectiveness of studies and quick graduation time: breadth of content and interaction are not necessarily considered valuable.

Overall, the contextual setting around the national motivations for university reform and the creation of a new "innovation university" (see section 3.1.1) played a role in the CS initiation. In academia amongst various professional fields, too, a need was identified to introduce sustainability inquiries into the educational agenda, as well as to promote interprofessional collaborations. However, at the same time, the setting for educational activities in the university has been put under increasing demand for efficiency and competitiveness. Tightening resources and schedules, and increasing competition between programs, puts stress on cross-school collaborations. Furthermore, success in these activities has proved to be difficult to measure.

4.4.2. The cross-cutting thematic categories identified in CS interaction

In general, CS as an educational inquiry into interprofessional design action for sustainability has been successful in introducing a new type of cross-school collaboration to the academic interaction at Aalto University by providing an open platform for professional dialogues on sustainability. Looking at the identified themes (see Table 40), the overall focus remains on collaborative interprofessional learning for sustainability. However, the novelty and the complex context of the CS interaction (contemporary academia with several disciplines) affects the interaction: at worst, it acted as a barrier in connecting experiences to learning and development.

Table 40. *Summarizing the themes emerging from the three sets of interviews and the contextual setting.*

Thematic categories identified in the data		
Initiators – Priming	**Educators – Implementing**	**Students – Experiencing**
• *Controversial sustainability* • *Building capacity for sustainability dialogues* • *Staging of context, setting the stage* • *Expanding disciplinary perceptions for learning and practice* • *Critical, professional perceptions on sustainability*	• *Tackling novelty and complexity* • *Expanding processes of learning* • *Sharing initiative* • *Institutional constraints and challenges* • *Developing one's own (teaching) profession*	• *Learning to swim in complexity* • *Access to and support from CS* • *Projects as stepping stones* • *Becoming a community change agent* • *Building a community for interprofessional (design) practice*
Context of activity: the university setting		
• *Academic structures as a challenge* • *Institutional (and national) motivations* • *Assessing success in academia*		

In interplay with notions emerging from the development of the analytical framework (see section 3.2.2), these 18 themes emerging from the interview materials and contextual insights help to develop the following five main integrated thematic categories of interest (see Table 41) that are then supported with connections to the specific interview sets.

Enabling dialogues for (creative) sustainability

The initiators emphasized how one main factor in developing a new understanding of sustainability challenges is to create the capacity and skill to be involved in collaborative, interprofessional dialogues and mediation on sustainability topics. In many ways, the shared CS studies are designed to offer the necessary competence to be involved in such activity, which then takes place in collaborative projects (e.g., advanced studies and research projects). In seeking the interdisciplinary orientation often necessary in intensive design collaboration, the goals of activity, the processes of collaboration, the utilized tools, and the communication of results must be agreed upon. Also, sharing spaces can be perceived as crucial.

Creativity in the name of the program can also be understood as one element very important to the students themselves in CS. For the CS Design students, the lack of creative content (such as art, culture) was perceived as something to improve, and some activities were initiated accordingly. For students, such a creative approach was also an essential ingredient in developing their future practice, visible not only in ingenious new solutions, but in the normal practice of collaboration in CS.

Learning through practice

During the initiation phase, there was an intention to involve students in interprofessional collaboration, to create new learning for contemporary practice. The practice of interprofessional knowledge-building took place on various levels of activity and in relation to different phases of interaction, ranging from the setting of the CS agenda in initiation, to the development of program and course content, and eventually to team-based inquiries in relation to various courses and projects. Projects connecting to research projects and real-world challenges were addressed as platforms to facilitate learning in all interview materials, and various activities were initiated with a project structure that then evolved into more official content.

Collaborative and peer-based learning acted as the identified emphases in CS teaching and in the program development. By connecting students at varying levels of expertise and at various stages of study with various experts from university teaching and research staff, the program has constantly expanded its body of collaborators, endorsing a shared motivation for change, mutual dialogues of progress, and respect for other disciplinary views and approaches.

New professionalism and expertise

In the initiator interviews, one aim of CS was to create new interprofessional expertise on sustainability. While initially there was only limited understanding of what type of professionalism CS would nurture, according to the student perceptions there exists a special approach to collaboration that is more dialogical, reflective, iterative, value-sensitive, and transdisciplinary in its outreach, expanding toward outside students and actors. While the disciplinary core is sustained, representing the most valuable input to the collaborative inquiry, the various encounters with other professionals help to develop a new approach toward collaboration.

Overall, there is an ongoing process in CS of sensitizing students to various disciplinary approaches to prepare for interprofessional practice. Various occasions of shifting roles in teaching and in initiating activities are tried out in preparation for further facilitation of interaction and collaborative learning.

Building an interprofessional community for sustainability practice

Overall, the main motivation in CS has been creating an interprofessional community in developing a practice for sustainable design. In many ways, this activity has been driven by champions active amongst both students and faculty. In the interviews, it also became obvious that the program director (and the preceding head of the CS preparations board) has been a key connector in developing course content, bringing student perspectives, official feedback, higher level inquiries, and teaching staff together. Teachers on the shared courses were nearly always recruited directly by the program director, and while most of the advanced studies were organized by other degree programs, the director had some influence even then. However, it became equally clear that the content itself was introduced to the interaction based on various professional and personal interests.

Besides the management and teaching staff, students themselves were eagerly involved in the development of the CS community and study content. However, their perceptions were not always that visible to the management, and it was also difficult to connect these learnings for future students. Yet CS students were motivated to contribute, sharing a special responsibility toward the topics of their study. While the active students in the CS community from the first few batches eventually left the core group, many of them are still in touch with the CS family. Ideas and inquiries on alumni events and interactions have also been under discussion, and the first alumni events were arranged in 2015.

Renewing academia as a platform

In general, contemporary academia is perceived both as a platform to try out new types of educational interaction and a context that creates special constraints to learning and collaboration, especially in cross-school and cross-department collaboration. Many of the institutional motivations in academia are addressed (for example, ideas on promoting innovation, interdisciplinarity, and

sustainability), and many of these also follow from the development of the national agenda. In terms of the national and institutional context, however, the increasing demands on efficiency are creating pressure. The fixed roles and agencies (potentially not transparent), mechanisms of decision-making, and differences in annual schedules and processes create invisible barriers to interaction.

The content that was introduced through initially informal student activities brought in new content and emphasis, and improved the CS program content. For the participating departments, CS as a program has also acted as a place to try out a new type of collaboration, to be expanded to other programs and education, and to transform academia and university studies as a whole. This process was resource heavy for both students and management, however, and many ideas and activities came to an end without proper continuation or follow-up.

Table 41. *The five integrated main thematic categories, with connected themes from the data.*

Integrated thematic category	Connected theme [interview sets I–III]	Description
Enabling dialogues for (creative) sustainability	*Building capacity for sustainability dialogues* [I]	Overall, in setting the stage for CS one main motivation was to enable new kind of, creative and yet scientifically rigorous dialogues on sustainability in academic context. Another idea was, that this new understanding then reaches out from the program, to transform practice. The theme becomes strongly visible in the initiator talks. And yet, also students perceive the ability to involve themselves to the developmental dialogue crucial as well, to promote the same overall agenda.
	Staging of context, setting the stage [I]	
	Controversial sustainability [I]	
	Critical, professional perceptions on sustainability [I]	
	Sharing initiative [II]	
	Building a community for interprofessional (design) practice [III]	
Learning through practice	*Expanding disciplinary perceptions for learning and practice* [I]	From the beginning of CS preparations, learning through practice (in projects, through collaboration) was identified as one key component, allowing the expansion of disciplinary perceptions and collaborative mediation. In many ways, the development of CS interaction was also learnt through practicing it for a while. Learning in practice can be supported with project-type work, in which roles and objectives are clearly set and tested in a given context.
	Expanding processes of learning [II]	
	Learning to swim in complexity [III]	
	Projects as stepping stones [III]	
	Developing one's own (teaching) profession [II]	

Table 41. *(continued...)*

Integrated thematic category	Connected theme [interview sets I–III]	Description
New professionalism and expertise	*Expanding disciplinary perceptions for learning and practice* [I]	In CS, the new professionalism emerges around interprofessional and transdisciplinary practices. Yet this competence becomes only meaningful in a team setting in which several people collaborate and learn together. For designers, the focus is on facilitating collaborative mediation, and for teachers to improve their teaching practice to support interprofessional learning.
	Tackling novelty and complexity [II]	
	Projects as stepping stones [III]	
	Developing one's own (teaching) profession [II]	
Building an interprofessional community for sustainability	*Staging of context, setting the stage* [I]	The overall motivation in CS activities was to connect certain professionals (from the professional fields of the initiators and involved partners) at the beginning, to tackle challenges, and seek transformation for sustainability. Eventually, students have become members of a new community of interprofessional practitioners that tackle sustainability challenges in a shared manner.
	Expanding disciplinary perceptions for learning and practice [I]	
	Sharing initiative [II]	
	Becoming a community change agent [III]	
	Building a community for interprofessional (design) practice [III]	
Renewing academia as a platform	*Staging of context, setting the stage* [I]	From the beginning of CS preparations, the idea was to introduce new academic interaction to tackle sustainability. Academia, however, acts as a context for good and bad, both promoting interprofessional action, scientific understanding of sustainability, and transdisciplinary action, but also as the long contested setting of different professional agendas, competitiveness, and transformation.
	Institutional constraints and challenges [II]	
	Institutional (and national) motivations	
	Academic structures as a challenge	
	Assessing success in education	

CS challenging conventional modes of teaching and learning

The idea in CS from the beginning was to introduce new academic collaboration. Transforming conventional structures, however, is challenging, more so if the development takes place between departments and schools. Curriculum development is "often connected" to a change initiated by "either external or internal factors" (Nummenmaa et al., 2005, p. 49). In the case of CS, a novel curriculum was developed, based on both external (sustainability) and internal (interprofessional, transdisciplinary research) pressure. Different views on the extent of interaction, and the lack of resources (funding, time) in staff interaction and student access, however, resulted in several mismatches or contradictory punctualizations (i.e., where actor-networks meet) in the system of activity.

Consequently, in introducing interprofessional activities to the Aalto University context — and in transdisciplinary sustainability even more so — the processes in teaching and management are expanded to a critical domain in which the learning activity itself also becomes an arena for improvement, extending to the future real-world practice. In introducing such activities to the (design) academia, the reflections from a transdisciplinary design process for sustainability introduce questions on participation, decision-making, and progress into a critical dialogue amongst not only academics, but also students as future professionals, and outside actors across the society.

In the case of CS, while the initial motivations also built on innovation and (academic) competitiveness, the internal factors emerging from the interaction and learning started to challenge conventional practices of understanding success and competence. However, this interaction was often performed by actors with only temporary involvement, and the director was key in linking everything together. The loose community also challenged communication and development.

In relation to the new interprofessional understanding, the teachers' and students' experiences become invaluable, but there are difficulties connecting to development, and contesting messages on professional and disciplinary expectations can create confusion. Such conflicts can be better understood — and improved — by taking the findings from a shared system of activity in which all three actor groups are connected to a specific phase in action.

5. IMPROVING LEARNING FOR SUSTAINABLE DESIGN

As the last phase of the analysis — following the development of the main thematic categories important in the CS program interaction, as well as the notions emerging from their interplay in three phases — the five categories are studied in relation to the context of interprofessional learning in academia in general (especially in design academia), with CS identified as a platform for piloting new interaction and learning. In this process, a special focus is put on assessing the conflicts in interaction to suggest improvements for theory and action.

Overall, while the earlier chapters focused on developing an understanding of how CS activities and the activities supporting interprofessional learning in general can be understood, this final phase introduces ideas for improvement, structuring the findings along a framework developed on the basis of understanding emerging from the activity theory (CHAT) framework. In this respect, the focus moves toward transformation in practice and to organizational learning. The shared unit of analysis is identified in the development of the CS program (and its focus in developing interprofessional learning for sustainability) as a system of activity and a project in itself, although various, more constrained areas of focus (i.e., projects, course contents, students' study journeys) also act as smaller components in the study.

In analyzing the main thematic categories, several connections can be identified with the three phases in CS interplay. Analyzing the process for interprofessional knowledge-building (as in transdisciplinary research in general), these three phases of activity become important in structuring the interaction. Academia as a setting creates the context for this interaction, also enforced by the phases of activity, and roles and agency set by the institutional structures. However, at the same time, potential conflicts in interaction become evident. Reflecting on the thematic categories in relation to the phases of interprofessional learning helps to create a more structured understanding of the challenges in CS interaction as a whole.

This chapter concludes the analysis and the assessment of the case, and structures the emerging findings with an activity theory (CHAT) lens. Based on the findings, propositions for improvement are offered and research questions are revisited.

5.1. Integrating and Structuring Findings Together

In CS, in interplay with the insights from the theoretical background study (see section 2.3.3), the main thematic categories emerging from the research revolve around the creation of a new educational platform to reach out for new collaborators and to develop — besides disciplinary expertise — new competence in interprofessional collaboration for sustainability (see Figure 21).

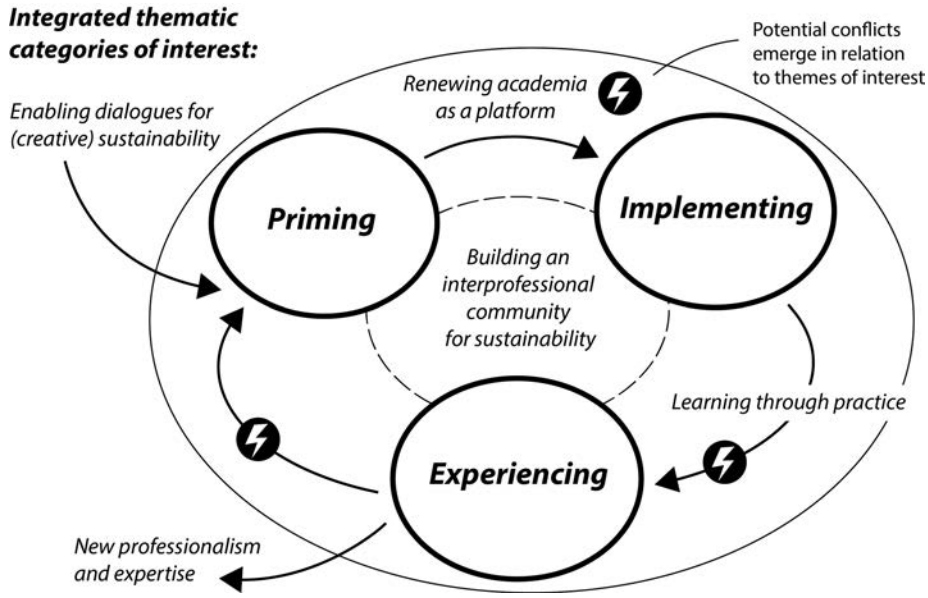

Figure 21. *Integrated thematic categories as important elements in the CS development.*
Source: Author

As discussed earlier (see Chapter 3, section 3.2), following the institutional structures and roles in academia, the interaction in CS developments can be structured into three phases of activity, priming, implementing, and experiencing. Together, these resemble the three phases of inquiry in a transdisciplinary research process as suggested by Hirsch Hadorn et al. (2008, 2010; see section 2.2.1) and act as the general phases of interprofessional learning in an academic context (see section 2.3.3). These phases of activity take place on several levels of activity in the program, with overlapping actors and activity to an extent. As discussed in Chapter 2 (see sections 2.1.2 and 2.3.3) in relation to the interprofessional, interdisciplinary, and transdisciplinary collaboration in general, the model for interprofessional (even transdisciplinary) expansive learning (cf. Engeström, 1987) can be structured into similar areas of focus.

The themes and conflicts that are identified in the materials can then be analyzed in relation to the conceptual elements emerging from the theory (as in section 3.2.2), revolving around the roles of participants, phases and temporal structures in activity, and the development (and consolidation) of activity (and practices) in

general. At the core of the phases of activity are the objects of activity, and at the outset resides the affecting context. In between, the interaction is affected by contradictions and conflicts between actors and instruments (often based on differences in disciplinary practice).

CS initiation and development as expansive learning activity

At best, CS acts as a shared problem space (see section 2.1.3) where collaborators across the actor groups can introduce not only their understanding of sustainability, but also their ideas on developing the learning activities themselves, introducing new emphases into the interaction. Hence, the shared objective in CS can be identified as developing interprofessional collaboration and learning for sustainability. As a result, tools that help to convey the agenda and to expand and reorient the inquiry become important. Gradually, a community of practitioners (cf. Lave & Wenger, 1991) emerges, at least amongst CS Design. CS as a whole, however, remains a more open community of interest (cf. Fischer, 2001), acting as a piloting platform for each department, and this same liberty is utilized by the students.

In looking at interprofessional learning, the concepts and constructs from the theoretical excursions become important (as explained in section 3.2.1). Engeström's model of expansive learning (1987, 2000; see section 2.1.2) explains such a process as developing from questioning to analysis, to improving the existing model of understanding and activity, and then to its implementation and reflection to consolidate new practice. However, in approaching contemporary, interprofessional collaboration, the phases in learning start to deconstruct into various sub-activities, performed by various constellations of actors.

The conflicts emerge in relation to contradictions in interaction within and between the three phases of interaction (and the actor roles within; as in Figure 21). In between the phases, knowledge is inscribed in materials, but also embodied in the competence of the involved professionals, (cf. Shove et al., 2012) and then again translated (cf. Latour, 1993) as the new phase of activity with new actors begins. The materials and knowledge become internalized, (cf. Vygotsky, 1978), and then appropriated into future practice in outside collaborations. The shared area of focus remains in CS program vision, in developing new, interprofessional understanding on sustainability.

In relation to the ideas on cultural mediation (cf. Vygotsky, 1978) and expansive learning, (cf. Engeström, 1987), the interprofessional sustainability context of activity expands the domains of learning further, as increasing amounts of input are welcomed in. In interprofessional learning, however, the shared problem space is dictated not only by the participating disciplinary inputs, but also the hierarchical roles and relationships between the actors, and their access to the content and phases of activity within the institutional constraints. In the contemporary academic setting, these three phases become enforced by both temporal and institutional structures, as well as the roles and motivations between actors who govern the power in their disciplines.

5.1.1. Assessing conflicts in CS interaction

In moving from the development of understanding of the phenomenon toward suggestions for improvement, the interview materials were also addressed in relation to potential conflicts in interaction, in connection to the three phases in developing interprofessional learning and collaboration in general.

Various challenges affected the development of teaching and learning in CS in relation to both academia and the complex sustainability challenges as a context, as well as the contemporary shortage in time and material resources. While CS benefitted from being especially funded as a pilot, the collaborators were still tied to the ever-increasing demands of contemporary professional life. For the future graduates in CS Design, their professional strength was created in the various activities and projects in which they were involved in interprofessional mediation and collaborative design. In these encounters, they were able to reflect on the theoretical learnings. However, the broad range of CS studies, as well as the novelty of the program, and even the promotive attitude toward broad course excursions, also created some confusion and frustration.

Table 42. *Conflicts emerging from the interviews and other data.*

Identified conflicts in the data		
Initiators – Priming	**Educators – Implementing**	**Students – Experiencing**
• *Conflicting dimensions of sustainability* • *Conflict between academia and the sustainability agenda* • *Sustainability as a goal of action versus a mindset in making*	• *Conflict in managing interprofessional education* • *Conflict emerging from clashing disciplinary frameworks* • *Conflict in relation to learning outcomes* • *Conflict in developing content and outreach*	• *Conflict in perceiving CS offerings* • *Conflict in developing CS contents* • *Conflict in sharing and experiencing* • *Conflict in evaluating success in learning*

Overall, to reflect on CS as a context for interaction, the data can be assessed in relation to conflicts that emerged (see Table 42). Within the interplay between these notions is a better understanding of how to identify contradictions in the interplay in CS, and in the interconnected phases of activity in interprofessional learning in general. Consequently, suggestions for improvement can be proposed.

Analyzing conflicts in priming CS

The controversies related to sustainability as a concept become evident in discussing, for example, how sustainable development for *"certain actors"* [#1] is often promoted with economic development, or when *"greenwashing"* takes place [#3], or whether design is about economic or social development. The three-pillar model (see section 1.2.3) is *"a nice logo"* [#1] but in many ways over-simplified. Various disciplines have different emphases when approaching sustainability, and

differences in understanding concepts, or in using language, or even specific tools. To promote sustainable transformation in contemporary practices, the concept itself calls for a more critical approach, in contrast with just using it as a superficial brand.

