CHALMERS

Sustainability Competences

A study based in Chalmers Challenge Lab

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Abstract

The sustainability challenges of today are complex and wicked, and can therefore not be easily comprehended and solved. In order to handle the complexity – e.g. stemming from lock-ins or conflicts of interests – 'sustainability competences' are needed, and subsequently such competences need to be fostered in the engineers of tomorrow. However, research on sustainability competences have yet to converge into an established field and consequently there is no clear consensus on what knowledge, skills and attitudes should be looked upon as crucial for sustainability. With the purpose of contributing to this convergence, aiming to capture the current view in research, this study reviews literature on sustainability competences and finds a synthesis between competences discussed in the fields of *education and sustainability*, *leadership and sustainability* and *transition management*. Moreover, the thesis draws inspiration from Chalmers Challenge Lab – a multi-stakeholder learning environment built around international engineering students undertaking their master's thesis through designing and implementing strategies to engage in sustainability transitions in a co-creating manner – which is studied through observations and interviews, in order to enrich the understanding of sustainability competences. In investigating Challenge Lab's contribution to this field, the study takes on the notion of learning through adaption, metaphorically viewing earlier research as an entity 'learning' from interaction with the phenomena Challenge Lab. Accordingly, the knowledge of sustainability competences found in earlier research is seen as held in a metaphorical 'cognitive structure', which is enriched with new understanding through accommodation and assimilation caused by the interaction with a new object of study, i.e. the Lab itself. The metaphorical structures are represented by frameworks of categories for sustainability competences, developed through a general inductive analysis procedure.

The study shows support in earlier research for at least nine categories of competences relevant for working with sustainability, namely *systems-thinking, anticipatory competence, normative competence, strategic competence, interpersonal competence* (Wiek et al., 2011)*, intrapersonal competence*, *being and owning, trans-rational thinking* and *leading with others.* These seem to be intricately interlinked. However, it remains to be determined which of the categories can be looked upon as 'key' competences for sustainability. Also, there are major similarities in the competence categories identified from earlier research, the competences that Challenge Lab aim to foster and the perceived competence development of the Challenge Lab students. Moreover, differences and similarities between earlier research and perspectives on sustainability competences at Challenge Lab point towards further clarification and justification of *anticipatory competences, intrapersonal competences* and specific attitudinal aspects (*being and owning*), as well as further investigation of less tangible ways of understanding systems and challenges (*trans-rational thinking*), and collective leadership competences guided by theories of emergence and complexity (*leading with others*) as potential areas of development for sustainability competence theory.

Keywords: sustainability competences, sustainability, education for sustainable development, leadership, transition management, Challenge Lab

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Oskar Hagvall Svensson

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1. Introduction

It would seem proper to start a thesis regarding sustainability competences by highlighting and stating the importance of achieving sustainable development of our society in a close future. But since this has been done repeatedly, the thesis will instead start from this:

> *"Higher education institutions bear a profound, moral responsibility to increase the awareness, knowledge, skills, and values needed to create a just and sustainable future"*

(Cortese, 2003, p. 17)

Cortese does not shy away from using big words: "a profound, moral responsibility".

The "awareness, knowledge, skills and values" that Cortese references are often denoted 'competences' (though most researchers seem to prefer 'attitudes' over 'values'). The specific competences "needed to create a just and sustainable future" will in this thesis be referred to as 'sustainability competences'. Researchers and practitioners have discussed at length what competences should be looked upon as crucial for achieving sustainability, and this thesis is a contribution to that discussion.

As was noted in the realization of this study, sustainability competences emerge from many fields of research. This is natural, since sustainability is a trans-disciplinary subject and could be looked upon as relevant for all of mankind's activity. The different fields have focused on different sets of skills, and sustainability competences in itself have yet to converge into an established field. However, it is agreed upon that sustainability challenges are complex and the problems are 'wicked', i.e. cannot be easily comprehended and solved. In response to this complexity, and the endeavor to achieve sustainability in public governance, the study of sustainability *transitions* have emerged, i.e. "transformation processes in which existing structures, institutions, culture and practices are broken down and new ones are established" Loorbach (2007, p. 17). Consequently, a contemporary way of approaching sustainability competences is through trying to determine what knowledge, skills and attitudes are needed when working with designing and implementing strategies for sustainability transitions.