Conflicting dimensions of sustainability

As discussed, the dimensions of sustainability were perceived as interconnected and often conflicting. In general, economic and sociocultural sustainability entail a lot more than any simple approach provides: *"There needs to be a lot more discussion of what goes into these,"* as the two contain all our *"social relations"* [#1]. However, economic imperatives are acknowledged as the driving force for development on all levels. Ecological sustainability, on the other hand, is perceived as a *"the kind of goal that it provides a little, quite little answers to how to do things"* [#1]. Ecological sustainability, like sustainability in general, can be perceived also as a consequence rather than a cause — as a result of successful progress in cultural, societal, and economic domains. As a result, the development toward sustainability becomes somewhat conflicted in its nature: for example, to truly understand and address ecological sustainability considerations, one has to have material and social security, and at the same time only ecological sustainable living can help to achieve this.

In all the initiator interviews, the respondents emphasized human over ecological aspects. In this respect, the perspective seems to be rather anthropocentric. One possible reason is that none of the interviewees has a background in architecture, and in business and design the scale of focus and interest is more on human aspects. A business background does introduce more focus toward economic reflection, and more justifications to this end, but this economic emphasis is to an extent shared by all respondents.

Conflict between academia and the sustainability agenda

The agenda for innovation in a contemporary university setting is clearly elaborated in the materials, and also elaborated in development of CS content. However, for the economic agenda, innovation is sought to increase the output, and this is in contrast to the sustainability agenda. Overall, while sustainability can be perceived as a benefit in future business, the urgency and broad scope of necessary transformation denotes disruptive changes to the system. Furthermore, the call for sustainability also denotes the initiation of open dialogues to discuss what is considered valuable and how change should be pursued. This requires expansion both inside the university and toward various outside actors who are considered important. As the initiators acknowledge, *"the kind of agenda of Creative Sustainability, or sustainability in general, cannot be pursued only... of course, not only in university"* [#1]. However, as the participants are welcome to introduce their own interests to CS as an open platform for sustainability dialogue, the scope for potentially conflicting ideas of proper education and actions to promote sustainable transformation increases further.

Sustainability as a goal of action versus a mindset in making

Sustainability can be seen merely as a concept in branding, or a goal for development in various projects, and a broader mindset in all activity. In general, sustainability can be perceived as a goal, as a process, and as a driving force — in a sense, as a cause and a consequence. For many people, sustainability connects to everyday life; for others, it is what's considered important in their professional practice. For some, however, it becomes a driver of activity in a broader sense. To them, it becomes a starting point for future practice and for personal growth.

And yet, even when sustainability can be perceived as a *"mindset"* [e.g., #3, #4], driving action from both ends, it also calls for a critical approach in its processes of development. Perceptions on the meanings of sustainability and sustainable development differ, and, of course, questions on underdevelopment and inequality are ethically challenging. However, from a pragmatic point of view, we as consumers in "developed" contexts are continuously undermining these rights of existence of people and places when purchasing products that are unsustainably produced and producing capital that is unsustainably invested. As a result, a reorientation in our global existence is needed.

Analyzing conflicts in implementing the shared CS studies

The challenges in implementing and managing studies in CS come from several levels. Firstly, the shared, introductory CS studies are organized in addition to the departmental degree-based joint studies, and often come later in priority for the departmental degree program management; furthermore, interaction between CS teaching staff and the departmental degree program management takes place at a slightly different level of the organization. Secondly, the CS content, aims, and study materials overlap to some extent, with a limited awareness of studies in other programs. Thirdly, the physical distance between the people and departments involved in CS may result in difficulties in taking part — or even understanding — program dynamics. However, most of the conflicts in collaboration and learning are related to the different approaches, practices, and expectations emerging from the academic and interprofessional context and sustainability.

Conflict in managing interprofessional education

Collaborative practices in interprofessional design are acknowledged across the participating degree programs. However, the practices of studying vary between schools and departments. Furthermore, in CS, information regarding the content of study, collaborations, and projects was often not initially visible and easily accessible, even for the CS teachers. Different practices of learning and management created conflicts in the planning and implementation of CS content. Furthermore, there was really no established mechanism for introducing changes in content (as the academic board did not yet operate in the first two years). While the proactive approach was supported, ideas did not always result in visible progress.

This connects to processes of learning, but also to assessment and evaluation, and *"what we measure"* to assess success [#5]. In managing interprofessional education, it is important to ensure and promote dialogues on content and teaching practice. In CS, however, this process was hindered by constraints in time and resources, and by the distance in both physical operations and the disciplinary frameworks for collaboration and interaction. Teamwork skills in projects, and group working skills in general, are identified as one of the *"most challenging part of the CS approach"* [#9a]. While sustainability problems may often be complex, interprofessional collaboration can be considered complex in itself [#9a].

An actual project case *"that exists in the real world"* is beneficial to have involved [#9a]; yet complex cases can lead to *"not having enough information, not knowing how to get the information"* [#9a], and that can easily frustrate the students [also #5, #6a]. Learning in various contexts and levels of the program introduces interaction within complex systems of potential content and directions, and within a complex setting there are *"small local rules"* [#10]. Acknowledging these can take extra time.

Conflict emerging from clashing disciplinary frameworks

Considerations on disciplinary differences exist, but are approached in various ways. While those with a research or engineering background are recognized as being *"very methodological in their research,"* designers emphasize *"facilitation," "being comfortable with ambiguity"* [#9b]. Another respondent says that in comparison with research, both engineering and design are *"solution-oriented,"* but *"the solution is sought in totally different ways"* [#8], and for a person looking for *"certainty"* and *"data"* (as often in engineering), the ambiguous setting for design can result in being *"almost locked"* [#9b]. In different fields, the professional *expertise "is built in a different way"* [#8] and the way a researcher approaches problems is different from an engineer's approach, which is again different from a designer's or an architect's. Furthermore, various cultural aspects can override the disciplinary or professional perspectives, as *"the cultural element… the nationality and the ethnic background"* can be *"deeper and more sensitive"* [#9b] than one's profession.

Sometimes an *"emotional aspect"* can help to overcome challenges *"theoretically and pedagogically"* [#5]. In developing CS community, however, access to certain activities remained limited, leading sometimes to a decrease in motivation. Sustainability in communication is an important aspect, as *"we cannot have other aspects of sustainability without having sustainable communication as the process, the capacity to work together"* [#10]: only by improving access to give input to CS interaction can such motivation be ensured. As *"design is so much about communication"* [#9b], interprofessional work that brings specialists together with designers and architects can help to introduce expert knowledge into collaboration. Similarly, students from business are often very fluent in project management and communication. However, in business and in design, the conventions vary, and many practices and communities are *"not always so teamwork-oriented and definitely not multi-professional"* [#6a].

Conflict in relation to learning outcomes

As discussed in the initiator interviews, the emphasis on interprofessional practices of work can also lead to shortcomings in, for example, the so-called academic skills-set [#2]. Overarching inquiries and broad project topics can also confuse students and result in extending studies (as seen in CS). Learning can take place within one course or even one session of teaching and interaction, but becoming a professional requires various excursions into reading and practice. Furthermore, the processes of interprofessional learning require a *"very strong feeling of trust, and a safe environment* [to have] *students start to try their limits"* [#10]. There are, however, great differences in the level of experience between different participants. In such a varied context of topical interests, expert views, and learning interests, you also have to pay attention to *"what is the starting point"* [#10].

Independently performed learning is a crucial component in CS, based on the often high motivations of the students and interacting staff, and earlier experiences. Support from the teaching staff is, however, crucial to such (at least partly) self-facilitated learning, as a reflective learning process benefits from structure and support, and face-to-face interaction with teachers gives constraints for work [as in #10]. However, in a bid to improve graduation times, the universities have increased their course offerings and simultaneously shortened course durations. While in 2010 there were four teaching periods in a year, with each one approximately 10 weeks, in 2012, the four-period structure was redesigned at Aalto University into five seven-week periods, with an additional summer period. This has resulted in more intensive course structures. Although the *"intensive approach works with some things"* [#8], bigger courses and content demand more time.

Conflict in developing contents and outreach

Besides the planning of study content and projects, there have been several outreach and student activities and some development events for the whole CS program. Such community development on various levels has continued throughout the years of operation of CS, and yet there has been a somewhat inconsistent approach to evaluation and follow-up. Only in Spring 2013 was a first, more official development workshop across students, staff, and directorship held: similar events have not been since initiated at that scale. However, for CS teachers across the participating schools, there have been annual meetings (e.g., in 2014 and 2016) for at least the main representatives of the shared introductory courses and other courses and projects.

In developing new content, one challenge for both the staff and the students is the ever-tightening annual study schedule (and reductions in study compensation fees, resulting in a need to earn money). Due to the challenge on a course level of making four departmental schedules meet, more informal content connecting students from across the CS degree programs (projects and additional courses) can become difficult to schedule. This time scarcity only worsens at higher levels of academic management and teaching. The professors are often *"burdened with*

administrative work," and researchers and teachers are *"for example,* [applying for] *funding"*: they cannot *"contribute with skills that they're really specialized in"* [#9b].

Developing new content is, after all, resource-heavy, and calls for flexible resourcing of funds and scheduling of work. In CS, this has partially been possible because of the special pilot funding, and because of the strong directorship of the program. At the same time, funding for university teaching is decreasing and the focus of funding is moving toward research. Without such support, however, some of the developments would not have happened. In comparison with more traditional, disciplinary education, in an interprofessional educational program, more resources are needed to develop content, and this activity must be maintained constantly.

Analyzing conflicts in experiencing CS as a student

Experiencing CS as a student begins when the decision to apply matures, and for the interviewed students there were often earlier encounters with sustainability and interdisciplinarity, increasing the motivation to be involved. As the student becomes involved with fellow students during the shared course and project encounters, a community of actors emerges. In a sense, the annual structures in academia also create annual batches of students, who then interact with the wider community of students at different phases of their studies. In CS, the lack of consistency, location, and focus has hindered the passing of information from one actor to another.

Conflict in perceiving CS offerings

Overall, content in CS was perceived as *"a pile of instruments to tackle the sustainability challenge"* [#15]. For students, *"the program leaves a lot of choice"* [#14] and *"we cannot really know what we will be working on afterwards"* [#14]. The study content was poorly communicated officially, and as this information was also poorly available, students stuck together to review interesting studies. However, motivated by the context of sustainability and interprofessional collaboration, the CS students eagerly involved themselves in studies, even more than was necessary graduation-wise. Overall, the broadness of CS studies was appreciated, but perceptions on teaching varied: some content was considered rather poor. Because of the heterogeneity of the student base and the motivations that were pursued under the broad umbrella of sustainability, various perceptions on the content or success became evident.

While the idea from the beginning was for each student to have meetings with the program director to plan their studies, such meetings did not take place regularly during the first few years of the program. Instead, students often just followed their interests in planning their studies, and then proceeded rather organically, seeking courses and content based on what they heard from others: in many ways, such an approach was supported by the program directorship. Tutoring students with such broad study content was challenging, even more so when the teachers were only visiting CS on an advanced course and mainly operating outside the cross-school program. Connecting student experiences of studies with

fresh students is another challenge. Finally, in relation to CS, where students can be even more aware of the program content than the teachers, their perceptions will be valuable to connect better to the program.

Conflict in developing CS contents

Student motivation to connect to program and course development was strong, and many of the CS Design students were interested in contributing to the development of both the CS community and content. Overall, as seen in the initiator talks, such student input was highly supported by staff and particularly the program director. As a result, a lot of informal activity and formal events evolved. Students' interest in teaching activities was also based on personal interest in developing the program itself [e.g., #13, #15, #18]. In relation to the outcomes of the development activities in 2012–2013, however, while many of the ideas resulted in improvements, open conversation in developing ideas and content was difficult to implement. This is partially also related to it being resource-heavy, as surveying, facilitating activities, and processing the findings takes time. Furthermore, the educational reform necessary in CS challenges the roles and structures in academia to an extent, where the institutional structures start to tremble. Even the students themselves identify the potential risks in such approach, and question *"how far we can let the student go"* [#14, #17]. Overall, despite attempts to increase the student contributions to program planning and teaching, structures of expanded ownership in developing study content and the program activities did not really formalize during the first few years.

Conflict in sharing and experiencing

While, in part, the lack of access to some information or specific content caused students to exchange experiences and react and organize something for themselves, shared studies and projects in advanced studies often also helped in sharing and exchanging experiences. However, several difficulties affected the exchange of information between the students, ranging from schedules to platforms of communication. Furthermore, when developments in content and community were discussed, conflicts between perceptions and interests emerged.

Access to AMF space was considered crucial in many ways (as in section 4.3.1), to create a place for hanging around and discussing with fellow students, and for organizing activity. However, the lack of a designated space was also perceived as "a mixed bag," as for CS students *"it almost makes sense that we don't have a space, that we're nomadic* [...] *There's something appropriate about it"* [#17]. Yet *"at the same time it makes things difficult"* [#17]. When describing the relationship between the space and collaboration, an interviewee involved in CS spaces design (#16) explains that *"the space is not in itself... what is going to make people go there and collaborate"* [#16]. Instead, for her, and for CS in general, it is more about *"how you involve people from the beginning... to the end"* and about *"the relationships that you can build with them"* [#16]. The emphasis on interaction, despite the challenges, was still focused on expanding participation and collaboration.

Conflict in evaluating success in learning

As the evaluation of outcomes of studies is often (besides in future professional life) only visible in grading and in school-based, advanced studies, the grading in CS is often done on a disciplinary basis (despite the participating students from other programs), there were conflicts between how students perceived their contribution in contrast with teacher perceptions. Furthermore, there was not always thorough feedback, and some students perceived this to be in conflict with the ideals of the critical approach to learning supposedly advocated in CS. Gradually, as the students perceived themselves as professionals in the interprofessional practice, they also challenged the evaluation of learning. To address these issues, students often got together to discuss improvements, and eventually progress, such as improvement in communication and the gradual development of a more formal CS student community.

As an interprofessional and cross-school study program without a clear center of activity (although, in some ways, CS Design can be seen as such as the leading partner and location), such aspects became even more important, as amongst CS initiators and staff, commitment to activities outside the focus of activity in the home department was sometimes difficult to make. And yet, as CS was created as a pilot, this project-like temporality, as well as the extra resources allocated, invited the collaborators in. For students, too, this novelty of the inquiry invited interested people to become involved in the development of the agenda. In the academic context, such an approach, breaking the conventional roles and practices between the management and students and staff, can initially cause friction.

5.1.2. Structuring the findings with the activity theory (CHAT) lens

As the final step in the analysis, the integrated findings are assessed as a whole, structured in relation to CS interaction in its three phases of activity, with a common objective of developing a shared inquiry into interprofessional knowledge-building for sustainability. From a CHAT perspective (cf. Engeström, 1987; Miettinen, 1993; Vygotsky, 1978), such knowledge-building is approached through a structure of various factors emerging from the context, connecting to communities, rules, and division of labor, instruments for collaboration, and various subjects tackling a shared objective. Conflicts can be perceived to emerge based on the contradictions between these components of the interaction.

In suggesting improvements for the CS program, the general, shared objectives of interaction can be identified to be in developing a new, interprofessional tradition for learning and collaboration, to promote sustainable transformation, and to reach out from and transform the existing disciplinary practices and perceptions. The shared goal of activities is located at the center of the interplay of the actor groups and phases of activity and the participating community and discipline-related factors at the outset, with tools and instruments for collaboration between these. Conflicts in interaction result from contradictions between the nodes in the shared system of activity (see Figure 22).

In CS interaction, the interdependent activity systems are also structured according to the hierarchical roles and temporal phases in the university context. Conflicts emerge between phases of interprofessional learning, in connecting understanding from one phase to another, and in connection with the actors (and their personal, cultural, and disciplinary expectations and views) who are involved and the instruments, tools, and processes that are used to support the collaborative inquiry.

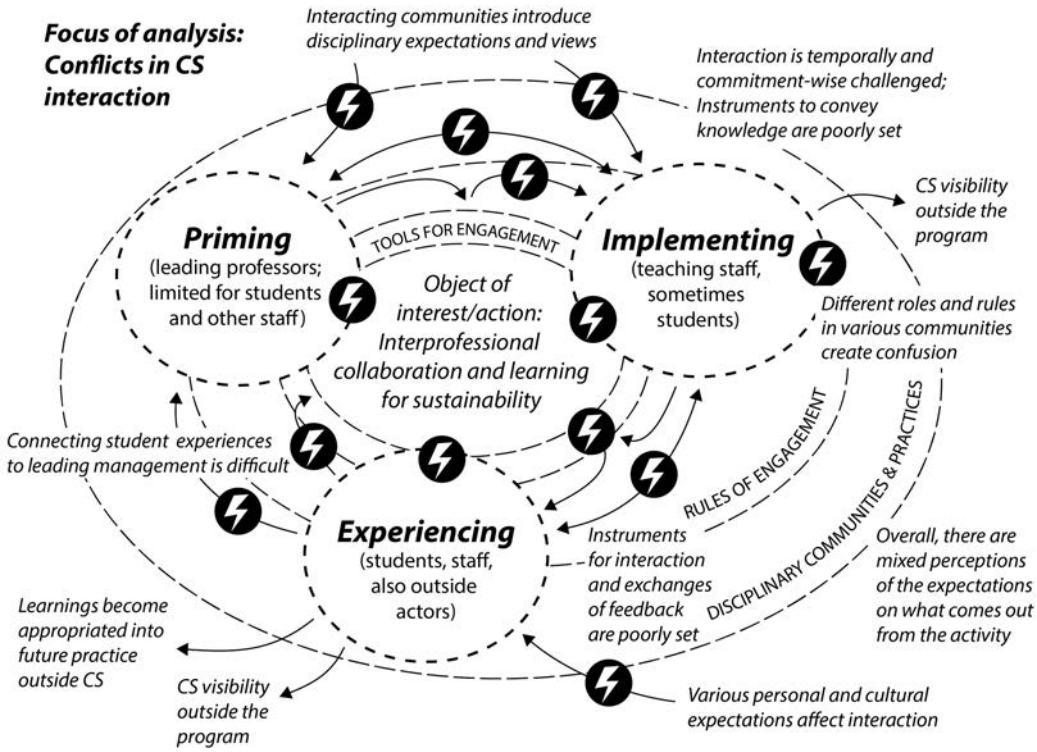

Figure 22. *Three phases of activity and their connections with conflicts in CS interaction.*

Source: Author

In Miettinen's study (1993, p. 240; see section 2.3.3), the main tools that are identified to be utilized in developing teaching are measurements to react to changes in professional life, theories and practices of learning, and means of evaluating results. The instruments that support the interaction in developing CS study content in are similar, but roles become mixed to a further extent, and even broken down occasionally. In the CS development and interaction, the scope of interest is expanded toward the participating disciplines and to the three actor groups that are involved in the interplay in the three phases of activity. As a result, as in approaching contemporary, interprofessional collaboration, the phases in learning start to deconstruct into various sub-activities performed by various constellations of actors. Within the academic context, the phases also become constrained by the institutional roles and processes.

CS interaction in three phases of interprofessional learning

In their work, Bruun et al. (2005, pp. 73–74) identify resources that are important in overcoming the barriers in interprofessional interaction. These are clustered in the "key conditions" for successfully implementing interdisciplinary activities (namely "research"), such as "building bridges" in the "initial states" of action, "supporting the project" (or "project" type interaction), supporting "facilities" for (also informal) interaction, and developing "organization/administration" that provides "professional recognition" of successful interdisciplinary practices (2005, pp. 73–74). Furthermore, various "conceptual and organizational variables" (such as resources and the "nature and level of the desired change") are necessary to be "identified and weighed" (2005, pp. 74–75), to reflect on "different beliefs about the nature and purpose of interdisciplinarity" and on "philosophies of change."

In developing new interprofessional expertise and new disciplinary practices in relation to sustainability, and to overcome the challenges of the rhizomatic nature of interprofessional collaboration and learning (cf. Deleuze & Guattari, 1987; see also Bruun et al., 2005), the three phases of transdisciplinary interaction need to be connected, and the connections and relations between actors, processes, and tools for collaboration must be elaborated on.