Chalmers University of Technology has profiled itself as a green actor, trying to fulfill the responsibility of helping engineering students develop sustainability competences. Hence, educating for sustainable development has been a priority, and at least one course on environmental issues and sustainable development is integrated into every engineering programme[1]. A relatively new initiative in this area is the Chalmers *Challenge Lab,* which was launched in January 2014 (Holmberg, 2014), with the goal to guide sustainability transitions in the region. The lab is built around international students undertaking their master's thesis at a

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[1]See Chalmers webpage, *Education for a sustainable future*:
http://www.chalmers.se/en/education/Pages/Education-for-a-sustainable-future.aspx

"student-driven transition arena" (Holmberg 2014, p. 97). Together with stakeholders from the *triple helix* of academia, industry and public institutions, the students formulate research questions and implement strategies to engage in sustainability challenges in a co-creating manner. This makes Challenge Lab a combination of an educational as well as a strategic instrument for Chalmers' endeavor to contribute to sustainability transitions in the region. It could therefore be argued that the Lab brings together at least three relevant areas of research in which sustainability competences are discussed; *education and sustainability*, *leadership and sustainability* and *transition management*. Moreover, Challenge Lab in itself could be a potential source of relevant information on sustainability competences, since the students at the Lab are actively engaged in contributing to real-world transition processes in the region, and are consequently potentially developing competences needed for working with sustainability and transitions. In addition, the facilitation team at Challenge Lab is in close contact with these transition processes through involvement in the students' projects and could therefore hold some insights regarding what competences have helped students be successful in their endeavors.

Synthesizing the discussion of sustainability competences in the areas of education and sustainability, leadership and sustainability and transition management could potentially help guide curricula in higher education to focus on relevant competences. Therefore, trying to contribute to the convergence of sustainability competences, this thesis investigates the competences discussed in the three aforementioned fields of research, using Chalmers Challenge Lab as an inspiration – a case which lends some additional insight in understanding how the competences can be interpreted and developed. Apart from contributing to the discussion of sustainability competences, the study also provided an opportunity for Challenge Lab personnel and students to reflect upon what competences they find relevant for working with sustainability, and how to understand such competences.

1.1. Aim

The thesis aims to shed light on the following questions:

RQ1: What is the current view in research on sustainability competences in the areas of *education and sustainability*, *leadership and sustainability* and *transition management*?

RQ2: What areas of development in sustainability competence theory can be identified through studying Challenge Lab using earlier research on sustainability competences as a theoretical lens?

1.2. Delimitation

This study is centered on sustainability competences, what such competences are discussed in the aforementioned areas of research, and how the competences can be understood. Accordingly, other sources for information on what competences might be relevant for

sustainability will not be directly studied, for example societal or industrial actors' perspectives on the need for sustainability competences.

Moreover, Challenge Lab is used as an example, a 'case', potentially contributing to the understanding of sustainability competences. Accordingly, the study will not directly evaluate the relevance of Challenge Lab, nor the educational design, the learning environment or the tools taught and used at the Lab. Therefore, aspects of Challenge Lab which could enrich the field of sustainability competences will be studied, but aspects of the field of sustainability competences which could enrich or improve Challenge Lab will not.

1.3. Method in summary

Two main methods are used in this thesis. The first is literature review, aiming towards investigation of RQ1. Accordingly, the literature review is made to find sustainability competences in the areas of education and sustainability, leadership and sustainability and transition management. Selection of literature is made mainly on number of citations, choosing articles with higher number of citations when possible. The competences found in the literature review is compiled into tables and synthesized through clustering and categorization of similar competences, resulting in nine competence categories relevant for working with sustainability.

To enable investigation of RQ2, i.e. Challenge Lab's contribution to the furthering of understanding of sustainability competences, two sub-questions are developed, namely:

RQ2.1: What competences does Challenge Lab aim to foster in their students?

RQ2.2: What are some common examples of competences that the students at Challenge Lab perceive to have developed?

These research questions are investigated through a case study, the second main method of this thesis, where the 'case' in this context is Challenge Lab itself. A pre-study is conducted using observations in order to procure a valid understanding of the context, and provide access to the learning environment. RQ2.1 (the ambition of Challenge Lab) is investigated through a group interview with Challenge Lab personnel and RQ2.2 (examples of the students' perceived development) through interviews with Challenge Lab students.

In an attempt to capture Challenge Lab's contribution to the furthering of the understanding of sustainability competences (RQ2), the study takes on the notion of learning through 'adaption', metaphorically viewing earlier research as an entity 'learning' from interaction with the phenomena Challenge Lab, through the process of accommodation and assimilation. Accordingly, aspects of sustainability competences at Challenge Lab that are consistent or inconsistent with earlier research are identified and discussed.

1.4. Thesis outline

After this introduction, some additional background is given in Section 2 (Pre-study), in order to put sustainability competences and Challenge Lab into context. Then, the methods used for investigation of RQ1 and RQ2 are described in further detail in Section 3 (Method). The results procured in the study are presented in Section 4 (Results), followed by discussion and conclusion of thesis in Section 5 and Section 6 respectively.

2. Pre-study

To put the sustainability competences that will be studied and discussed into context, some initial notes on sustainability, the concept of competence, education that strives to develop sustainability competences and Chalmers Challenge Lab are needed. Accordingly, this section offers some additional background, rendered mainly through literature review.

2.1. On sustainability, transitions and competences

'Sustainability', i.e. a systems capacity to endure, has ever since the Brundtland Report (Brundtland, 1987) been almost synonym with 'sustainable development', i.e. "development that meets the needs and aspirations of the present without compromising the ability of future generations to meet their own needs" (ibid., p. 16). There are many perspectives on how to interpret the term and although being contested, the most common divides it in three dimensions: ecological sustainability, social sustainability and economic sustainability (Giddings et al., 2002). Accordingly, 'sustainability challenges' could be interpreted as any process or phenomenon that hinders the achievement of sustainable ecologic, social or economic development.

There are many characteristics of sustainability challenges that make them complex. They are often depicted as 'wicked', i.e. they have no optimal solutions, and no clear and undisputed problem definitions (Rittel and Webber, 1973). Their complex dynamic lie for example in their *scale* – often caused by and influencing numerous actors and large socio-technical systems – their *time* – embedded in long set practices and affecting social and ecological systems for a long time to come – and in their *value ladenness* – influenced by conflicting interests, culture, moral and ethics. Such preconditions causes sustainability issues to suffer from various 'lock-ins', for example the 'carbon lock-in', hindering the establishment of alternative renewable energy and transport technology.

In order to tackle such difficulties, in the context of sustainability and public policy, a particular field of research, *transition management,* have emerged during the early 21st century (see for example Rotmans et al., 2001). As stated in the introduction to this thesis, *transitions* are, according to Loorbach (2007, p. 17), "transformation processes in which existing structures, institutions, culture and practices are broken down and new ones are established". Loorbach argues that transitions (and thus transition management), are needed in order to break the lock-in of society's unsustainable ways. Transition management, then, is a needed tool that can help for example policy makers transcend current thinking, which created many of the problems that society faces. On the same note, Wals and Schwarzin (2012) argue that the needed systemic change demands more than optimizing our current practices and that sustainable development rather requires fundamental redesign of those practices and the values that society pursue.

Many researchers have highlighted that the transition to a more sustainable society necessitates the development of certain key competences (e.g. Wiek et al. (2011), Wals and Schwarzin (2012)). Moreover, Mochizuki et al. (2010, p. 391), state that in an educational context there is

"a growing interest in competence-based approaches from institutions of higher education and their stakeholders in different parts of the world". As sustainability issues, and the transitions they necessitate, are complex matters, these needed 'key' competences are not evident. Coupled with the trans-disciplinarity of sustainability, this has caused sustainability competences to be researched from many different points of view, starting from diverging field. Accordingly, the field of sustainability competences in itself is not well-established, and there are not many comprehensive reviews on the subject.