Based on the CHAT view, in CS as a shared system of activity for interprofessional collaboration and learning, the contradictions in interaction can emerge from: sharing understanding regarding the object of activity; the choice of instruments and tools (and between the tools for interprofessional collaboration and for disciplinary processes); and the participating community, its division of labor, and rules. In the following, the analytical findings based on the CHAT approach are extrapolated along the three phases that become important in the interaction.

Priming: setting the stage for sustainability dialogues

In developing interprofessional collaboration and learning, the first phase is focused around priming the process, based on the identified questions and challenges. Next, the collaborators are involved in analyzing the problem. In CS, the early talks between academic professionals acted as the initiation point, but in many ways, the ideas behind the CS initiative were also connected to developments in the national (innovation strategy) and global (sustainability) context.

Overall, in setting up the scope (object of activity) and in selecting the participants (with their choice of instruments and tools), discussion on the origins of each input and the possible connection points between the perspectives becomes important (community as context of activity). In CS, however, the objective for activity was somewhat mixed, and contested within the academic context. Furthermore, due to the vast potential scope for sustainability dialogues, the staging becomes even more important. The author's personal perceptions as a collaborator (assistant) during the CS initiation phase (2009–2010) paints a

picture of CS (besides the ambitiousness and importance of the program) as an arena of contesting agendas, personal interests, and academic ambitions. Developing the CS minor was a fluent process between only a few actors, as it simply meant connecting a few existing courses under one title supported with a short, shared introductory content. However, when the plan for the CS major went through and funding was acquired, several new collaborators joined in with various interests, at the same time potentially challenging the earlier ideas.

The priming phase also includes ideation on new solutions and mediation on possible models of improvement. In developing a common understanding in CS, and to prime the implementation of the collaborative learning activity, further mediation on suitable tools, instruments, and processes, on important values and prioritizations, and on definitions, concepts, and language was needed. During the initiation, the tension between the disciplinary and collaborative processes of learning was discussed, and it is indeed identified as a crucial aspect to address in implementing the CS studies. For the future graduates, however, another tension emerged from the ability to connect their experiences back to the ideas on which the program is built and to be able to improve the program content for future students

Implementing: involving (inter)professional practice

When the activity for interprofessional learning has been primed, it progresses to implementation. In this phase, the new models are studied and taken toward execution. However, in interdisciplinarity and transdisciplinarity learning, this phase also involves the expansion in participating collaborators: new perspectives (as instruments) are introduced into the process (into community in activity), potentially challenging the content and goals of the solution in implementation (objective). In CS, as the agenda was set, new actors were introduced to the interaction, some of whom were not that aware of the initial ideas behind the program, with a main focus on operating in their home department context. Furthermore, students from various backgrounds were introduced into the program.

In academia, the development of practice takes place when practical learnings are connected to earlier theoretical understanding. However, the processing of the theoretical, academic text remained an area of challenge and development in CS Design, and the variance in such skill in relation to certain disciplinary backgrounds was debated. However, despite the disciplinary background, some students were simply more oriented toward consuming and producing academic material (several eventually also pursued doctoral studies). It might well be that in approaching interprofessional sustainability, there are simply so many sources and so many different ways to utilize academic materials (e.g., guiding theory building, design action) that perhaps not all methods or topics are equally motivating. The scientific robustness of the approach remains; nevertheless it is crucial to enable further validation.

In supporting collaborative learning in academia (object of activity), the processing of various theories from various fields becomes crucial, and yet in CS as a combination of different disciplinary perspectives and traditions, the theories and models are not always well aligned or connected, and more activity on analyzing existing and synthesizing new knowledge is needed. In many ways, introducing a systemic approach with interconnected concepts helped in this (as attempted in the Systems Thinking course). However, a stronger emphasis on skills for co-operation is also needed, as the creation of a trustful setting in which people are willing to contribute and challenge their own perceptions is even more important.

Overall, the shared CS studies seem to have aimed at creating a basis for interprofessional design collaboration and sustainability dialogues. The basic idea for the joint content was to prime students from several fields to work together around a shared problem. The actual collaboration was then taken toward a real-world setting in project-based study modules, introduced by each participating department. However, to support the ability to reflect on the interaction and to collaboratively examine the ingredients in the model, the development in the priming phase should have been better connected with the expectations on implementation. Overall, the implementation and the following assessment would also have benefitted from a more collaborative approach (despite efforts to promote such interaction). This calls for an increase in transparency in the process, opening the curtains between the phases of priming, implementation, and experiencing.

Experiencing: finding meaningful learning

As phases in interprofessional learning, implementation and experiencing in many ways overlap, as experiencing involves reflection and examination of the models that are implemented, and only then can a renewed practice emerge. In this phase of activity, the model for interaction and learning is implemented, and the collaborators reflect on the process and the model itself. Eventually, the collaborative reflection can lead to improvement in practice. In approaching experiencing as a phase in interprofessional learning, the scope for participants must again be expanded. In reviewing the success of interdisciplinary and transdisciplinary activities, the assessment must remain open for various inputs and perspectives.

When students entered the CS program, there was a substantial motivation to be involved in its development (object of activity). At the same time (and with new teachers involved), the students also introduced their disciplinary, personal, and cultural backgrounds to the interplay As such, the shared introductory courses in CS were not giving a comprehensive picture of the studies, as a lot of introductory content (depending on degree program) was also offered at school level and on degree program level, and a lot of advanced content only connected to a limited number of CS students from other departments. This was, however, also a strong potential of the CS program, as due to this expanded network, it could connect various disciplinary contents together into the more general CS inquiry.

In CS, to sensitize the participants quickly to the models that are implemented, and to examine and reflect on them collaboratively (object of activity), various co-creation activities helped to gather experience and strengthen relations. In relation to courses, however, information was poorly available for students and even CS staff. The written course descriptions themselves were often rather minimal and vague. This was later somewhat improved following web site renewal, and even more so by allocating resources to a communications officer position.

In reflecting on the scope of activity collaboratively, the students gradually created a new, professional understanding of their activity, and some of these ideas were also introduced into the program content. Similarly, teacher contributions in developing content were supported. This process was, however, challenged by the lack of resources in terms of both participating staff and time. Furthermore, while understanding of program success existed on the CS level, it was not always easy to connect it back with the executive management in departments, as these were also facilitating various other, more discipline-focused study programs. In connecting experiencing with priming, further emphasis is also needed on mechanisms and activities (instruments) that can be used in evaluating and assessing, and in communicating success for the next phases of development. However, in CS, such activities did not become established. Their development is still in progress.

Reflecting on the conflicts in interaction

When approaching the conflicts in interprofessional collaboration, the usual suspects are focused around different understandings of the materials and processes in interaction, as well as the competing objectives of work and the agendas that drive them forward. These potential pitfalls emerge from the historical setting and the differences in approaches that evolved through the processes of specialized disciplinarization that have taken place during the development of our modern society. However, in interprofessional collaboration in the academic context, the interplay of actors and activity is further related to the three phases of activity, as identified in the progress of the research and analysis and in relation to the analysis of contradictions and conflicts in interaction (see Table 43).

Table 43. *Identified conflicts from the CHAT analysis in relation to the three phases of interaction in CS activity and development.*

Area of contradiction	Emerging conflicts in relation to phase of activity		
	Priming	**Implementing**	**Experiencing**
Object in activity	Understanding of the object (and objectives) in interaction can be challenging to set openly and iteratively. It also has to be passed on to implementers. In CS, some involved teachers were not that aware of the program expectations.	New input is introduced and the object becomes renegotiated. In the process, it is crucial that the initial objectives and their justifications are made visible. In the academic context, the CS agenda also involved potentially disruptive interaction.	New understanding that emerges in the activity must be again reconnected with future priming and implementation. In CS, while in the end students became professionals in understanding the program objective, there was a lack of mechanism to connect the learnings to CS development.
Instruments and tools	Selection of participants, processes, and tools have to be justified and transparent. In CS, as in contemporary academia in general, this is constrained, and not always visible in material forms. The lack of information on content created a challenge for both students and staff.	In general, the tools involve skills for collaborative mediation, and analysis and synthesizing. The new input introduced, however, can challenge the primed setting if there is no room for iteration. In CS, students were willing to involve themselves more, but resource constraints prevented this.	Overall, a community was formed with skill in performing various dialogues, from one project to another, connecting in a loose network of similarly oriented practitioners under the broad interest in sustainability. There was also a hope to take the approach outside, but this was constrained to various one-time excursions.
Participating communities	Involved actors introduce their own expectations but also their professional and personal bias. Furthermore, constrained roles in academia hinder horizontal collaboration. In CS, tension between the analytical (scientific) and proactive (designerly) approach also affects the interplay.	In CS interaction as a cross-school program, the shared problem space of the CS community (interprofessional sustainability) and the disciplinary communities are in interplay. Connecting to other disciplines, however, remained difficult, and the disciplinary presence for the program was difficult to set.	While expectations on the outcomes can also vary according to discipline and personality, in CS new understanding on interprofessional practice was emerging. However, as CS students were kind of loose from the traditional departmental structure, the connection to other programs remained rather thin.

Table 43. *(continued...)*

Area of contradiction	Emerging conflicts in relation to phase of activity		
	Priming	**Implementing**	**Experiencing**
Rules, division of labor	Someone needs to take the lead, but the rules and roles have to be loose and open to allow all inputs. In contemporary academia, however, conventional roles are still enforced. In CS, the priming was open for high-level management, but took place as a rather internal process. As a result, rules were challenged when the interaction began, and students wanted to change some content.	In implementation, the overall processes are often constrained by a lack of resources. While overall the idea is to support active, constructive learning processes in which roles and rules for learning are more open, often, however, there really is not enough time to properly structure such interaction. In CS as an interprofessional, cross-school program, the various disciplinary, professional expectations affect interaction.	Overall, while in CS there was an open approach toward new input, the way the staff was structured (from various schools and disciplinary orientations) hindered interaction. In the end, students felt that they had acquired special expertise on interprofessional collaboration, and yet their role as both a client and an object in education hindered their access to evaluation and development.

In approaching the CS development in relation to its university context, the idea has been to create a platform for the different disciplinary branches, to involve them in collaborative dialogues on sustainability. In relation to university learning and the emerging professionalism — especially in relation to design action — the idea was to gradually take the students from introductory studies and short excursions in theory to actually practicing work with the knowledge, to leverage the skills into real professionalism.

However, in interdisciplinary and transdisciplinary collaboration, there are various levels of skill and professionalism in interplay and, as is visible in CS, there is also uncertainty in relation to the outcomes of the learning and collaboration. Consequently, the interplay between disciplinary (and cultural and personal) perceptions created mismatches in the orientation of collaboration, and the academic setting as the context of interaction created constraints that became visible in schedules, roles, and resources for teaching.

Lastly, with Aalto University as the context of activity with its orientation towards innovation, to answer to broad national, economic, and societal needs (as discussed in section 3.1.1), CS began to foster more critical discussions — and learning in general amongst students — than is visible in many other, more discipline-based programs. In this process, the agenda of the program expanded further to challenge conventional disciplines and conventional practices of learning. In the end, this process could have led to even greater development had resources and managerial motivations supported such a process.

5.2. Improving Interprofessional Learning for Sustainable Design

Improving the institutional structures in academia so that new agendas can be brought to education flexibly is demanding in many ways. In introducing interdisciplinarity, transdisciplinarity, and sustainability to the academic context, a need emerges to create more open arenas to introduce new content and activity to the university, calling for new interprofessional interaction between disciplines and departments to develop new types of inquiry, knowledge, and practice. In brief, the goal in CS is activities has been twofold: on the one hand, the goal has been to produce new knowledge and action in relation to sustainability; on the other, the aim is to produce professionals promoting and expanding transformation for sustainability, not only in the output of their work, but also in their whole practice and life in general, even in the processes of their studies. In relation to the variety of sustainability perceptions and the extent to which these should be extended into academia, such agendas introduce challenges.

In CS, the activities are driven by various motivations, but some can be identified as serving more common interest. Overall, while each participant in CS is attending for personal gain — be it institutional motivation, academic career motivation, or acquiring a profession — a shared motivation for interaction can be identified in the development of new, interprofessional knowledge for sustainable design action to transform both professional practice and learning in academia. In his research, Miettinen (1993) divided the development of pedagogy and content under the following principles: selectiveness (of studies and content) (cf. Illich, 1970), voluntarism, co-operation (in teaching and learning), high level of quality, proper documentation and evaluation of results, and their communication and utilization in several forums. In CS, as in interprofessional learning in general, such selectiveness and co-operation can be perceived as a mixed benefit: while it provides a possibility for new openings in topics and interactions, it adds a layer of potential conflicts to the interplay.

Summarizing the evaluation practices on interdisciplinary research, Bruun et al. (2005, p. 154) identify five principles: 1) validity; 2) effectiveness and impact; 3) integration; 4) interaction of social and cognitive factors; and 5) feedback and transparency in a continuous and comprehensive system. According to their work, challenges persist with several principles (Bruun et al., 2005, pp. 155–161), as validity, effectiveness, and impact are still often evaluated in disciplinary domains, integration between disciplinary domains in general might receive mixed responses, and “conflicts” between “values” require “compromise and negotiation” (Bruun et al., 2005, p. 158). Interaction and the influential social and cognitive factors can be hindered by lack of “structure […] joint work activities, and common instruments” (Bruun et al., 2005, p. 159). Lastly, both feedback and transparency can be challenged by a discontinuity in activities and a lack of structure or clear comprehension of its dynamics and aims. Similar challenges were visible in CS interaction. Both validity and impact were focused on in teaching, in connecting to the broad theoretical body and real-world action, and yet this was difficult to connect with emerging disciplinary views. Interaction and

integration proved challenging, leading to circumstantial evolution of content and a lot of ideas to simply try out. At the same time, the feedback loops were often considered insufficient for comprehending the complexities of teaching and learning.

5.2.1. Suggesting improvements to interprofessional learning for sustainable design

Interprofessional, transdisciplinary learning activities for sustainable design call for an open and iterative approach, and they perform best in an open, integrative community that supports collaborative dialogues addressing all levels of the design inquiry, from details to societal level, and from personal to interdisciplinary understanding. The aspects perceived as important in the conclusive analysis were related to the transparent setting of the problem space, dialogues on the proper use of tools, and open access to the development of content.

As discussed in our earlier research (Marttila & Kohtala, 2014), an ideal teaching platform for interprofessional and transdisciplinary sustainability problem-solving enables collaborative teamwork, where the teams are first trained in teamwork processes and then encouraged to interact informally, directly, and frequently with specific problem contexts. Team members have specific professional perspectives, but are encouraged to reflect on new information with respect to their own disciplinary experience. Similarly, the CS students are encouraged to keep and develop their own disciplinary professional identity, but in a way that promotes shared understanding and communication skills, discouraging the lock-in from conflicting disciplinary perceptions.

In such a learning context, however, the community (and its management) must support participation in the epistemic translation of complex data and professional views into design-relevant, shared understanding, and boost the facilitation of design dialogues among a wide range of participants, addressing sustainability in its various contexts and forms. Ideally, such interaction, and the learning process itself, is led by a facilitator with both the social skills to facilitate and experience in more than one discipline (as in Marttila & Kohtala, 2014). As a result, teachers themselves need such competences to an extent, as well as the understanding to be open to inter- and transdisciplinary processes, expanding the inquiry further.

To support the sustainable transformation of professional practice, critical and potentially disruptive activities must also be tolerated. There must be more emphasis on channels through which content can be challenged and new openings can be introduced, emerging from both staff and students. This, of course, must happen on the basis of invested resources and an ability to manage the process. From the management perspective, there must be enough resources allocated to the development of content; from the teacher perspective, the teaching must be structured flexibly to include more peer-based reflection and mixing of roles; and from the student perspective, there must be sufficient structure and tutoring to graduate on time, and yet supported channels and activities to support dialogues on content. Overall, in setting up and managing

such collaboration, it is important to make the expectations visible, and to connect different phases of interaction and the resulting understanding.

In this process, design activities exist on several levels and in relation to several phases of interaction and implementation. As discussed, interprofessional collaboration must also be properly primed in relation to focus, context, actors, and activities, and this calls for design itself; but as an agenda for innovation — even more so in connection with sustainability — design in general becomes a contested topic, too.

As an example of an interprofessional platform for academic learning and development, CS can create understanding of potential improvements to such interaction in general to guide future actions. In general, adding transparency to processes of development and evaluation helps to make visible the rules and division of labor implied by the community and epistemic tradition. However, investments in activity must also be made. Overall, the findings are focused around collaborative processes in developing the content and activities in CS and in interprofessional education in general. As a result, to overcome the challenges of developing interprofessional learning in academia, and to promote sustainability-driven transformations in professional practices and processes of teaching and learning, five main areas of improvement can be identified. These areas are structured based on the five main integrated thematic categories (see section 4.4.2) emerging from the assessment in this research, also addressed as crucial points of interest to structure such activities better.

First of all, to enable collaboration, sustainability needs to act as an underlying context for the inquiry, but conflicting perceptions of it should not hinder interaction. Instead, the interaction must be structured in such a way that there is room for various approaches to sustainability and to collaboration in general. Secondly, there is a need to create a setting for collaboration that is fixed enough and based on sufficient structure, yet remains open for new inputs and expansive actions. Thirdly, a willingness must be created in this space, and resources to implement critical dialogues on disciplinary perceptions and practice, also connecting to outside actors. Lastly, and in connection with this research's special focus on design education, various well structured and well managed design activities can support such progress in teaching and outreach. If such aspects are considered in the process of developing academic knowledge-making and learning and if such a proactive approach to change is promoted — then the interprofessional emphasis and sustainability agenda can act as catalysts in renewing academia itself, to be able better to flexibly produce applicable knowledge to tackle the complex contemporary challenges.

In many ways, promoting interprofessional interaction and learning is motivated by seeking development in academia as a whole as a place for study and research, but also as a community of fellow actors within close proximity. Another motivation is simply in developing personal professionalism. To utilize this motivation, there must be the resources (e.g., time and space) to connect these interests. Furthermore, as sustainability dialogues are often value-ridden, if a shared orientation can be found, this can offer additional motivation. Such an

orientation, however, cannot be too narrow in relation to sustainability, instead being oriented in relation to the processes of collaboration itself, still embracing various, heterogeneous views on sustainability as a concept and a goal of action.

Sustainability as a mindset rather than a constraining concept

The general objective of the CS program was to strengthen sustainability as a mindset and context in academic interaction, enabling the multidisciplinary approach to evolve further toward inter- and transdisciplinarity (see also Marttila & Kohtala, 2010, 2014). The CS program has helped Aalto University to integrate the perspectives of sustainability more strongly into its teaching activities: several views were tolerated in CS as just one component of diversity that links to the sustainability in the program name. Hence, in the light shed by this research, in relation to the typification of specialists and more broad problem-solvers (e.g., Pohl, 2005), or the disciplinary and hybrid experts (cf. Hukkinen, 2008), the interprofessional design framework for sustainability can support both detached processes (dialogical reflective and integrative skills, often related to personal, value-centered views) and specific, engaged skills (profession-specific, based in disciplinary concepts), as well as general skills for management and collaboration.

To enable dialogues for (creative) sustainability (main theme #1), there are thus two aspects to take into account: one has to consider the output and changes in the impacts of activity and the process itself. Whereas in simple multidisciplinary interaction the processes take place in disciplinary domains and the output remains similarly divided into separate professional communities, in interdisciplinarity the processes become more and more shared (as in section 2.1.1), and the output similarly novel, based on various inputs that are gradually synthesized into a shared understanding. Similarly, sustainability can be perceived in two ways: as a guiding concept perceived from conflicting professional and personal views, or as a common orientation under which activity and testing takes place.

Stage-setting for shared problem-solving

In staging education in an interprofessional, transdisciplinary context, learning through practice (main theme #2) acts as a crucial component in the interaction to create the experiences on which collaborative reflection can be based. Kolb's experiential learning theory (see section 3.2.1), as an established approach in adult education theory (Miettinen, 2000), has gathered inspiration from diverse sources, in "T-group movement, the learning style technology, humanistic psychology and critical social theory" (Miettinen, 2000, p. 54).[101] As a general concept, it fits with the CS program rather well.