In addition, the term 'competence' is somewhat ambiguous, and when researching the term there is an abundant amount of definitions to be found. For example, White (1959, p. 297), in the context of psychological research, refers to competence as "an organism's capacity to interact effectively with its environment". Boyatzis defined it as "underlying characteristics of a person that leads to or causes superior or effective performance" in the context of organizational research (Yeung, 1996, p. 119). In the context of education for sustainable development, Wiek et al. (2011, p. 204) state that competence can be understood as a "functionally linked complex of knowledge, skills and attitudes that enables successful task performance". Further, Segalàs et al. (2009, p. 18) state that, in an educational context, having a competence means that a person "must be able to put into play a certain capacity or skill and perform a task, where he or she is able to demonstrate the ability to do so in a way that allows evaluation of the level of achievement". These definitions reflect two aspects of competences which sometimes diverge between different uses found in literature. Regarding the *specificity* of the definition, competence can be referred to in general terms of capacity or capability or more explicitly as complexes of knowledge, skills and attitudes. Regarding *manifestation* of competences, the term is sometimes used only under the condition that the construct studied can manifest itself in observable and potentially assessable behaviors. In this thesis, the definition presented by Wiek et al. (2011) will be used since it could be looked upon as forming some middle-ground.

Regardless of the enduring ambiguity of contemporary sustainability competences, educators have long tried to foster relevant competences aimed at sustainability in their students. In order to set the stage for the competences that will be studied and discussed in this thesis, and the educational initiative that inspired this study, common ways to organize and think about such education and the competences they entail are presented below.

2.2. On education and sustainability

In this section, some general perspective on education and sustainability will be discussed. First, there is a need for some terminology. At least three terms are seen used somewhat interchangeably when researching the field of intersection between sustainability and education: *sustainability education*, *education for sustainable development* (ESD) and *education for sustainability* (EfS). Education for sustainable development (ESD) seems to be the most prevalent (e.g. yielding more results when using Google Scholar). However, Sterling and Thomas (2006, p. 370) state that while "ESD is the term favoured by governments and the UN, […] [others] prefer EfS seeing ESD as too tied to economic development, too instrumentally oriented, and missing cultural, personal and valuative dimensions". The

distinction made in this thesis will be the following: *sustainability education* will be used as a broad term, denoting any educational initiative, course or programme aiming at the acquisition of competences in the field of sustainability, while *education for sustainable development* will be looked upon as the prevailing perspective (or theoretical lens) on how to think about or operationalize such educational initiatives in a manner which contributes to the furthering of sustainable development. *Education for sustainability* will not be used, since the term seems to be the least prevalent in earlier research.

2.2.1. Perspectives on sustainability education

Sterling and Thomas (2006) state that the debate around *education for sustainable development* stems from a reexamination of what education is and what it should aim to accomplish, in the modern world of growing uncertainty and unsustainability. Acknowledging education as a tool to meet sustainability challenges and trying to stimulate action towards broader implementation of sustainability education, the UN declared 2005-2014 to be the Decade of Education for Sustainable Development (DESD) (Sterling and Thomas, 2006). As a starting point for the monitoring and evaluation of the results of the initiatives, Tilbury (2011) reviewed educational initiatives in order to find learning processes that are aligned with the aims of ESD. Tilbury (2011, p. 20) states that in contrast with the classical notion of education "ESD occurs in a wide variety of social contexts". Four common key learning processes in ESD frameworks are identified:

- ❖ "processes of collaboration and dialogue (including multi-stakeholder and intercultural dialogue);
- ❖ processes which engage the 'whole system';
- ❖ processes which stimulate innovation within curricula as well as through teaching and learning experiences; and,
- ❖ processes of active and participatory learning" (Tilbury, 2011, p. 39).

Moreover, six common areas of learning in ESD are identified (learning to):

- ❖ "ask critical questions;
- ❖ clarify values;
- ❖ envision more positive futures;
- ❖ think systemically;
- ❖ respond through applied learning;
- ❖ explore the dialectic between tradition and innovation" (Tilbury, 2011, p. 29).

In addition to the processes identified by Tilbury, Barth et al. (2007, p. 419) state that in sustainability education in general, the development of key competencies requires that the learning processes are *competence-oriented* ("focus […] on attaining relevant key competencies")*,* have *societal orientation* ("takes place in real-life situations")*,* and *individual centering* ("change from teacher to learner-centring" also considering informal learning processes). Further, Barth et al. (2007) state that the learner should get the opportunity to

explore and reflect upon his or her own value system (in order to acquire non-cognitive dimensions of competences), learning processes should be oriented towards interdisciplinarity and self-direction of the learner.