However, in Miettinen's view (2000, p. 61), the most crucial shortcoming in Kolb's model is the over-simplification of the concept of "immediate personal

[101] Kolb defines the historical context for his theory as emerging from concepts by John Dewey, Kurt Lewin, and Jean Piaget (Miettinen, 2000, p. 56; see also Kolb, 1984) that were further developed by "therapeutic psychologies based on psychoanalysis" (i.e., Carl Jung's work), "humanistic psychology" (i.e., Abraham Maslow's work), and "radical educationists" such as Paolo Freire or Ivan Illich (Miettinen, 2000, p. 56).

experience" on which the reflection and development in the model is grounded. According to Miettinen, the "dialectical tension" described by Kolb that exists between the experiential and the conceptual and that acts as the foundation for reflection and learning, is instead "indispensably related" in a dialectical sense, and "dialectical logic" shows how these two are "determined through each other" (Miettinen, 1993, p. 61). In CS activity, this has been visible in underestimating both disciplinary (teachers, students) and cultural (mainly students) differences in reasoning and action. To overcome the challenge, these tensions must be opened to inquiry for the whole community.

In his 1993 study, Miettinen also identified the teaching staff work contract setting as a barrier in developing teaching (Miettinen, 1993, p. 245). Many teachers contributed only a few hours to teaching, and for some their main profession might be outside the university. This is increasingly the case today. In CS, only a few members of the teaching staff have been enrolled into the university as lecturers or professors, and many are doctoral students or project researchers. While their connections based on their outside roles may prove to be valuable in building new openings and topics for inquiry or in introducing ideas to develop teaching, their resources for contributing to the development of studies might be very limited.

One crucial element in setting up learning on a larger scale is to plan study content well ahead of time. For this to happen, students and staff must have access to information and experiences regarding the courses. One aspect in this is formal, as the university communicates course contents on several levels (public information prior to enrolling; external communications and advertising) and in different locations (e.g., study guides, web pages). The other is more informal, covering word-of-mouth talk of experiences and social media content, for example. In CS, the lack of effort in developing the descriptions and communication at the beginning resulted in student confusion. On the other hand, if properly structured, such vague constraints for topical interests also allow new focuses to be introduced, perceived as important from the sustainability perspective.

Learning out from the paradigmatic perspectives and roles

The new professionalism and expertise (main theme #3) in CS are about interprofessional collaboration, and in many ways students grew to understand this context even better than some teachers. However, in the contemporary academia, processes and roles are still rather fixed. Already in 1993, Miettinen's work suggested areas for development, ranging from the management of the school to teachers, students, and outside contacts, to "recognize their pedagogic role" (Miettinen, 1993, p. 240, translated by author). For the management, this division of labor emphasizes "supporting the development of pedagogical content." Teaching staff (often partially mixed with management) primarily have "initiative, preparative, and organizatory responsibility," and students are "involved in planning, and main actors in implementation" (Miettinen, 1993, p. 240).

As general guidelines for development in his particular context of study — and fitting to study higher level education more broadly — Miettinen (1993, pp. 241–243) suggests moving the emphasis toward "learning rather than teaching"; building the ability for critical thinking rather than simple orientation to practices of studying; developing new topics and teaching methods with "controlled diversity"; and reflecting on actual ongoing professional practice. In this development, "networks of learning" between teachers, students, and alumni are essential and can help to build new projects of interest (Miettinen, 1993, p. 244). In Miettinen's work (1993), these networks are grounded on three levels of contact: family and friends, contacts from outside work and projects, and former students and staff (p. 244). In CS, such networks have also been crucial, and the trust that developed in the community enabled new, unexpected openings.

In approaching interprofessional interaction, epistemic translation (see section 2.1.2) is taking place between the context and the content, and between the tools and instruments — with the inscribed professional and community-related knowledge — and the development in activity. Inscription (cf. ANT) and translation take place on various levels of activity and affect all phases of CS development and implementation when tacit knowledge and understanding are embodied in artifacts used in the CS management and development, or in the learning processes themselves, on courses and within the student community. In the longer term, a similar reflection takes place between professional practice and experienced outcomes of work, individual learning and community development, and the ideals of the subject and the mediated shared goal of activity. Such understanding can be recorded in various locations, and yet most of it becomes visible only in involvement into everyday practices. To support the processes of translation that the everyday practices empower, effort must be put on structuring such knowledge and making it visible.

Transdisciplinary activities are based on the integration of theoretic and practical knowledge, discussions in the ethical dimension, and "experimental, designerly modes of inquiry" (as in Doucet & Janssens, 2011, p. 2). In CS, the emphasis moved in this direction when new actors with new competences were introduced and when students wanted to interact with outside actors.

Collaborative design mediation on new knowledge and action

In interprofessional collaboration and learning for sustainability, expansion of the actor base and inputs becomes important. The inquiry itself must be set as a divergent and convergent, iterative and reflective process between personal understanding, collaboratively mediated new knowledge, and its expressions in material form. Design as a broad concept naturally resonates throughout the program: CS is the product of a collaborative design process in the first place, and for CS Design students it eventually becomes a profession. In expanding the design activity as collaborative meaning-making, the terms on which knowledge-making, decision-making, and awareness-making (as in section 2.3.2) are based must also be collaboratively renegotiated. In building an interprofessional community for sustainability (main theme #4), making design activities more explicit can help.

The contested concept of sustainability brings in several questions regarding the ideas at hand, but the processes of design also involve questions. To deal with the potential tension between sustainability and development, and to progress toward a proactive approach, the professional understanding on these topics must be assessed. As discussed earlier (see Chapter 3), the framework for an interprofessional and transdisciplinary design process should emphasize at least the four different dimensions of abilities: 1) disciplinary competence (e.g., design thinking skills, conceptual design skills, DfS skills, etc.); 2) skills to synthesize and translate knowledge (critical and analytic skills); 3) collaborative skills (facilitation and teamwork skills); and 4) (self-)management (developed from Marttila, 2011a; 2012). Disciplinary competence is needed to be able to contribute to knowledge-making; skills to synthesize and translate knowledge are necessary for integrating knowledge; collaborative skills enable one to take part in or facilitate collaboration; and (self-)management is needed to reflect on the actual practice of involvement and collaborative design. The two latter can be combined into one set of skills focusing on managing the collaboration and work.

Dewey (cited in Miettinen, 2001, p. 303) emphasized "the significance of cultural environment and, specifically, of language," which is the means of communication and coordination of actions in "a community of action" (Dewey, 1938, p. 52). However, instead of having communication as the focus of design action, and to transcend the conventional professional scope in sustainable design, there is a need to go higher in levels of focus and take activity itself as a foundational concept for assessment. In this respect, the contents of sustainability are not a communicative phenomenon in sustainable design, but rather an activity and a process with a focus on producing content rather than disseminating content. In this respect, the (design) activities in CS will have an emphasis on knowledge production for a particular purpose: for sustainable transformation. In articulating this viewpoint, there is a better position to mediate and develop knowledge production procedures. Such an activity approach can help to progress toward the operationalization of knowledge rather than just transmission and translation.

Renewing the (design) academia

In CS, one main goal has been renewing academia as a platform (main theme #5) for interprofessional and transdisciplinary dialogues on sustainability. In facing the challenges of the contemporary sustainability crisis, academia is facing a challenge. Furthermore, the ever-increasing global competition moves the emphasis on the dynamic ability to connect new, interprofessional understanding with technological and cultural innovation. In connection with the National Innovation Strategy (as explained in section 3.1.1), CS acted as a test site for new interprofessional interaction and innovations, albeit the focus in sustainability was not that clearly stated in the strategy. Education for Sustainable Development (ESD; see section 1.2.3), as UNESCO describes it (2014), puts emphasis on access to knowledge, and the participation and empowerment of minority voices. In an academic context, such an emphasis can also be perceived as disruptive to the traditional setting. CS was protected by it being initiated as a pilot, however. Following its initiation, other cross-school contents have been initiated, albeit mainly at minor level only.

Problems in the contemporary philosophy of education connect to freedom of action, openness of individual development and in future society, and how interaction is structured (as in Pikkarainen, 2013). In CS, the freedom of action was exhaustive and even counterproductive in places, and yet the openness of the approach in the program produced new compositions of professionalism and new interaction between professions. Furthermore, as the skills-set for interprofessional sustainability connects with the contemporary world in many ways, the future opportunities for graduates can be perceived to be rather good. However, interaction was sometimes conflicted and not always explicitly explained in any material form. As a result, developing the interaction remained partial and episodic.

Interprofessional production of new knowledge, "however trans-disciplinary, however heterogeneous, however reflexive" (Nowotny et al., 2003, p. 189) must be managed. Both fluidity and stability are requirements for future organizational transformation (Engeström, 2008). In earlier studies regarding multi-professional environmental research, most of the thinking about transdisciplinary collaboration was found to exist "at the level of program management" (Pohl, 2005, p. 1159). In many ways, this seems to hold in CS, too: the early ideas on interprofessional sustainability emerged at a topical time, and the talks with initiators and teaching staff introduced this point several times. However, in CS, it seems that the students themselves have this as a stronger emphasis than even the CS staff themselves.

From the level of management, such an ideal — to openly introduce actors around a shared table to discuss development and sustainability — might be perceived as challenging. In approaching interprofessional learning as a practice or sustainability as a concept, a range of perspectives and definitions compete. As a result, both the development of these topical areas and the journey of learning into profession and practice must be made more visible and better defined. For the management of such interaction, this means a more open and transparent — and more proactive — approach to communication between students, staff, and outside actors such as other university actors, alumni, or corporate partners. It also means the promotion of shared activities that explain this development and involve the aforementioned actors in development.

5.2.2. Suggesting improvements for managing interprofessional study programs

To support the development of new knowledge at the boundaries of disciplines, identified as necessary in the challenge, there is also a need to support activities that enable interprofessional dialogues between the high-level management, teachers, and students from schools and departments across the university. To support such activities, there must be open platforms to perform such dialogues and open mechanisms to convey knowledge from one activity to another.

Different professional or personal perspectives, roles, or aims should not prevent collaboration. As one CS educator puts it, *"it's crucial in any field that you really can be aware of the fact that the other person* [...] *thinks in a different way* [...] *you do not need to agree* [...] *and you can still cooperate with the people with whom you do not share values* [or] *ways of thinking"* [#10]. For the CS students, too, there was a need to expand outside the program. From the student perspective, the idea was to serve the university community as a whole. The instruments, tools, and processes in use, however, are always grounded on the (political) meanings in the background. Their meanings emerge from the surrounding society and institutions that play a role in implementing activities and as disciplinary backgrounds of practice. This happens even more in the context of politically controversial ideas of sustainability and sustainable development. Dialogues between disciplines are important, but to empower such dialogues, formal investments of time and resources are necessary, especially in interprofessional education.

In CS interaction, getting feedback on the ideas under development was perceived as crucial. Gradually, the students grew to be experts in their field of interprofessional design for sustainability, and yet the response to student ideas, albeit almost always positive, was not always evident in future practice. Crossing the hierarchical roles between teachers and students also created conflict when teachers, as professionals, failed to perform as examples of future practice and students, with a more refined understanding, were still there just as students. Furthermore, when some progress did take place, it was not always openly discussed, and thus many improvements in content remained somewhat invisible for the students [as in #17]. Many student activities, however, also dried up at the end of the research period due to students simply (eventually) graduating.

In the end, the CS activities align with the original initiators' ideas rather well. To this end, from the beginning, the potential benefits of new academic interaction between disciplines were perceived as greater than the challenges that this created for professional practice. In this sense, during its first five years of activity, CS managed to justify its existence, and a shared orientation and motivation for the interaction was identified. Consequently, the aspects in CS that this work suggests as improvements for developing and implementing interprofessional learning (see Table 44) can be related to the transparent setting of a shared problem space, the shared justifications for the choices of tools, and open management that supports the activities and connects them within the given operational space.

Table 44. *Proposing improvements in relation to the three phases of interprofessional and transdisciplinary learning.*

Area of contradiction	Suggestions for improvements in relation to each phase of activity		
	Priming	**Implementing**	**Experiencing**
Object of activity	Interprofessional activities benefit from dialogues on aims and objectives of activity. There must be ways to connect to the priming processes, and the justifications should be made visible in material forms.	In implementing interprofessional and transdisciplinary activities, the objective has to be clearly articulated, and mechanisms to add new input (facilitating collaboration, peer learning) and to provide feedback (collaborative reflection) are necessary.	The end results must be collaboratively compared with the initial ideas. Presenting the outputs more broadly (assignments, project results, thesis works) could help to develop the culture of collaboration further and improve the quality of the work.
Instruments and tools	Processes and tools for collaboration must be openly presented and collaboratively justified. Making instruments visible helps to make them more accessible in further implementation and iteration.	For implementing collaboration and learning, there must be processes that allow new personal and professional input and support collaborative mediation to agree on actions and outcomes.	Besides communication skills and tools, promoting shared activities (presenting work, feedback sessions), peer matching, and networks helps to share experiences, and reflect collaboratively on the process.
Participating communities	To begin the process of developing a shared inquiry, common concepts and goals must be identified to be elaborated upon. Professional expertise provides competence and has to be connected with according to the context of action.	The various emphases between (disciplinary) approaches should be openly discussed. The facilitators (e.g., teachers) themselves become disciplinary examples.	Collaborative reflection on the process and output helps to bridge new, hybrid knowledge back into professional practice in various, participating communities.
Rules, division of labor	In priming activity, rules and divisions of roles and tasks must be collaboratively set and openly communicated. However, even differences in perceptions must be tolerated and discussed openly.	Rules and processes should be made visible for outside actors as well. There must also be an ability to flexibly renegotiate the rules, and resources to make changes to the structure of the work.	The disciplinary contributions and the roles in a team can be made more visible and better articulated to connect to the shared development of the inquiry.

5.2.3. Creating new professionalism through the interplay of CS activities

The general objective of the CS program was to strengthen interaction on sustainability at Aalto University, at the same time enabling the multidisciplinary approach to evolve further towards inter- and transdisciplinary activities. However, the dimensions of sustainability and their dynamics can often be perceived in various ways, and this leads to differences in prioritizing actions. Sustainability has different meanings in its different dimensions and for different people. Overall, the various expectations on the outcomes and processes of work create conflicts and discontinuity of collaboration.

Sustainability and the call for interdisciplinary interaction in academia can also introduce potentially disrupting changes to the existing agendas, posing a challenge to the management, even more so as the interaction is hindered by temporal sequences and actor roles, as enforced by the academic setting. To overcome the challenges of the rhizomatic nature of developing interprofessional collaboration and learning (cf. Deleuze & Guattari, 1987; see also Bruun et al., 2005), the cycle of expansive learning proposed by Engeström (1987, 2000) can be structured further into three phases, combining partially different actors and partially different goals for the activity. In CS, these partially interdependent activity systems were nested around the hierarchical roles and temporal phases in the development of university studies, but also around the three phases in interprofessional collaboration in general.

In introducing new agendas, interaction and content to academia, various paradigms of research that are potentially "incommensurable" come into an interplay (cf. Kuhn, 1962), and are compared against another. As a result, analogies in language and tools – and new instruments and processes developed on this basis – have to be sought and brought into the interaction. In a summary, the shared CS introductory studies seem to have aimed at creating a basis for interprofessional design collaboration and sustainability dialogues. The grounding idea was to prime students from several fields to work together around a shared problem, involving value dialogues on sustainability during the way. The actual collaboration was then taken towards real-world setting in project-based studies, introduced by each participating department. As a result, new understanding and competence was created.

In developing new interprofessional expertise and new disciplinary practices, the interaction in interprofessional learning needs to be connected, and the connections and relations between actors, processes, and tools for collaboration must be elaborated. In CS, the development of the program agenda, content, and community can be perceived to be set in a similar sequential manner, building from the identification of the agenda toward the implementation and reflection of outcomes, supported by exercises on banking existing theory, on ideating, developing, and testing (material, conceptual) artifacts, and on reflecting on the process critically and collaboratively. In approaching the CS projects carried out among students (in relation to advanced study content), the approach was often similar. Hence, in CS, the reflection on interprofessional sustainability resulted in a

broad understanding of how to promote the general agendas for transdisciplinarity and sustainable transformation in practice (see Table 45).

Table 45. *The what, how and why of the CS study program.*

What:	Creating an academic platform for interprofessional dialogues on sustainability.
How:	By bringing people into shared dialogues on, and collaborative mediation on the meanings of sustainability.
Why:	To seek sustainable transformations in both practices of teaching and professional activities and understanding.

In interprofessional learning, professionals (and students as apprentices) involve themselves in processes of epistemic translation of knowledge and experiences to produce shared understanding (see section 2.1.3). However, in promoting transformation for sustainability, continuous ontological reflection is also needed (how something can be done), and eventually also communication on ethics (why something is done, as in section 2.2.2). In this process, projects and the collaboration within them can then act as the unit of activity and analysis (cf. Blunden, 2009, 2010) in which these considerations can together be assessed.

The three aspects in relation to the development of community of practice (cf. Wenger et al., 2002) are identified as a shared domain, which in CS has been in developing interprofessional collaboration and learning for sustainability; communities, which in CS were the participating disciplines, but also the three actor groups — the high-level management priming activity, teaching (and some research) staff implementing teaching, and students developing new professionalism; and practices in relation to both entity (practice-as-entity: CS community as a whole and its involved partners) and performance (practice-as-performance: in CS, in the interprofessional dialogues and meaning-making).

In looking at CS as a system of activity, it is clear that several communities based on academic and disciplinary roles are in an interplay. Overall, CS as a community for interprofessional sustainability dialogues and practice is expanding from a conventional, disciplinary community in which participation is dictated by professional competence toward a more open, even integrative community centered on a shared interest in sustainable transformation in practice.

Design connecting interaction in CS

With one specific focus in research on the role of design, it becomes evident that in CS development various design activities took place on several levels and in relation to all phases of interaction. Firstly, in taking the step from initial talks toward the preparation process, there needed to be an understanding of the challenge and a concept to proceed with. During the preparation phase (and the priming of the CS program piloting as a project), the group of participants

expanded, and design activities were carried out in connection with various details, ranging from course structures and content to descriptions and communication, including for the overall study program. In implementation, design is connected with the planning of teaching, with the collaborative concept development in various team setups, and with communication in and facilitation of collaboration. Finally, in experiencing, the output is connected with previous understanding and knowledge, concluding the reflective loop and developing professional skills further. Along the way, new design competence to tackle sustainability challenges was created.

In interprofessional collaboration, access to content that relates to the activity in connection with the objective and goal, and the potential instruments and tools that can be used in conveying the knowledge from one phase of activity to another, must be supported, and design activities on various levels can support this. To this end, more organizational transparency and emphasis on creating a horizontal setting for interaction is needed to bring actors (and actor groups) in each phase of activity together into a collaborative mediation and learning. To justify investments in time and effort, another emphasis must be on communicating the results outward to seek new collaborations and expand the activity to new areas of activity and interest. Spaces act as hubs of activity, and although in principle students and staff are very flexible, some central location(s) for activities are also important and act as hubs connecting actors together. However, in relation to professional growth and building the community of practitioners with a shared orientation and goal in activity, projects act as crucial experiences in developing collaboration and activity. Communicating the various projects also becomes crucial to properly connect the learnings and new knowledge into the shared inquiry of the community.

However, design can also be identified as a part of the contextual agenda from which CS emerged. As a part of the increasing emphasis on innovation (e.g., National Innovation Strategy), interdisciplinarity has been emphasized in economic development (and in education); due to its interprofessional nature, design played a part in this discourse. Consequently, a design method can be perceived as an instrument, a competence, and an agenda (Keinonen, 2009) also in the context sustainability, as in approaching innovation in general.

In approaching technological transformations as described by Geels (2002; see section 1.2.3), the development of the new (technological) trajectories (cf. Geels & Raven, 2006) takes place in their cultural context, connecting new stakeholders and actors to the process and thus supporting experimenting at the local level in different projects to scale up the successful ones further. Similarly, what is needed in assessing successful design innovation — “playing with the method conceptualizing frames, switching between them, and setting methods to completely new ones” (Keinonen, 2009, p. 289) — is also needed in assessing the success of interprofessional, sustainable design. However, in this context openness and transdisciplinarity, and the reflexibility of the progress through the three phases of interaction, become crucial.

In many ways, academia can act as a powerful engine producing new openings and interaction for sustainability; at the same time, however, various conflicting agendas are certainly introduced to the activity. Orienting collaboration in such a manner that new input is allowed in and transformation is of mutual interest helps to justify actions and gather momentum. As a result, the design method needs to expand the inquiry on all levels, better facilitating reflective collaborative mediation on the topic of interest and communication to outside the academia, and creating competence to support such activities and collaborations in the future.

6. REFLECTION AND DISCUSSION

At the beginning of this work, an interesting example of developing a new, interprofessional platform for collaboration and learning in academia to promote sustainable transformation in practice was identified, and a broad question was coined on how to approach and study interprofessional design education for sustainability and how to improve it. To conclude the assessment and analysis, first the three broad areas of interprofessional learning, sustainability as a context of education, and the role of design are reflected on. The research questions as identified and elaborated earlier in this work (see the introduction and section 3.2.3) are ultimately revisited and answered.

Assessing sustainability in higher (design) education

Sustainability is a predicament of modernity, and it cannot be answered with the logic that gave birth to the original problem. In many ways, the emergence of the sustainability movement that reaches forward from the traditional thinking guided by ideals of modern efficiency — in its whole spectrum, ranging from initial ideas of eco-efficiency to mitigate impacts on the biosphere to initiatives that emphasize the importance of cultural diversity — has been based on a counter-discourse against the technological and societal utopias of modernity. Hence, in many ways, sustainability in design must be about unpacking the totalizing abstractions and dialogical thinking in modern perceptions of life and admitting that there is no true-false type knowledge regarding the complexities. However, this should not mean that problem-solving activities in such contexts become impossible.

The CS approach to interaction can be perceived as problem-based learning (PBL) tackling sustainability challenges. While CS as a PBL-driven program has inevitably sensitized students from its various collaborating disciplines into collaborative work, students often ended up sticking to their professional roles. However, at the same time, the program cultivated hybridization of expertise and various supportive facilitation strategies and methods, and many of its graduates felt that this was a core skill they had acquired.

Interprofessional collaboration and learning can be identified as a powerful mechanism to introduce new topics and interaction to the academic context to be assessed in collaborative constellations structured as loose networks of professionals, extending toward inducing transdisciplinary interactions with outside actors and the general public. Furthermore, the design profession has a distinctive role in supporting the facilitation of such activities. When taking this inquiry back to the case under study, the CS program, it seems evident that this is just what is needed: in an enterprise to create a sustainable shift in our existence, both creativity and sustainability are needed as components of a critical inquiry. Together, these concepts can draw together various theories in knowledge production.

In CS, sustainability is brought forward by:

- The academization of content, robust willingness to ground teaching in academic research, and strong acknowledgement of the fact that sustainability calls for systematic and critical assessment.
- The intentional outreach to other domains that share an interest in sustainability and openness to participation.
- The transdisciplinarity in a multitude of projects combining several professions together with a real-world problem, along with its stakeholders.

...and creativity is sustained by:

- The lack of domination of theories and concepts from one specific scientific discipline or community of practice.
- The efforts that are put into the creation and expansion of a shared problem space.
- The informal support for student activities.

Creativity, in connection with the contemporary design action and education, calls for a more nuanced assessment which is based on the fluidity of interaction, and an expanded, transdisciplinary access to a problem space, accompanied by a looser community of shared professional interest. However, such creativity cannot refer to lower standards in relation to scientific interaction: rather, the opposite is true. In essence, sustainability brings forth the tension between a modernist understanding of science and development and the societal, postmodern understanding of consumerism as the guiding force mediating our societal existence, and calls for a trans-scientific approach that is guided by academic research in connection with economic and political bodies. Design as both a method and an agenda (cf. Keinonen, 2009) can help in this process.

Transdisciplinary collaboration and learning for sustainability

Interprofessional, interdisciplinary interaction can be perceived to take place in three phases, through priming, to implementation, and to experiencing. This three-phase structure becomes even more evident in the academic context, where the roles are enforced and temporal structures are fixed to the annual schedule. As in each base the actor base varies, the structuring of the activity into three specific phases helps to manage the interprofessional mediation and the transdisciplinary development of the inquiry. The PIE model for interprofessional collaboration and learning reminds how, as in relation to cooking a pie, the production of new knowledge calls first for acquiring a recipe and ingredients and seeking new combinations (priming), then structuring, sequencing, and performing the act of cooking itself (implementation), and then eating of the pie (experiencing).

In transdisciplinarity, which is needed to promote widespread societal transformation for sustainability, the act of cooking must become more and more transparent and accessible to give all their share of participation and ownership. In relation to developing interprofessional learning, however, while support for

student activities and informal outreach must be appreciated, the resources needed to manage such complex interaction should not be underestimated. Consequently, the themes that become important in such interaction are around ensuring that sufficient resources (time, space) and competence (skills, understanding) are offered to initiate dialogues which are then taken into practical inquiries in real-world interaction. Eventually, a new kind of professionalism emerges, developing a new community of practice and renewing academia as a platform for future interprofessional and transdisciplinary action. At the same time, however, this new interaction can become conflicted with existing interests and disciplinary and cultural conventions.

While there is a "long history of debates between materialist and idealist perspectives," "organizational researchers have paid little attention" to bringing "materialism and idealism into critical contact" (Adler & Borys, 1993, pp. 674–675). In Dewey's (1938) perception, "once philosophers give up these time-honoured distinctions — between appearance and reality, theory and practice, knowledge and action, fact and value — they will see through the ill-posed problems of traditional epistemology and metaphysics" (McDermid, 2017).

Brown (2010c, p. 287) suggests that the strongest challenge for an "open [and] transdisciplinary community of practice" is the establishment of an "open transdisciplinary inquiry" (cf. Russell, 2010) in which a "critical inquiry accepts an open ontology, an open epistemology and a transparent ethic" (Brown, 2010c, p. 287). As a result, the three phases of interprofessional meaning-making connect with all three dimensions in an expansive interplay that seeks collaborative grounds for further action.

The designers' contribution

As a practice, design connects with the contemporary culture of mass consumption and now it has to restructure itself similarly. In a sense, the transformation toward sustainability also calls for a more activist approach for the designer (cf. Thorpe, 2008). However, if we instead manage to perceive this rather strong label from a postmodern perspective, community is the counterpart of the individual, and individual development calls for development in the community. For a postmodernist, a design activist is no more than an individual seeking her way out of the postmodern setting that has been put upon her by the still prevailing modernity.

The designer as an activist and even as a facilitator, however, is a decision-maker and creator in a modernist sense. The modernist dialogic approach still guides contexts that are fixed in modernist perspectives in established institutions or practice. To prevent yet another fall to the false prophets of modernity, the decision-making and meaning-creation systems must be challenged. As a result, when redirection in design is called for (cf. Fry, 2008), it involves redirection not only from the destructive to the viable, but also from details in artifacts to meanings (cf. Krippendorff, 2006) embodied in acts of consumption, and from well-established capitalist consumerism as the only societal activity toward new forms of meaning-making in society and the economy.

The domain of sustainable development is surely the greatest of all policy challenges. To overcome the challenge, there must be a complete socio-metabolic transformation (cf. Haberl et al., 2011) to proceed to the age of sustainability as the new cycle in our economic and technological, and meta-ethical and philosophical activities. To answer this call, the humanities, social and natural sciences, and engineering must come together to tackle its challenges together in interprofessional collaboration with a transdisciplinary mode of action. If contemporary design education can provide the future design professionals with the skills for such a process to help to transform our unsustainable existence into a new one, the next century can indeed be acknowledged as "the century of design" (Fischer, 2012).

6.1. Revisiting the Research Inquiry

areas of interest and their important theoretical frameworks. The results are discussed. At the end, the research questions are answered. Overall, this work began as an inquiry into the design methods and tools to promote sustainable design but evolved gradually into a study into how interprofessional learning and collaboration are taking place in the contemporary academic setting, and how they should be developed to support sustainable transformation. In parallel with the creation of the research proposal, a case of interest was identified in CS and its preparations, to which I personally contributed as a project assistant.

The analysis was performed and iterated several times as the inquiry kept evolving and expanding. The first round of coding was done for each set of interviews individually, but as the initial themes emerged, when adding new data or findings the context in which they played a part became increasingly complex. Finally, the findings were integrated into five main thematic categories of interest in interplay, reflected on in three specific phases of activity, based on which propositions for improvement are presented. This summarizing analysis connects the findings, relating them to the original areas of interest.

The outcome of this work is thus also a work of design in itself, as several iterations of content were carried out and concise findings were eventually structured based on this process. As such, this work does not rigorously develop theory further, but instead tests it in connection with the identified case as an example of interprofessional education for sustainability in practice. However, through the assessment, some new theoretical understanding emerges.

Connecting the findings with sustainability, design, and interprofessional learning

What is needed in assessing successful design innovation activities — “playing with the method conceptualizing frames, switching between them, and setting methods to completely new ones” (Keinonen, 2009, p. 289) — is also needed in assessing sustainable design. However, in this context, the openness and transdisciplinarity and the reflexibility of the process become further emphasized. Furthermore, when taken into the educational context, this may become a challenge for the conventional roles and practices, but also an engine for the production of new understanding.

From the activity theory perspective (CHAT), the connections between the phases of activity (in Chapter 5) play a key role in how potential conflicts can be avoided. While in this research these phases are identified as subunits of analysis, in another research the phases could be structured differently, and each phase could be further expanded into series of activities. In all the phases, however, the progress resembles and involves expansive learning, and their interplay acts as a similar exercise as a whole. In relation to expansive learning, the overall shared motivation and goal in the CS interplay continues to be knowledge-building for sustainability, both for disciplinary competence and in the sense of spearheading strategic areas at Aalto University.

Discussing and expanding the activities and practices, and the community and its rules, including as an epistemic tradition and a collaborative culture, can improve the transparency in management, hence creating more trust among the collaborators. As an interprofessional and open arena of participation, the CS community, with students at the forefront, has welcomed all types of input, to be collaborated with in various activities. In developing a skills-set for interprofessional and transdisciplinary collaboration, this became the normal approach for the experienced CS students.

6.1.1. Approaching and improving interprofessional learning

Interprofessional collaboration emphasizes the interaction between several systems of activity and communities of practitioners, with different motivations and goals. In assessing and analyzing the development and implementation of the CS study program, several mismatches, gaps, barriers, and challenges between and within the systems of activity were identified and reflected on. Overall, CS can be perceived as a project that is driven by strong motivations to improve current practice and to take responsibility for answering the future challenges of both interdisciplinarity and sustainability in an academic context. As such, it also acts as a good example representing such new, interprofessional learning in an academic context.

Managing interprofessional learning

When the earlier studies on knowledge-building through artifact-mediated processes are introduced to the setting in CS, two aspects are worth noticing. Firstly, an approach to interprofessional education must take into account both the horizontal breadth of the topical range and, at the same time, the great difference in professional experience between collaborators. Secondly, as the goals of action might be different for different actor groups, these should be made clearly visible from the beginning.

Managing horizontally broad networks

The activity systems that play a part in the management and development of the learning processes (e.g., design of instruments, managing, teaching, etc.) are hierarchically organized. These processes need to be viewed within a unified system of interactions aimed to develop knowledge-making for sustainability. Within the identified activity systems, there exist unidirectional transactions that are hierarchical, and reciprocal transactions between equal collaborators (Engeström, 2008). In CS, while many transactions are horizontal and others are expanded to involve a broader group of actors, there are tensions between disciplinary and collaborative processes of study and practice, and between actors on various levels of the organization, potentially with an obstructed view of activities on other levels. While the management in CS connects its participating departments to a collaborative process of program management, as a cross-school program it is not always connected to the highest levels of management in departments or schools of the university. Furthermore, as CS consists of studies

that are offered by the participating departments, managing the content, output, and evaluation from this broad stock can be challenging.

Interdisciplinarity in education, as well as in research (see Bruun et al., 2005), is not only challenging to manage but also difficult to assess. Narrow approaches in evaluation (e.g., conventional metrics, statistics) "fail to capture the complexity, contingency, and emergent discovery and novelty" of the outputs (Bruun et al., 2005, p. 166). Understanding interprofessional collaboration is perhaps most necessary for those that try to facilitate and manage the process. This is evident in the way that respondents from management and staff relate to existing theories on constructive knowledge-building and collaboration between professionals. In CS, however, the students seem to really learn this as well, and further, on a very practical level. In education, such interaction may act as a "crucial boundary-crossing change agent, carrying, translating and helping to implement new ideas" between institutions and workplaces (Engeström & Sannino, 2010, p. 13) to improve collaboration. Connecting the inputs better into a shared system of interaction and assessment helps.

Synthesizing a shared understanding

While professional stereotypes exist and some of them are based on a degree of truth, the ability to be involved in interprofessional collaboration and design does not necessarily correlate with disciplinary background, but is rather based on previous personal exposures and experiences. The findings support this hypothesis:[102] there seem to be two approaches toward interprofessional design collaboration — people either like it or they do not. These approaches might be dictated by the type of people and their prior experience, but also by the set-up of the collaboration, professional approaches, choice of tools, and management. To be able to tackle this binary approach, the instruments for collaboration and its management should be openly discussed from the beginning, and more open culture for collaboration becomes a necessity. Furthermore, the interaction should be structured in a manner such that both disciplinary and interdisciplinary processes are appreciated and able to connect to the process.

When looking into the development of practice, it seems to take place only through sharing experiences between people who are committed to the process and aware of the initial goals. To promote such activity, there must be a level of shared motivation, and yet there must be space for developing personal motivations. The meaningful development of concepts and artifacts related to clearly described goals, with an expansive learning approach that is supported by structures and tools that are introduced and consolidated in collaborative dialogues still aiming at personal, professional growth, can be perceived as such a self-enabling method for self-management and collaborative development.

[102] Also based on and expanding earlier research by Marttila (2012).

Connecting the three phases of interaction

In managing interprofessional learning, Engeström's (1987) expansive learning cycle can be further restructured into three phases. Priming, implementing, and experiencing act as specific phases in which constellations of people (community), rules, and division of labor change, and yet the common orientation and object for activity remains similar. In CS priming, the academics interacted to introduce a new agenda to the forthcoming Aalto University, to develop new interprofessional collaboration for knowledge-building for sustainability. In the program implementation, operated in three schools and in secondary connection with several projects, the orientation developed further in connection with the emphases, knowledge, and practices emerging from the participating communities (of practice). However, in a collaboration such as CS, only the students are really able to experience the outcomes and collect the learnings — perhaps in addition to the program director, with a connection to each student through tutoring — and personal tutoring was not that strong at the start of the program.

These phases of interaction together, however, form the interdisciplinary activity system in CS. This results in a need to reflect on CS as an activity system on its own, aimed at inducing interdisciplinary collaborations within the context of sustainability. As a result, CS activities, as an example of interprofessional learning and collaboration in general, can be studied from a range of perspectives, namely from the learning perspective (not restricted only to students, as teachers and management also learns; the teaching perspective (both interdisciplinary and disciplinary professionalism must be transferred); the management perspective (as such an effort of cohorted disciplinarity — not to mention transdisciplinary pursuits in projects and collaborations — must be well managed); and finally the perspective of interprofessional sustainability. In the assessment, all these aspects were considered and then taken forward into suggestions for development.

Sustainability as a context for interprofessional collaboration

The broad, commonly shared aim in CS activities can be identified as promoting interprofessional learning and collaboration for sustainability within the academic context. In this respect, the CS output is twofold, relating to knowledge regarding sustainability and interprofessional interaction in education, and to new professionalism that emerges in the program graduates.

Sustainability as a challenge and a driver

In regard to sustainability, it is important to discuss why something is done. CS offers a promise to critically assess sustainability (and unsustainability) in contemporary practices of design, planning, making, and management. As such, it must live up to this promise by introducing areas where such dialogues can be performed. In sustainability, as the context of activity, the breadth and contested nature of the concept becomes evident. To motivate collaboration, perceptions on sustainability must be connected to the overall inquiry. As a result, the shared

orientation must be based on shared interest rather than on conventional, disciplinary practices that are separated into professional silos. Hence, the management of such activity has to be more open to heterogeneous input.

According to Engeström and Sannino (2010, p. 3), the "inner contradictions of capitalist production and organization of work" remain "at the center of research on expansive learning." To this day, school connects to the making of our everyday unsustainable existence. In the words of Ivan Illich (1970), it is a component in initiating our modern "Myth of Unending Consumption," grounded "in the belief that process inevitably produces something of value and, therefore, production necessarily produces demand" (p. 38). In the controversial and contested context of interprofessional sustainability, the pre-assumption that "value can be measured and documented by grades and certificates" (Illich, 1970, p. 39) becomes contested as well.

In general, the emphasis in CS has been on increasing critical approaches to sustainability in design to induce critical and broad dialogues around sustainability. Further on, these dialogues must also reflect on the CS program itself (as evident in the students' interviews) to support the development of its overall aims. In this sense, while sustainability acts as a catalyst in promoting several activities, it also challenges conventional structures and existing views and seeks a transformation in contemporary activities across the contemporary professional fields.

Sustainability in interprofessional community of practice

As explained earlier (see sections 2.1.1 and 3.2.1), a community of practice is a group of people who are active in mutual interaction and who share a focus in action. Its four characteristics (Li et al., 2009, p. 2) can be identified in interaction in both "formal and informal settings," in "sharing knowledge," in collaborating together "to create new knowledge," and fostering "the development of a shared-identity among members." As Lave and Wenger note (1991, p. 94), "mastery resides not in the master but in the organization of the community of practice of which the master is a part." When looking at CS from this perspective, at least for the students there emerged a new community and a new type of approach to practice combining various professional competences in a loose network.

The levels of learning, as described by Bateson (1972; see section 2.3.3), ascend in parallel with the depth of interaction in internalization and appropriation of the new knowledge (cf. Vygotsky; as in Daniels et al., 2007). At the same time the knowing-what is transformed into knowing-how (Daniels et al., 2007). In interprofessional learning, the activities must be brought into the shared problem space (see section 2.1.2) to be assessed together, to produce new, hybrid knowledge and mutually negotiated principles for future action and to help to develop higher levels of learning action.

In approaching the university context, project-based, interprofessional interaction and learning provides a new way of introducing content to academia. Team- and project-based peer learning helps to structure a setting in which the emerging understanding can be tested and validated in a real-world context. According to Miettinen and Virkkunen (2005, p. 450), however, such new project or "team-based inspection practice" cannot necessarily be managed "in accordance with the old procedures and organization of management." In CS, the management of activities was similarly challenged by the variety of new content from both the program perspective (director, educational staff) and the student end.

Sustainability developing practice

Disciplinary, professional practices are governed by academic and professional traditions, communities, and networks. In CS as an academic program, entities also formed around three actor groups based on roles in academia, developing CS into an interprofessional, joint community of practice with students at the front of this new professionalism. Practices also connect with performance (cf. Shove et al., 2012; see section 2.1.2), and in interprofessional collaboration the various professionals also act as examples of their professional approach. In CS, however, as in any loosely structured interprofessional study program stretching across the conventional departmental structures, the teaching staff arriving from various professional contexts were not always similarly oriented toward the emerging interdisciplinarity in the student community that already acted as an interprofessional community of practice.

As CS was set up as an open arena for interprofessional sustainability, the engagement and repertoire expanded as new actors joined in. Consequently, though challenged in various ways, CS acted as an open, even integrative community, promoting the transformation from discipline-centered assessment toward interprofessional, transdisciplinary mediation and meaning-making in a community of interest for sustainability, to produce new knowledge and practice for both the future graduates and the educators.

The role of design

The identification of "social and cultural impacts of new technologies" has produced initiatives that "involve citizens in policy making and regulation of new science" (Allen et al., 2003). Contemporary design activities can reach even further and involve citizens in the actual making and governance of knowledge, science, and technologies. The sustainability crisis, however, calls for a new type of responsibility in design, a new approach to facilitation and participation, and a willingness to redesign the practice itself (as discussed in Chapter 1). Sustainable design requires interprofessional collaboration and sustainable transformation calls for transdisciplinary action. Consequently, for a designer, skills to facilitate such processes might well become one of the most important elements in their future professional life. To answer this call, the contemporary design academia must evolve accordingly and create new openings for collaboration within and outside the university, with a focus on looking at shared topics of sustainability.