2.2.2. Perspectives on learning outcomes

Moving towards the formulation of specific competences for sustainability, Sterling and Thomas (2006, p. 367) state that a key mechanisms for the design of sustainability education is "the identification of learning outcomes or the capabilities that we expect students to attain during and upon completing the educational experiences". Two examples of approaches that have been frequently used to move from the idea of sustainability education to its implementation in desired competency development is presented below.

One approach to formulating intended outcomes of education is to aim towards creating *change agents for sustainability*. In a business context, Caldwell (2003, p. 139) classifies a change agent as an "internal or external individual [...] responsible for initiating, sponsoring, directing, managing or implementing a specific change initiative". In discussion of how to educate change agents, Hesselbarth and Schaltegger (2014, p. 26) use the term more generally as "driving forces in change processes". They go on to review literature on competences that should be fostered through sustainability education. In general the key competences are described as "skills, motivations and affective dispositions" that are "multifunctional and context-independent" (Hesselbarth and Schaltegger, 2014, p. 27). Such change agent-competences, from a review by Svanström et al. (2008), are presented in Section 4.1.1.1. However, Hesselbarth and Schaltegger (2014) point out that there is not much previous research to build on regarding change agency for sustainability in management education.

Another approach of sustainability education is the development of *action competences*. According to Jensen and Schnack (1997) the action competences approach was initiated in an attempt to move away from classical academic schooling and behavior modification that sustainability education could be too focused on. Further, Mogensen and Schnack (2010) state that action competence refers to an educational ideal and not "a specific competence among many others", and that it is an approach for environmental and health education that:

- ❖ "works with democratic and participatory ideas";
- ❖ "regards environmental problems as societal issues that involve conflicting interests"; and,
- ❖ "works with a positive and broad conception of health, including not only life-styles, but also living conditions".

Jensen and Schnack (1997) state that *action* must incorporate finding possible solutions to such a problem and focus on change, in contrast to *activity*, which could be any non-passive studying of certain environmental problems such as excursions or discussion. Specific competences that could be developed when partaking in education with an action competence approach are presented in Section 4.1.1.1.

Before moving on to the particular educational initiative inspiring this study, a comment about normativity in education needs to be made, as competences in this thesis is looked upon as including attitudinal dimensions. Shephard (2008, p. 95) discusses affective learning outcomes in higher education, and argues that "a central element of education for sustainability is a quest for affective learning outcomes of values, attitudes and behaviours". A comparison is made with other domains of education where affective learning outcomes are considered, e.g. health sciences. In contrast, Jickling (1992) criticizes education for sustainable development on the grounds of it having inappropriate normative dimensions. The argument made by Jickling (1992, p. 8) is that the purpose of any education is "enabling people to think for themselves", and this is said to be inconsistent with the endeavor to create sustainable development through education. In general, according to Shepard (2008), educators have avoided affective goals. However, in the field of sustainability education, many such intended learning outcomes can be found, as discussed coupled with the competences for sustainability presented in Section 4.1.1.1.

2.3 On Challenge Lab

As was stated in the introduction to this thesis, Chalmers *Challenge Lab* was initiated with the goal to guide sustainable transitions in the region. The lab is built around international and Swedish students undertaking their master's thesis in a "student-driven transition arena" (Holmberg 2014, p. 97). As such, Challenge Lab is an educational initiative, where students design and implement strategies to engage in sustainability transitions together with stakeholders from the *triple helix*, i.e. academia, industry and public sector. The aim of Challenge Lab is to become a hub for triple helix actors, where trust can be built around the students on the basis that they can be perceived as both challenging (since they are knowledgeable) and unthreatening (since they are relatable and does not form competition) . In that sense, the students act as *change agents* for sustainability. In addition, providing an arena to engage in transition processes also gives the students "the opportunity to develop unique skills in working across disciplines and from a challenge-driven perspective" (Holmberg, 2014, p. 97).