Contemporary design competences

In interprofessional, transdisciplinary design collaboration for sustainability, in addition to the general professional skills (e.g., drawing skills, conceptual design skills; see section 1.2.2) or, for example, digital tools, new media skills, and sustainability-specific understanding (e.g., lifecycle design, material impacts, social assessment), the design team must also have an understanding of the semantics of sustainability from various professional perspectives to facilitate collaboration for mediating new understanding and to seek synthesis and embody this understanding into new materials, concepts, and artifacts. The role of the designer is to support such transdisciplinary design dialogues (Wahl & Baxter, 2008) — reflective and expansive journeys into the topic of sustainability in which new understanding is collaboratively created and the objective of the activity is constantly renegotiated.

In the contemporary collaborative design activity, not all team members (even when from the design discipline) need to be facilitators. Some can act as other topical experts, or just be visualizing ideas in discussion. However, each designer that involves herself in sustainable design should have at least some understanding of processes of collaboration and facilitation, and of mediation of meanings, to proceed toward further steps of action.

In looking at interprofessional learning, and CS as its example, design takes place on various levels — in planning the content and interaction at the beginning; in developing courses; in structuring learning within a course, within a team, or within a project; or in communication (and in the actual concept design process as well). Design ability in both expanding the inquiry with new input and producing a convergent synthesis is needed to structure the interaction. The dialectical nature of design activities — the existing interplay between ideas and materials and the reflective practice in problem-solving that can progress through the interplay between abstract concepts and things and matter and forms — is very present in the outcomes of the analysis. Consequently, design knowhow can be used as a method to develop interprofessional, transdisciplinary problem-solving (Marttila & Kohtala, 2014). Due to its ability to facilitate collaboration and creatively experiment and iterate, it is a fitting approach to develop instruments and concepts, too. This, however, calls for a better understanding of the instruments used in translating the knowledge and managing the work.

6.1.2. Answering the research questions

Based on the findings from the assessment and analysis, answers to the four research questions [RQ1–RQ4] that were refined from the general inquiry (as explained in section 3.2.3) can be provided.

How is sustainability argued for and/or efforts legitimized, and who should be involved (and where)? (RQ1)

Sustainable development, and its Agenda 21 (see section 1.2.3) puts emphasis on shared governance and open participation. Sustainable development outcomes should be effective in several respects (e.g., social and economic), requiring input from several experts and from the common public, and interprofessional, transdisciplinary activities. In assessing sustainability, open dialogues assessing values and worldviews are needed, and the assessment must take place in a "parliament of things" (see Latour, 1993, p. 142), where natural and social phenomena and the discourse about them come together as hybrids, assessed through the public interaction of people, things, and concepts.

The contemporary challenges in the sustainability discourse also connect to the dialectical logic between the conflicting concepts (see Pratt, 2002) in modernity. As a result, sustainability should not be approached as a fixed concept, but rather as a component of a collaborative process. In CS, there were various interpretations of sustainability in an interplay, ranging from viewing it as an incremental process of development to a complete overhaul of current practices of production and consumption. However, by acknowledging the shared focus in facilitating interprofessional dialogues, the broad range of views was tolerated well.

Sustainability as a topic connects to a complex range of controversies, and in CS these were openly introduced into an open assessment. As a result, conflicting views on how this interaction should be set up emerged, and various participating departments had slightly different traditions to this end. Furthermore, despite the openness to new input and various emphases, students' ability to connect to the program development was limited. In the academic setting of CS, the roles and schedules through which the activities were primed (CS as a program pilot, course content each year) were still not easily accessible to students. As a result, students introduced various informal activities to bring in topics that were important to them.

However, at Aalto, the sustainability aims are not always articulated clearly or operationalized well (see, for example, Kivimaa et al., 2017). In the academic context, sustainability is not really addressed as a measure of success in assessing education or research, either.[103] To improve the collaborative mediation on interdisciplinary sustainability, the expectations should be articulated in an open dialogue, and to this end interprofessional and even transdisciplinary activities must be supported. To better share the inquiry in respect to the

[103] While as a topic it is assessed in terms of quantity in Aalto sustainability reporting, in assessing success in academia it remains a secondary area of focus after the disciplinary interests.

language of collaboration and the goals and aims of activity, the participating communities of practice must open up and develop towards being a community with a shared interest (cf. Fischer, 2001). Such communities focusing on sustainability challenges have to be open to participation with a transdisciplinary mode of action.

How has design profession and practice evolved to face the challenges of sustainability, and what insights can it offer to collaboration and transformation? (RQ2)

Design acts weakly as a discipline in the sense that it remains at the academic borderline between soft and hard science, constantly open for new input, and yet strongly as a practice, as it is already distributed to various contexts as a component of activity and disciplinary input. While in its industrial context design is often related to conception and product design (or even branding and marketing), in relation to sustainability its focus must be on collaborative action, and collaborative mediation on sustainable transformation. Such transformation, however, has to be informed by transdisciplinary activities to better adjust to the complexity in the social reality and connect to lay perceptions and several expert domains. As a result, communication of processes and goals must also extend out from the university. Contemporary design activities can connect to all these levels of inquiry and can also connect various levels together. The dialectical nature of design activity, in its interaction with both material artifacts and abstract concepts and in its reflection between professional understanding and the products of collaboration, helps to support such a development toward interprofessional meaning-making.

However, design as a process of development and problem-solving, and as a general agenda (cf. Keinonen, 2009), inevitably also resonates with the views generated in the midst of creation of the developed Western way of life, linking to the development of scientific thinking in general, thus connecting to questions on the philosophy of science and technology. This turns the focus to questions on epistemology, ontology, and ethics — what is perceived to exist, and how and why it should be interacted with. At the same time, many different design practices have been anchoring themselves in specific scientific or academic discourses and historical and cultural developments, thus becoming “disciplinarized” into specific domains of professionalism, mostly discussing with well-established partners. Sustainable design deepens both of these perspectives.

In interprofessional, transdisciplinary design collaboration for sustainability, in addition to general professional skills and sustainability-specific understanding, the design team must also have an understanding of the semantics of sustainability and the skills to approach the issue from various perspectives. This refers to a paradigm shift in design, from an emphasis on artifacts’ styling or function to what they mean to those affected by them (cf. Krippendorff, 2006; see section 1.2.2). In this process, the role of the designer is to take the participants together into transdisciplinary design dialogues on sustainability (cf. Wahl & Baxter, 2008) in which new understanding and action are created.

The emergence of design collaborations provoking questions on consumption can act as suggestions to allow people to challenge existing norms (Marttila, 2011c). Furthermore, the linkage to people's social reality can help to make systems and their feedback more concise for their users. As a result, sustainable design education should aim not just to downscale consumption models by the development of top-down systems, but also approach it through projects and collaborations — artistic explorations with critical, constructive, and collaborative reflection in real problem contexts and with several professional and personal perspectives.

What type of competence is needed in crossing professional boundaries, and what are its conditions and consequences? (RQ3)

In assessing the societal impacts of academic research, the focus can be drawn to "epistemological, artefactual and interactive-institutional" dimensions (Miettinen et al., 2015, p. 257). The structure of this work and its analysis aims to contribute in these respects. A most common stumbling block in transdisciplinary education (Marttila & Kohtala, 2014; Wiesmann et al., 2008) is perhaps the exposure to the conflicting reference systems of one's own discipline, the interdisciplinary context, and the overall society concerned. In CS, all three challenges — comparing the transdisciplinary approach with disciplinary practices and emphases, balancing the interests in developing professional skill in comparison with collaborative processes, and connecting the overall sustainability agenda with internal and outside actors — are introduced into an disciplinary and institutional interplay.

Contemporary professionalism is governed by disciplinary communities and networks in academia and in outside professional practice, and together these form various smaller communities of practice (Lave & Wenger, 1991). CS, as a community of actors, can be perceived and assessed as such, despite being rather openly oriented as a community of interest (Fischer, 2001) around sustainability and consisting of various actor groups. Following Shove et al. (2012), the three phases in developing such a community develop from sharing mutual engagement to the development of shared methods, evolving into a shared understanding. Despite challenges, the ideals on openness and transparency in activity helped the CS community to remain open to input and to connect it further.

In crossing professional boundaries, the different epistemologies are also brought into an interplay. In setting up the interprofessional learning process, attention must be paid to the structuring of the interaction, and how participants are introduced and the choices of processes of interaction, instruments and tools, and objectives and tasks negotiated. As a result, the collaborators form a shared problem space (see section 2.1.2) in which the existing understanding is translated into new, hybrid knowledge that is of a new mode (cf. Mode 2) and tied to its context of interaction and focus. In CS, as a community for interprofessional design action for sustainability, this new knowledge was then tied to the facilitation of interdisciplinary and transdisciplinary dialogues on sustainability topics. In CS, theory acted as a starting point and a primer, but the actual

emphasis was on learning in practice and on applying various professional and theoretic inputs in various interprofessional project collaborations.

In interprofessional learning, however, the professional inputs and outcomes are more heterogeneous and depend on the emerging interests as well as the structures that guide action. Some graduates become rather "traditional" professionals in their discipline, yet with more experience of how to interact in complex settings of transdisciplinary sustainability, while others create a new core skill in connecting various areas of expertise, creating bridges between areas of knowledge and action, and acting as future hybrid experts (cf. Hukkinen, 2008) in promoting sustainable transformation. Both areas of competence are needed to create the professional communities (and various projects) that can tackle contemporary, complex challenges and connect them further.

How are the processes, roles and outcomes of learning and development conceptualized and managed in interprofessional higher education for sustainability, and how does this affect the practices of teaching and learning? (RQ4)

The questions on contemporary knowledge production are not only related to its dissemination, but tied to the values and goals of activities between several actors, such as universities, companies, government, and civil society (Marttila & Kohtala, 2014; Nieminen, 2004). These values should promote sustainable development and open diffusion of knowledge within the society. The shift toward transdisciplinary, interprofessional practices has specific requirements for education, including the development of platforms of shared problem spaces for professional dialogues and outside contribution (Marttila & Kohtala, 2010, 2014). This new approach can be seen as a transdisciplinary approach through interprofessional education.

In his 1970 book *Deschooling Society,* Ivan Illich predicted that "our reliance on specialized, full time instruction through school will now decrease, and we must find new ways to learn and teach: the educational quality of all institutions must increase again" (p. 23). While specialized skills have remained in power in the contemporary institutional and corporate interplay, the role of academia has been undermined and its resources have tightened. The learnings from CS portray the difficulty in assessing the quality of the studies and the challenge in linking different perceptions. Furthermore, they point out how structures in academia are not always fond of such endeavor.

As interprofessional interaction stretches across the conventional structures in academia, access to information becomes challenged further, as it is located in various communities and constellations of actors, in various departments and schools. As a result, recording information in material forms becomes even more crucial. When new understanding can be inscribed into material forms (Lopes, 2011), it can also be connected with, and translated for, future activities. In CS, however, access to such information, and the ability to connect it with development, was challenged by the unclear roles and rules. As both the topic of

sustainability and the program agenda in developing new learning and collaboration invited conflicting perceptions, clearly structured and transparent mechanisms for interaction (including outside the program) are needed. In relation to developing interprofessional competences for sustainability, the students, as future experts, should also be empowered to provide their experience in the process.

Whilst Illich predicted changes in education that have gradually become a part of our contemporary reality, his call continues to resonate in approaching sustainable design. As "contemporary society is the result of conscious designs," the various educational opportunities "must be designed into them" (Illich, 1970, p. 22). As a result, one solution for an educational platform (as in Marttila & Kohtala, 2014) is to ensure that understanding of sustainability — together with its technological aspects — is promoted in disciplinary-related education and that socio-cultural sustainability and the different institutional perspectives are emphasized in projects that are taken forward. In the interests of transdisciplinarity, lay stakeholders should also be involved where possible in a co-design process facilitated by design students with experience in participative co-creation methods.

6.2. Discussing Implications

In summary, the contributions in the analysis of the birth and the five first years of the CS program at Aalto University, though using a single perspective on the analyzed material in relation to what really went on, are structured around two main points. The first point concerns the methodological and theoretical contributions that emerge from the research. The second is about how design in an academic setting can contribute to (the management of) interprofessional learning to empower sustainable transformations in practice.

In this process, the different views on sustainability and sustainable development need to be consolidated and brought together into a shared dialogue. To orientate the momentum toward a collaborative understanding, expansion in participation in and governance of the development of learning is also necessary. And yet, within a complex problem context with multiple definitions and aspects of the inquiry, such as in sustainable design, it might be impossible to align understanding under a shared vision. Instead, the work must be based on collaboration that agrees on how different perspectives are taken into account, debated, and justified, and how they affect the problem at hand.

Consequently, instead of approaching sustainability using dualistic and dialogical terms such as “strong” and “weak” or eco-centric and anthropocentric (or technocentric, as in section 1.2.3), one must look to reflect these in the setting from which sustainability views are emerging — the institutions of practice and culture, and the modernity with its inherent contradictions within which these terms arise.

6.2.1. Reflection on methodology and theoretical contributions

In approaching the CS interaction, the CHAT lens, supported by various other theoretical contributions, was utilized both to structure the assessment and to develop the final assessment and analysis, as described in Chapter 3 (see section 3.2.2). However, in line with a GTM process the interview data and other materials, as assessed in Chapter 4, were analyzed and coded individually, resulting in the gradual development of more general labels and eventually the integrated main thematic categories of interest. In interplay with these categories, CHAT also moved the focus to the identification of the emerging conflicts and contradictions within the activity. Eventually, for the final analysis (in Chapter 5), these thematic categories and conflicts were connected in interplay within the three phases of activity to propose suggestions for improvement. In this process, various emerging insights on theory-building can be identified. While GTM as a methodological choice allowed a more deliberative process of analysis, structuring the assessment on CS interaction along the CHAT framework, as an expansive learning cycle (cf. Engeström, 1987, 2000), helped to connect and structure the insights from several phases of action and actor groups.

Activity theory in assessing interprofessional interaction and learning in academia

In general, CHAT acts as a good guiding framework for analysis. The simpler it is, the more complexity it can accommodate. It is grounded on the notion of artifact-mediated activity (e.g., with tools and signs) and focuses on learning-as-process (Vygotsky, 1978). It is based on dialectical logic and theoretical generalization — identification through experimentation and transformation. Such dialectical materialism implies (fittingly to design) that human beings, besides acquiring knowledge, also produce and transform culture. These foundations help to define grounds for activities supporting interprofessional design collaboration between different epistemic traditions.

The use of CHAT as a theory to guide educational research has "dramatically increased [...] over the last two decades" (Nussbaumer, 2012, p. 37). In studying the use of CHAT in educational research, Nussbaumer (2012, p. 45) points out that in the reviewed research, CHAT "lends itself not only to thorough collection of rich data" contributing "to the depth and quality of description of the context," but also "manifests its applicability to classroom research." Despite its "inherent complexity," CHAT can "reveal embedded organizational and contextual influences" when applied to "relationships between various constructs and components" (Nussbaumer, 2012, p. 45; see also Yamagata-Lynch, 2007).

However, while CHAT and its models for activity systems offer a concise way to analyze and understand such collaboration and learning, it should not be approached as a model of reality. Rather, it introduces a lens to structure understanding around complex phenomena involving several different motivations, processes and practices, and actors. This work can therefore also be perceived as a contribution to how insights from CHAT can be utilized in approaching the complex context of developing academia for the twenty-first century, with a focus on the sustainable transformation of our unsustainable contemporary existence.

In CHAT, the internalization and externalization processes concern an "understanding of context and processes in order to organize them with external artifacts to carry out an activity" (Nussbaumer, 2012, p. 44). The materials and tools that can be used to guide such interaction, however, also introduce their agency to the process (ANT; Latour, 1993), and access to them can be limited. In developing new, interprofessional practice, the black boxes of information and the punctualizations through which actor-networks interact (which include intangible, embodied knowledge and knowledge with restricted access) must be opened further to support collaborative mediation and to connect different phases in activity. In relation to knowledge in interprofessional collaboration, the inscription of tacit understanding into material forms allows more functional translation back into the shared learning process and helps to develop the community and its shared practice further (cf. Lopes, 2011; see section 3.2.3).

Overall, while the CHAT view helps to understand and develop interaction within the fixed constraints of the academic setting, ANT contains concepts that "can be

used as tools to better reveal the complexities of our sociotechnical world" (Cressmann, 2009, p. 2). To continue from Miettinen (1999), while ANT as a methodological insight works well in analyzing complex interactions, in progressing to development, CHAT helps by offering a model through which contextual constraints are easier to articulate. Criticism of the CHAT view suggests that it may "not be suitable for understanding relationships between individual minds and culture" (Toomela, 2000, p. 354) or unconscious psychological factors in decision-making. However, in approaching the development of new practices in an organizational context, this is not the main focus of this work. Instead, if the activity is structured in specific phases within an iterative (and project-type) structure, and a collaborative, shared orientation for each phase is identified, the interaction can deepen despite the differences in these views.

Developing and implementing interprofessional learning in academia

As we have expressed already earlier (see Marttila & Kohtala, 2014), the three main improvements to promote transdisciplinarity in teaching interprofessional design can be identified as promoting active, constructivist education; strengthening bridge-building across various actors and activities; and emphasizing social sustainability to connect to the anthropocentric focus in activity, having people as the focus of design action and process. Through this research, the important thematic areas in this process were identified along the three phases of interaction to take into consideration in all interprofessional learning within the academic context.

The process of interprofessional learning is developing from recalling facts and knowledge to application, analysis, evaluation, and the creation of new understanding tied to a given context of activity. Such a process evolving from the identification of an initial problem to its collaborative mediation, development, and utilization also resonates with Engeström's (1987) model for expansive learning, used as a component in the analysis in this study. All the assessed models, however, draw a picture of a process of progression from analysis of a situation toward modeling and experimenting, and synthesizing new understanding based on results. In essence, these all continue the discourse on constructive education, and education as a social construct, that became a part of the mainstream in education through Dewey's (1938) work.

In respect of communities of practice (Lave & Wenger, 1991; see section 2.1.1), the CS community has always remained more open and more expansive than a traditional CoP, tolerating contesting views on processes and output. Furthermore, CS as a community also supported loose assemblages of people in various project constellations (both formal and informal) to develop new interaction and content under a shared interest in sustainability (as in CoI; Fischer, 2001). Through this interaction, a new type of community is developed around the agenda of sustainability that is looser and more dispersed.

Consequently, interprofessional interaction in academia can be a powerful engine in producing new content and topics to the academic inquiry. Various projects that take place in loose networks of communities of interest can act as

components in progressing new research programs in the sense that Lakatos (1970) suggested, to develop new interprofessional and transdisciplinary paradigms to tackle the challenges of sustainability.

And yet, today, the pedagogic discourses still often put their focus on teacher activity rather than on the activity of learning (Miettinen, 1990; as in section 2.3.3). Instead, to support the creation of shared understanding and action, the process of learning must be assessed as a whole, beginning from the practicing community enforcing a certain discipline, to the teaching methods and structure (and to potential constraints and conflicts arising from the context), and finally to collaborative and transparent evaluation of the process. Such a view becomes even more strongly evident in interprofessional learning, as collaboration is looser and the community is connected to various other constellations that may have more resources, power, and/or momentum.

Interprofessional sustainability and the future of academia

Only by connecting the rigorous professional and academic understanding with future practices (and students as the future practitioners) can existing conventions be transformed. Similarly, in studying technological transitions transforming the socio-technologic regimes (cf. Geels, 2002; as in section 1.2.1), the new interest in interprofessional and transdisciplinary sustainability in academia is transforming the landscape for learning and practice. Interdisciplinarity in its "instrumental," "strategic," "pragmatic," or "opportunistic" forms (Bruun et al., 2005, p. 29; emphasis [quotes] in original text) can be aimed merely at "efficiency and commercial value," and yet its "critical" and "reflexive" forms are interested in challenging and replacing "the existing structure of knowledge, education and problem solving" (Bruun et al., 2005, p. 29).

In the contemporary evermore competitive academia, however, there is a risk that the interprofessional interest in providing new content for the emerging third role of academia — to create novel, hybrid connections between different domains of society to promote (economic) innovation — results in simultaneous doubts on sustaining the highest research competence and the role as the provider of the highest level of professional education. And yet, to be able to provide such education successfully, there also needs to be a high level of understanding of contemporary, interprofessional reality.

In introducing new content to academia — even more so in the context of interprofessional topics such as sustainability — the students as future professionals are at the core of the future practice, in the sense that they have the best knowledge about the required competence. Ensuring that there are resources to connect this knowledge to the development becomes important, and mechanisms that support such activity are of benefit. Events in which learnings are shared become crucial as well. As a result, programs supporting such interaction need to connect together both informal and formal activities to provide platforms for critical post-disciplinary dialogues in relation to sustainability as a broad area of interest and interaction.

6.2.2. Practical implications

Following the theoretical notions, improvement for practice can also be identified in both professional design and design education. The general suggestions for improving practice are considered in relation to design activity, interprofessional collaboration and learning, and transdisciplinarity.

Contributions to interprofessional design and education practice

Contemporary design activities connect to several levels of focus (see section 1.2.1) and involve various methods and approaches. Due to the broadness of the field, there are various possible branches more or less considered to be a part of professional design activity. For a designer interested in sustainability, the disciplinary competences involve, for example, creative skills, conceptual design skills, DfS skills, digital tool skills, and more (see Figure 23). Furthermore, project management and the facilitation of collaborative mediation has become a crucial component in contemporary team- and project-based design activities. In general, these competences can be structured in various compositions, but it is also evident that when moving from the detailed level to developing organizations, communicating topics to general public, and even involving them in transdisciplinary design collaboration, the transformative potential in design action grows.

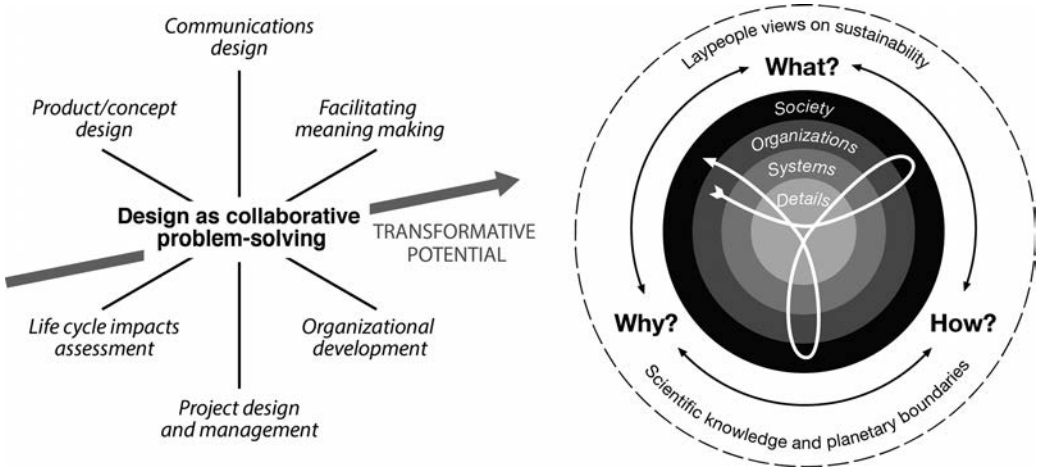

Figure 23. *Professional design practices (left) and the design action for transdisciplinary meaning-making for sustainable transformation (right).*
Source: Author

In sustainable design, important skills relate to facilitation and collaborative mediation, taking the lead in the process, and being comfortable with ambiguity. The designer approach is already familiar with working with unfinished ideas, being solution-oriented in relation to various processes of problem-solving. In transdisciplinary processes of learning, design can make contributions to all the phases of the process, but it is in real-life implementation and testing that the most obvious opportunity resides (Marttila & Kohtala, 2014). In this larger sense,

"design as [a] producer of social content, functions and culture operates [...] in the boundary zones [...] between the user and the machine, the stakeholder and the system, the citizen and policy-making, and the need and its satisfaction" (Marttila & Kohtala, 2014, p. 459). Design activity can set up platforms that connect stakeholders and experts together to discuss problems within these specific contexts.

According to Keinonen (2009), design can be perceived as an instrument, competence or agenda (see section 1.2.1), and in the CS interplay this existed on all these levels. Similarly, in light of this, design can act on all three levels as a placeholder connecting the emerging aspects of interest (see Figure 24). Design as a competence in its various contemporary professional domains is by its nature hybrid (cf. Hukkinen, 2008) to an extent, combining artistic reflection in science-making, or meeting business management with insights from social studies, or aligning engineering with user behavior. The nature of design, connecting abstract reasoning with material excursions or theoretic understanding with action in general, invites hybrid approaches to expertise and knowledge.

As an agenda, design also acts as a key focus in innovation policy development, and this attracts interest in developing higher education to meet the new need for societal sense-making. These new ideas emphasize more fluid constellations of projects and people, able to respond to the evermore dynamic setting of the contemporary world; and yet, when this sense-making is introduced into the context of sustainability, it may challenge the existing conventions in education and practice.

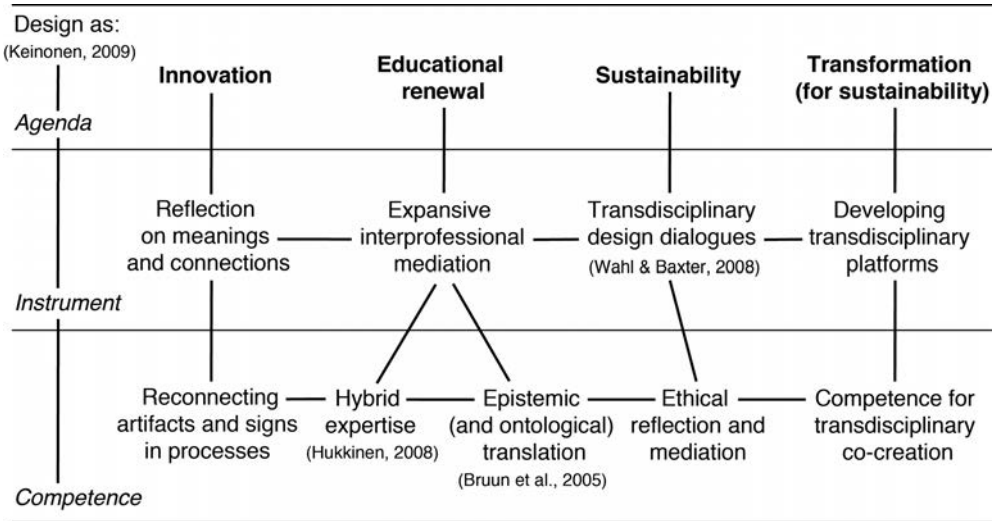

Figure 24. *Revisiting the connections between design practice and selected contents from this research.*

Source: Author

Hence, design as a professional concept of collaborative problem-solving that is proactively solution-oriented in integrating and synthesizing different views and yet guided by scientifically robust knowledge and critical and analytic thinking, can function as a well-grounded basis for sustainable transformation. As its orientation is connected with the context and collaboration, the new knowledge then transfers through new types of community, centered on topical areas of interest, to new projects and interactions. Consequently, as a component in interprofessional learning, design as a disciplinary component seems a justified choice.

In an academic context, if tuned for open participation and critical inquiry, design is an instrument to manage interaction and development, and a managerial competence in inducing change. Design, along with sustainability, acts as an agenda inviting actors to involve themselves with future activity or to connect with broad societal progress (see Figure 25).

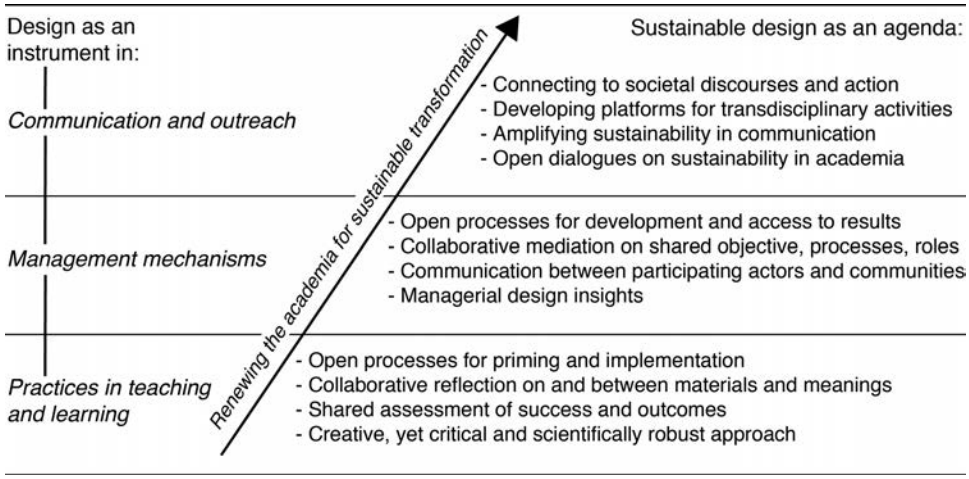

Figure 25. *Design as an instrument in interprofessional academic interaction for transdisciplinary sustainability.*

Source: Author

According to Krippendorff (2006, p. 24), contemporary design "must support the lives of ideally large communities [...] and must make sense to most, ideally to all who have a stake in them." The new way of connecting activities under a shared interest suggests the role of a designer that focuses on collaborative, expansive mediation in various contexts of activity and with a broad focus on action for sustainable transformation. In this process, knowledge-making, decision-making, and awareness-making can be supported and expanded with design in relation to both processes and material and conceptual excursions.

With a professional focus on communication, design competence in this respect can also help to amplify messages regarding the challenges and initiatives, and help to connect earlier work to existing projects and further action (transition paths; Geels, 2002). Consequently, in relation to approaches to sustainable design

(as discussed in section 1.2.2), and in addition to transforming or redirecting the practice in general (cf. Fry, 2008), the communicative and critical approach, connecting to further action, has the most potential to transformation and change (see Figure 26).

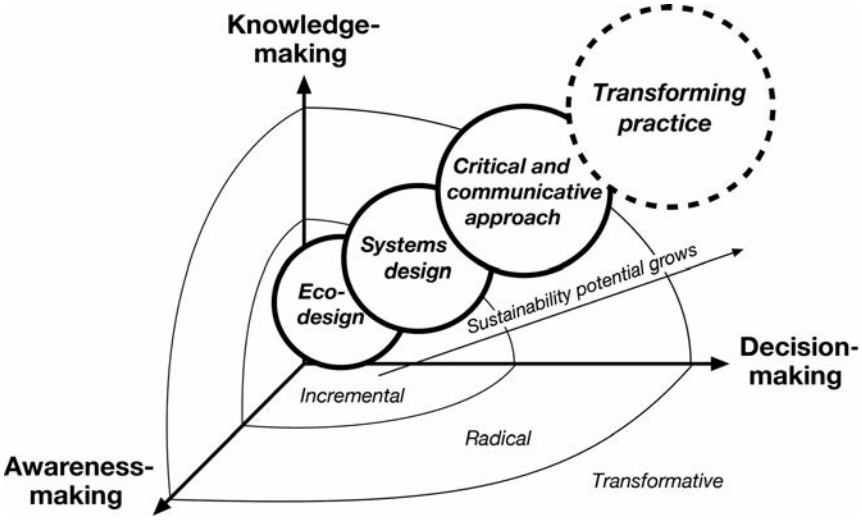

Figure 26. *Promoting transformation with different approaches to sustainable design.*

Source: Author

As discussed, in the context of sustainability, the contradictory approach to technology and development must be taken into account in the dialogue, and if the scope of action reaches outward from academia, criticism of science in general must be tolerated. However, given that technology and science as concepts can be understood in quite a broad sense in connection with the techniques, knowledge, and methods integral to human action and culture, these will always remain involved in the design process for sustainable development. Creative reflection and collaborative contesting of the problem boundaries can help to justify the selected choices for further action in this respect.

Promoting and managing interprofessional learning in academia

A learning community combining different disciplines, professions, and roles introduces a complex setting. To co-operate and properly manage such an educational program in a university, appropriate mechanisms for management and development are needed. One challenge in developing new practice is that "it involves a complex process of acquiring and converting both explicit and tacit knowledge into [new] activities" (Li et al., 2009, p. 2). In approaching interdisciplinarity and transdisciplinarity, these areas of knowledge — tacit (knowing how) and explicit (knowing what) Duguid, 2005) — can create a contrast, and in interprofessional, loose networks, such a contrast can be multiplied if new input is connected to the inquiry and the previous knowledge has not yet been made explicit.

As identified above (see section 3.2.1), one weakness in CHAT is the difficulty of addressing several connected activity systems and their interplay within shared activity (cf. Yamagata-Lynch, 2007). In this work, this challenge was overcome by addressing the interconnected activity systems in a different way, with CHAT elements as components in a new type of structure. The findings, elaborated into general notions guiding interprofessional collaboration and learning in the academic context (see Figure 27), can also help in guiding developers and participants of similar activity.

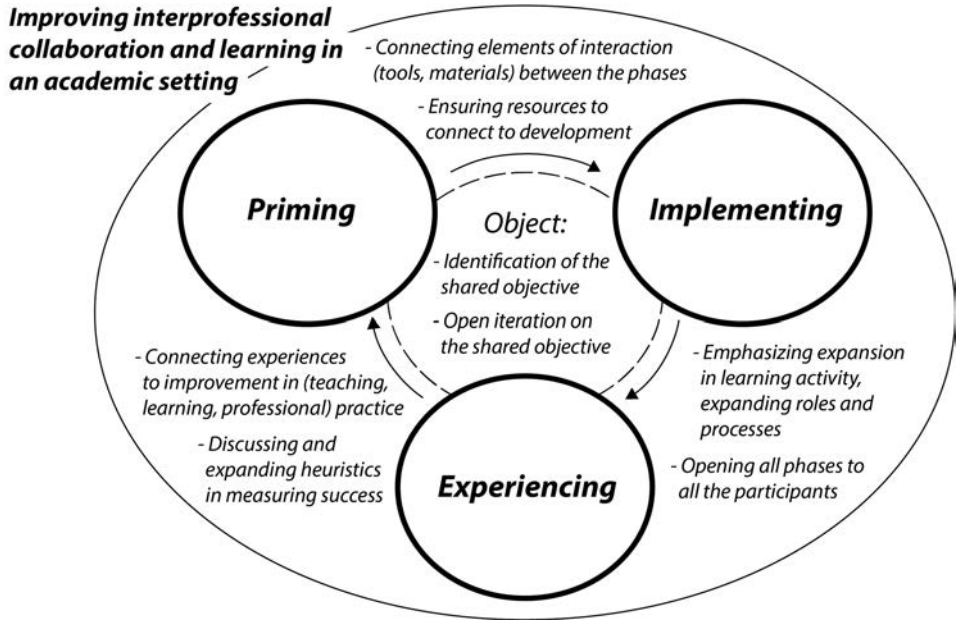

Figure 27. *Modeling theory and action for interprofessional learning.*
Source: Author

In the process of expansive, interprofessional meaning-making and learning, each activity involves the phases of priming, implementation, and experiencing. From the perspective of organizational learning and design, these three all connect with materials and meaning, management, and measurement, and to promote an expansive view to learning, (especially in inter- and transdisciplinary learning), this understanding is needed to build the development on. These three stages are in many ways based on conventional phases in organizational development, and in this sense may seem conventionally hierarchic and linear. However, in interprofessional, transdisciplinary learning and action, the expansion, openness, and connectivity in each phase are further emphasized and can be supported by professional design action.

As a result, a special focus on leadership must be present in several levels of processes. Such leadership must be present not only in managing education within one program or course, but also in steering development and dialogues between the departments and teachers. At the same time, this leadership needs

to promote the collaborative and reflective planning of studies, supported by thorough teacher interactions between departments. Finally, the leadership must support various student activities, both formal and informal, for co-created meaning-making.

6.2.3. Limitations and further work

This research has focused on interprofessional interaction and organizational learning and development. The phenomenon was approached from the perspective of activity between the involved actor groups (management, teaching staff, students) as the participating communities. As such, its findings do not relate well to a psychological understanding of how learning happens, or how competence matures from the internal, personal perspective.

In addition to these aspects rigorous longitudinal studies are needed in the future to ascertain how such programs can change learning and interaction in universities in the longer term. While this work aimed to offer an insight into making one such study program, comparative studies are still needed. In this process, however, the difficulty of measuring output and success can become a challenge. Although many studies have been carried out with a similar area of focus, all-encompassing studies on such programs and their impact are still needed. In this process, the heuristics for success also have to be further refined.

Limitations

While this research connects to several theoretic domains, it does not aim to be a rigorous theory-constructing work. Rather, the idea is to take theoretic understanding that relates to a phenomenon, test it with a real-world case, and suggest improved models for interaction. In many ways, the CS program acts as a great example of interprofessional education for sustainability, but as each such program acts under the terms given by its context (national, academic, scientific, disciplinary variations), findings are not easily generalizable. However, at the same time, many of the findings can point to important aspects in such interaction in other contexts.

In the contemporary discourse on practice research, increasing criticism is also directed at reflecting the awareness or intentionality of actors (in relation to simply reacting to structures with unconscious and unreflexive processes). Although this work does not address this dimension in any special sense, the CHAT-based framework that is utilized in the assessment aims to transcend this dichotomy. Rather, this research suggests taking an organizational learning perspective, supported by reflection on design action on various levels of the process: this question of intentionality is simply introduced as an epistemic and ontological element in the approach rather than as a potentially conflicting component in the assessment. In this process, rather than reflecting on the issue from a theoretical perspective, the view introduces a more practical emphasis.

Lastly, the approach in this work is surely biased by both personal views (background, culture, discipline) and continuous involvement in the program. As a result, there is a limitation in that the research focus is oriented — at least to an extent — according to my own personal and professional expectations.

Further research

Although the comprehensive amount of material in this research would allow several different directions for further research, some clear examples are identified below. Obviously, the initial area is to continue follow-up on CS Design students, and on CS in general, as an example of a project challenging and transforming conventional practices in academic learning.

Refining theories on transdisciplinary meaning-making

Further research can be aimed at studying the connections between different theories on interdisciplinary, professional collaboration and community-building to provide a better understanding of how professional practices develop in loose networks and how communities should be approached to understand the differences in approach, ranging from closed to open and to integrative, expansive constellations. On the same note, studying theories that model meaning-making processes and the differences between intra-psychological (between people) and inter-psychological (individual) reflection and mediation can help to discover how meanings evolve in complex networks of actors and artifacts and what the conditions are that become introduced by the university as a context of activity.

Assessing pedagogies for interprofessional education

Transformative pedagogies challenge conventional practices in teaching and learning. In the context of transdisciplinary sustainability, the conventional progressive pedagogies (e.g., problem-based learning) can also be perceived as insufficient. And yet an important question is raised in connection with the dynamics in building up the momentum for change. More research needs to take place, focusing on the institutional and community-based conditions for transformation. However, interprofessional learning for sustainable design builds on, and expands from, the components of problem-based learning, aiming for a comprehensive change in the learning environment and action and emphasizing contextual and actor-driven aspects in the problem-solving process.

In this respect, more research focusing on studying various disciplinary perceptions of and approaches to sustainability and learning is still needed. In the context of interprofessional education, this also calls for better insights into how teachers convey their personal and professional views in their teaching and how these are connected with learning.

Comparative transdisciplinary studies

Finally, more research can compare various interprofessional programs, seeking typologies in practices of collaboration and motivations in relation to integration

and synthesis in professional work. Hence, research can also look at how shared studies and disciplinary studies relate in various other, interprofessional educational programs, and how their management and development can be better organized.

AFTERWORD

This work aimed to provide a comprehensive standpoint to promote transdisciplinary design activities for learning sustainability in a contemporary higher education context. Such a design process incorporates several expert views together with laypeople's understanding, and proceeds to facilitate collaborative mediation of meanings and change-making. At the same time, however, conventional practices for teaching, learning, and professional practice also become contested. The ingredients on which the inquiry is based emerge from disciplinary, personal and cultural, and professional backgrounds. In this inquiry, conceptual and design artifacts, and platforms that can support expansion and interaction, have a special role.

A similar standpoint to interprofessional and transdisciplinary action has been advocated by many others who can be considered more accountable (see, for example, Brown et al., 2010; Frodeman et al., 2010). Personally, however, my inquiry emerged through contemporary industrial and media design education. As a result, my work focuses further to strengthen the bridge between contemporary design studies and practice, and the scientific understanding of interdisciplinary and transdisciplinary activities (see, for example, Boradkar, 2010; Turnbull Hocking, 2010). The existing models of processes and activities in both domains have shown peculiar similarities, and as such their views can be incorporated into a still simpler model for a transdisciplinary design process that nevertheless includes the necessary main ingredients.

For sustainability, however, a simple model for transdisciplinary design remains insufficient. From the perspective of the unsustainability crisis, the processes must nevertheless operate within the boundaries of ecological constraints. The meanings of sustainability, not only as a value proposition but as a boundary concept, must be negotiated within a larger process of collaborative mediation that takes place across areas of action and interest in the real world. Hence, transdisciplinarity for sustainability must also support community-building and expansion.

In academia, the faculty consists of various roles divided into students seeking graduation and disciplinary competence, apprentices (doctoral students, non-tenured researchers and lecturers), and masters (tenured people) interested in professional academic work. While all groups can be involved in interaction for learning, and the two latter groups are both well-involved in teaching, only the last group of people is closely connected to the management. In understanding the contemporary, post-modern academic setting, the focus needs increasingly to address these roles for people in various positions to better contribute to teaching, research, and networking outside the program, as well as the development of these activities themselves. In an academic setting, these three perspectives — student, educator, and management — can be perceived to invest different interests in their shared activity, and their expectations of the outcomes may differ. In learning sustainability, these aspects must be emphasized further.

In an educational context, besides the disciplines, students, and faculty from schools, degree programs, or fields of professional action, there are also areas of shared interest where communities for interprofessional practice can emerge and evolve. Similarly, the traditional communities of practice in design have to get together into a larger, networked community of interest for sustainability that supports transdisciplinary design inquiry and activities.

In the end, this dissertation could have been very different and far better. Perhaps it would have been wiser to collect a standardized questionnaire from students each year. But the questions that I now know that I would have had to ask were clear to me only in the final phases of the work. Despite its shortcomings, as an academic contribution I hope it will connect to a larger transition path through which the design academia — and the university as an institution — will be renewed to work as a laboratory for change and an advocate for transdisciplinary meaning-making across society as a whole.

The CS program today, and in the future

As a final word in reflection, focus can be turned to the present (2017) status of the CS program. Since the end of the 2015 Spring term, the program has operated for more than a year based on the interest of participating programs, funded by the programs themselves. The introductory studies are now implemented in such a way that each of the participating departments introduces some content. From CS Design, there are Creative Teamwork (2 ECTS) and Knowledge-Making for Sustainability (2 ECTS), and from CS Business, Sustainable Business and Consumption (6 ECTS). Finally, the School of Engineering (Department of Built Environment, also an SGT program now as a collaborator) offers State of the World and Development (2 ECTS) and Systems Thinking for a Sustainable Living Environment (5 ECTS). Founded in 2016, the Department of Built Environment combined the previous Department of Civil and Environmental Engineering and Department of Real Estate, Planning and Geoinformatics into a single CS partner.

Furthermore, both CS Design and CS Business students are now obliged to take the Sustainable Product and Service Design (SPSD) module (led by CS Design), which is now only a 5-ECTS theory course (although half of its content is hands-on team-based exercises), continuing to the Capstone in Creative Sustainability course (6 ECTS), where the focus is on tutored project work in teams, with real-world client assignments. Since 2014, in CS Design there has also been a mandatory course on eco-auditing (2 ECTS), with a focus on quantitative LCA-based (SLCA; see section 1.2.2) assessment of impacts of products and services.

The number of compulsory studies has at the same time increased. At the beginning of CS, students could just pick from a broad array of content (already in the structure there were 20 ECTS as optional); now, compulsory studies are increased and only 10 ECTS are optional. This has reduced the area of operation for excursions into new topics, but can at the same time help with confusion at the beginning of the CS studies and promote quicker graduation. Furthermore, student tutoring has also become more formalized since the first years.

Overall, much of the content is now better defined, and much also has better, more refined information online (mainly on the CS web page) with descriptions of past experiences. This helps to form a better understanding of CS as a whole for both students (past, present, future) and teachers (with more or less distance from the core of CS activities). Furthermore, annual teacher workshops are becoming a tradition and student activities have continued: there is even interest to restart ASC ry., the student association in making in CS student community between 2012 and 2014.

Furthermore, the first alumni questionnaire was issued in Fall 2016. The results show that CS students are located well in professional life, in various positions ranging from entrepreneurial and corporate positions (e.g., sustainability coordinators, consultants, design), to NGOs and several governmental positions (many have also returned to their home country), and to postgraduate studies. While the CS community has produced a really heterogenous group of professionals across disciplinary fields located all across the world, it is pleasing to see that, in general, the alumni perceived their studies to be applicable to their current work (average 3.61 on a 1–5 scale; median 4). Of the 31 respondents, all wanted to stay in touch, and 28 (>90%) wanted to participate in future alumni activities (meetings, gatherings).

In looking at the initiation and progress of the development of CS and comparing its current status with the initial ideas discussed in its making, the whole process can be described in many ways as a success. During the Aalto University merger, it was no coincidence that programs in innovation and in sustainability were funded. As explained, the initiation of CS coincides with national efforts in university renewal, with development relating to the revised innovation strategy (NIS). While CS can be perceived as a successful effort to take the ideas from these developments further, the context continues to evolve rapidly. In many ways, as the future of academia remains uncertain, so the ways in which sustainability as an agenda is integrated into the future activities, and CS itself, must continue to evolve.

To draw a picture of the development that took place in CS between 2010 and 2015, and to conclude the assessment in this research, I will quote one of the CS program initiators, who left the program in 2016:

> *As one of the original founders of the program, it's encouraging to have followed how quickly ecological and sustainable development principles and ethics have been absorbed into our daily lives and work activities within Aalto as well as the ongoing development of transdisciplinary working methods. Although the program and its offshoots have made remarkable progress since their inception, there remains much to be tackled still before the program really makes a consistent impact both nationally and internationally. I wish you all every success in the struggles ahead and thanks again for the opportunity to have been a part of this pioneering adventure.* (Personal communication, July 8, 2016)

Appendices

APPENDIX 1: Initiator interview form (1/2)

Tatu Marttila & Cindy Kohtala
(updated 14.5.2010)

Questionnaire on sustainability in design and management processes:

* *The comparison in this questionnaire is based on differentiation in three dimensions of sustainability and in three professional areas related to Creative Sustainability programme:*

1. From your professional point of view, which dimensions of sustainability should be emphasized over another, when pursuing more sustainable solutions for products, services and living environments in urban context?

Economic sustainability	☐☐☐☐☐☐☐☐☐	*Ecological sustainability*
Ecological sustainability	☐☐☐☐☐☐☐☐☐	*Sociocultural sustainability*
Sociocultural sustainability	☐☐☐☐☐☐☐☐☐	*Economic sustainability*

2. How do you perceive the importance of different dimensions of sustainability in industrial management, when pursuing more sustainable urban solutions?

Economic sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*
Ecological sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*
Sociocultural sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*

3. How do you perceive the importance of different dimensions of sustainability in the processes of design and architecture, when pursuing more sustainable urban solutions?

Economic sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*
Ecological sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*
Sociocultural sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*

4. How do you perceive the importance of different dimensions of sustainability in business management, when pursuing more sustainable urban solutions?

Economic sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*
Ecological sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*
Sociocultural sustainability:	*Some importance*	☐☐☐☐☐☐☐☐☐	*Most important*

5. How crucial role do different disciplines play in urban context sustainable design process, if compared to each other?

Business management	☐☐☐☐☐☐☐☐☐	*Industrial management*
Industrial management	☐☐☐☐☐☐☐☐☐	*Design & Architecture*
Design & Architecture	☐☐☐☐☐☐☐☐☐	*Business management*

APPENDIX 1: Initiator interview form (2/2)

Tatu Marttila & Cindy Kohtala
(updated 14.5.2010)

Questions on sustainability in design and management processes:

1. From your professional point of view, which dimensions of sustainability should be emphasized over another, when pursuing more sustainable solutions for products, services and living environments in urban context?
   - Explain emphasizes over another; why is it so, and what it means; examples?
   - How is the status quo now and how it should be changed?

2. How do you perceive the importance of different dimensions of sustainability in industrial management, when pursuing more sustainable urban solutions?
   - Explain weak and strong importances; why is it so, and what it means; examples?
   - How is the status quo now and how it should be changed?

3. How do you perceive the importance of different dimensions of sustainability in the processes of design and architecture, when pursuing more sustainable urban solutions?
   - Explain weak and strong importances; why is it so, and what it means; examples?
   - How is the status quo now and how it should be changed?

4. How do you perceive the importance of different dimensions of sustainability in business management, when pursuing more sustainable urban solutions?
   - Explain weak and strong importances; why is it so, and what it means; examples?
   - How is the status quo now and how it should be changed?

5. How crucial role do different disciplines play in urban context sustainable design process, if compared to each other?
   - Are some disciplines over-emphasized in the design process?
   - Should the importance of certain disciplines be strenghtened, and if so then how?

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6. How strong is the importance of collaboration between several disciplines in design process for an urban design solution?
   - Describe this collaboration in design process and the pros and cons caused by it.
   - Should the interaction between different professions be strengthened? If so, how could this be achieved?
   - Should working methods be brought together or kept different between different disciplines?
   - Should professional knowledge on sustainability be brought more together or kept different between different disciplines?

7. What are the most important frameworks and approaches (methodologies) for designing more sustainable solutions in your profession?
   - Are these frameworks and approaches sufficient to deal with the issues of sustainability?
   - How are these approaches understood and utilized by other professions collaborating in the design process?
   - Is it necessary to promote the use of similar approaches for sustainable design process also for other disciplines? If so, define what methods, tools or approaches should be shared.

8. How do you perceive the future of Creative Sustainability programme and how should the co-operation between its fields of disciplines be developed?
   - What are the most important design drivers in CS and are these shared between professions?
   - Should the cross-disciplinary content be developed towards deepening interdisciplinarity, and if so how?

APPENDIX 2: Teacher interview form

Thematic interview structure [date]:

I [Course name] course:
- History and background of the course
- The setting up of the courses (e.g. models used, expectations)
- Modes of working (e.g. workshop, project type)

II The flow and learning process within the course:
- Tools and methods used during the course and in the group work
- Learning processes and transactions (e.g. disciplinary variations, flow, meaningful moments)
- The flow of the courses (e.g. student dynamics, conflicts, elaborations)
- Outcomes of the courses (and success, short-comings)

III The Creative Sustainability context - inter-professionality and sustainability:
- The terms "inter-professionality" and "sustainability", and their definition
- Sustainability as a context for inter-professional design collaboration: Benefits and barriers

APPENDIX 3: Student interview form

Questions regarding CS activities:

Activities:
- Describe your involvement in CS development activities
- How did your involvement begin?
- Descriptions, targets, processes, outcomes?

Your motivations:
- Was there a common driver to be involved with these activities?
- Personal motivations to be involved in developing CS?

Being a student in CS:
- How do CS students perceive themselves? Would you consider them somehow different from other Aalto students?
- Who forms the CS community, and how does it represent itself to you?
- How do you perceive the student role in developing CS?
- What type of possibilities exist and how are they supported by the program?

APPENDIX 4: Excerpt from a conference paper

Marttila, T. (2011a). Creating a collaborative action: Benefits and barriers in inter-professional design process for sustainability. In N. F. M. Roozenburg, L. L. Chen, & P. J. Stappers (Eds.), *Proceedings of IASDR2011, the 4th World Conference on Design Research: Diversity and unity.* Paper presented at IASDR2011 conference, 31 Oct. – 4 Nov., Delft, the Netherlands.

(CS STUDENT QUESTIONNAIRE) DATA AND RESULTS

Data was gathered during Autumn 2010 and Spring 2011 from two study modules in the multidisciplinary CS programme, another organized by Department of Design, and the other by Department of Architecture. These modules had students with backgrounds in various design fields, such as industrial (7), product (2), spatial (2) and graphic design (2), and in engineering (2), architecture (6), real estate (2), business and management (2) and media communication (1). The total sample size is thus 28. Majority of the respondents were females (17 of 28) and many had foreign backgrounds (12).

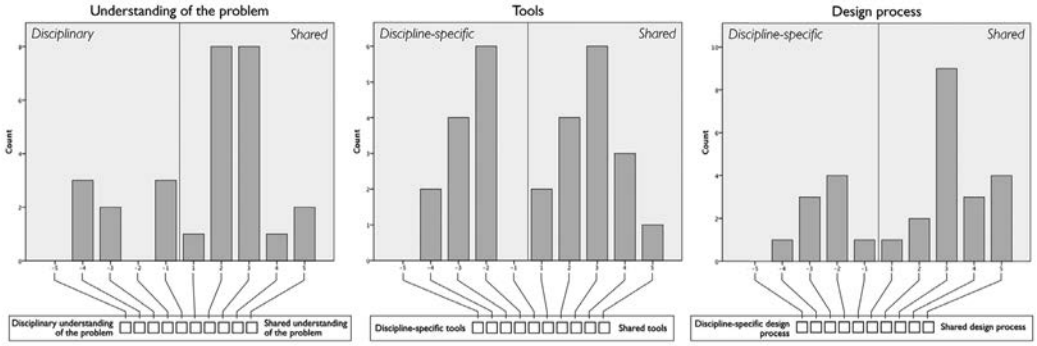

Figure 5. *Results to the second part of the interview (n=28).*

12 out of the 28 answerers preferred disciple-centered tools (see Fig. 6), and of them more than half preferred also discipline-centered process (see Fig. 7). Of the 16 answerers preferring shared tools, majority (14 out of 16) preferred shared process as well (see Fig. 7). Interestingly, however, the second group (unshaded) that is more oriented towards shared tools is also more clearly oriented towards shared process (see Fig. 7). This may suggest, that as one learns to participate into interdisciplinary design collaboration that shares understanding and goals, one also learns to better appreciate the shared tools and processes.

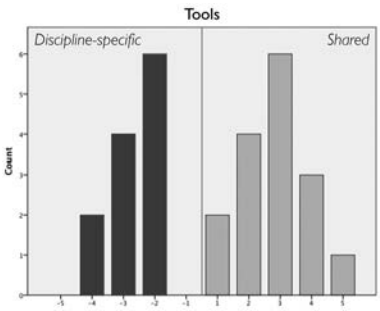

Figure 6. *Repondents appreciating discipline-specific tools (group 1: shaded) or shared tools (group 2: unshaded).*

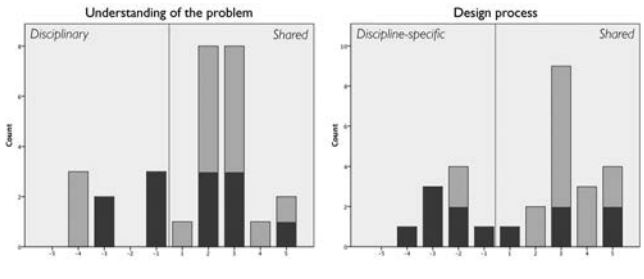

Figure 7. *Distribution of the replies that emphasized discipline-specific tools (group 1: shaded) over shared tools (group 2: unshaded).*

APPENDIX 5: Interview (sets I–III) codes, thematic labelling, and conflicts (1/2)

Interview set I codes and labels:

Initial codes
Novelty of the CS program
Heterogeneity of approaches to SD
Negotiation and sharing
Common grounds for collaboration
Ownership and access
Transparency in processes
(Disciplinary) identities
Real-world connections
Choices of instruments
Skill-set for sustainable design
Developing academic learning

Developed thematic labels
Controversial sustainability
Building capacity for sustainability dialogues
Staging of context, setting the stage
Expanding disciplinary perceptions for learning and practice
Critical, professional perceptions on sustainability

Elaborated conflicts
Conflicting dimensions of sustainability
Conflict between the academia and sustainability agenda
Sustainability as a goal of action versus a mindset in making

Interview set II codes and labels:

Initial codes
Negotiation and sharing
(Self-)reflection in learning
Common grounds for collaboration
Mind-set for sharing
Disciplinary identities and differences
Disciplinarity affectinh teaching
Learning approaches, styles
Real-world connections in learning
Team roles and dynamics
Choices of instruments, tools
Skill-set for interprofessional collaboration

Developed thematic labels
Tackling novelty and complexity
Expanding processes of learning
Sharing initiative
Institutional constraints and challenges
Developing one's own (teaching) profession

Elaborated conflicts
Conflict in managing interprofessional education
Conflict emerging from clashing disciplinary frameworks
Conflict in relation to learning outcomes
Conflict in developing contents and outreach

Interview set III codes and labels:

Initial codes
Motivation
Common grounds for collaboration
Mind-set for sharing
Sharing a place
Sharing initiative
Moments of learning
Being a CS student
Support from CS management
Real-world connections in learning
Challenging CS contents
Ideas for development
Future practice

Developed thematic labels
Learning to swim in complexity
Access to and support from CS
Projects as stepping stones
Becoming a community change agent
Building a community for interprofessional (design) practice

Elaborated conflicts
Conflict in perceiving CS offerings
Conflict in developing CS contents
Conflict in sharing and experiencing
Conflict in evaluating success in learning

APPENDIX 5: Interview (sets I–III) codes, thematic labelling, and conflicts (2/2)

Labels developed based on context of operation:

Thematic labels
Academic structures as a challenge
Institutional (and national) motivations
Assessing success in education

Integrated thematic categories and themes of improvement:

Connected thematic labels [interview set I–III]	**Integrated thematic category**	**Suggested improvement**
Building capacity for sustainability dialogues [I]	*Enabling dialogues for (creative) sustainability*	*Sustainability as a mindset rather than a constraining concept*
Staging of context, setting the stage [I]		
Controversial sustainability [I]		
Critical, professional perceptions on sustainability [I]		
Sharing initiative [II]		
Building a community for interprofessional (design) practice [III]		
Expanding disciplinary perceptions for learning and practice [I]	*Learning through practice*	*Stage-setting for shared problem-solving*
Expanding processes of learning [II]		
Learning to swim in complexity [III]		
Projects as stepping stones [III]		
Developing one's own (teaching) profession [II]		
Expanding disciplinary perceptions for learning and practice [I]	*New professionalism and expertise*	*Learning out from the paradigmatic perspectives and roles*
Tackling novelty and complexity [II]		
Projects as stepping stones [III]		
Developing one's own (teaching) profession [II]		
Staging of context, setting the stage [I]	*Building an interprofessional community for sustainability*	*Collaborative design mediation on new knowledge and action*
Expanding disciplinary perceptions for learning and practice [I]		
Sharing initiative [II]		
Becoming a community change agent [III]		
Building a community for interprofessional (design) practice [III]		
Staging of context, setting the stage [I]	*Renewing academia as a platform*	*Renewing the (design) academia*
Institutional constraints and challenges [II]		
Institutional (and national) motivations		
Academic structures as a challenge		
Assessing success in education		

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Tatu Marttila is a researcher and lecturer focusing on sustainable design, and an alumnus from the School of ARTS in Aalto University, Finland. His interest is in understanding how future design professionals can develop to become an effectual part in facilitating sustainable change, in projects and collaborations as platforms for transdisciplinary action.

Aalto-DD 154/2018

Sustainable development as an interprofessional context for design and planning challenges not only conventional roles and expertise, but also the understanding of sustainability itself. When introduced into the contemporary academic context, this interplay extends gradually also to everyday practices in learning, teaching and management. This calls for further reflection on how the roles and activities in formal education are set to support it. Moreover, if properly conceived, such novel interaction can act as a powerful mechanism to renew academic and professional practice.

This dissertation examines the initiation and implementation of Creative Sustainability: a new interprofessional Master's degree program in Aalto University, Finland. By focusing on the first five years of operation (2010–2015), this study identifies three phases in activities – priming, implementation and experiencing – that need to be connected together in a transparent and iterative circle. As analytic components, these phases can be of help in identifying and overcoming conflicts in the interaction and management of interprofessional study programs in design for sustainability.

ISBN 978-952-60-8135-9
ISBN 978-952-60-8136-6 (pdf)
ISSN 1799-4934
ISSN 1799-4942 (electronic)

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