The students undertaking their master's thesis at Challenge Lab initially go through a four week start-up phase during which sustainability projects are defined and teams are formed. In this phase, the students work with understanding sustainability and their own development, conduct dialogues with external stakeholders in order to connect to, study and understand sustainability challenges and transition processes in the region, search for critical leverage points, identify research questions and finally form thesis projects (Holmberg, 2014). The remaining sixteen weeks of the thesis work is spent on conducting the projects in collaboration with external stakeholders. The students are to some extent guided through the process, in particular during the start-up phase, by a facilitation team. This team sets up some conditions for engaging in real-life processes, and are at times available at the Lab to help with *how* to approach the master thesis work, however not guiding *what* questions to investigate.

The structure of the thesis work is designed as a 'Backcasting' process, a method for strategic planning which aims at managing complex problems and breaking out of past trends (Holmberg and Robert, 2000). A graphical representation can be seen in Figure 1. This schematic is reflected in the design of the four week start-up phase. Backcasting is used to design strategies and initiatives for sustainability. In order not to be too affected by the current situation while visioning, the first step is to define criteria for a sustainable future society or situation (1). Next, the present situation is analyzed in relation to the defined sustainability framework (2). The third step is to envision future solutions (3) and finally strategies to reach the envisioned scenarios are designed (4).
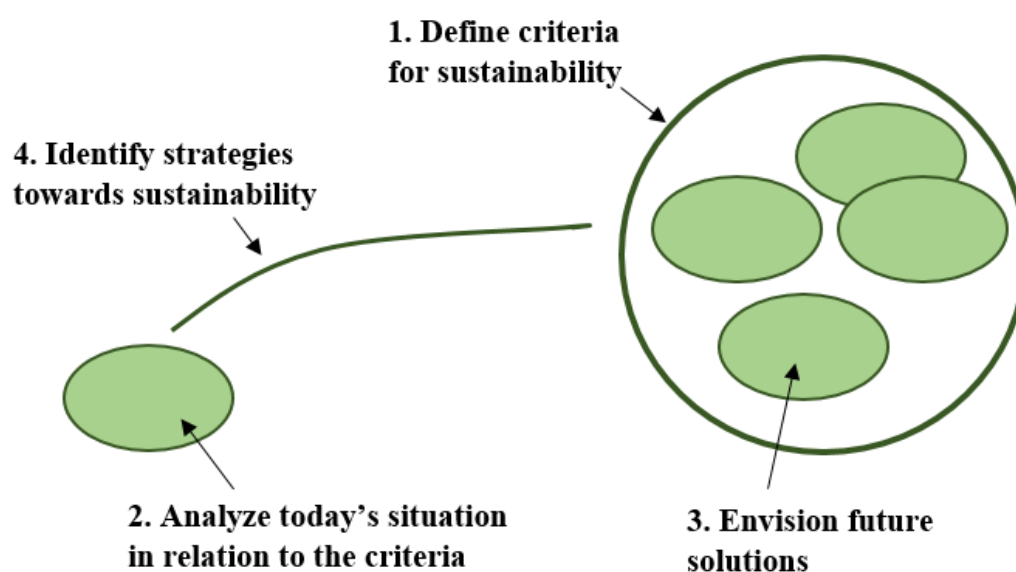
Figure 1: Graphical representation of a Backcasting process, adapted from Holmberg (1998).

An important characteristic of the four start-up weeks is the recurrent dialogues with triple helix stakeholders. The students arrange and facilitate these dialogues, and invite relevant stakeholders, partly using the network of the facilitation team. The dialogues serves a dual purpose. First, they can provide the students with relevant information about today's situation in order to enable the carrying out of the second and third step of the Backcasting process. Second, the students are provided with opportunities to connect to some of the people involved in transition processes in the region.

Another distinguishing aspect of Challenge Lab is the physical space provided to the students. The Lab is situated in a science park located at Chalmers University of Technology, and there the students have access to a large open space, with different workspaces and rooms. This is also the center for the four week start-up phase, where the dialogues are held and consequently where the students spend the majority of their time. Accordingly, this space "allows a deeper collaboration between the students and opens up for discussion between disciplines and projects" (Malmqvist et al., 2015).

Two mental models are frequently used in the discourse at Challenge Lab: *transformative/integrative* and *inside-out/outside-in*. The transformative dimension means the

need to find solutions or strategies that challenge the existing societal structures. Since sustainability issues are complex, it is argued at the Lab that to be able to achieve this, one needs to work in an integrative way, with more than one aspect at a time, together with others. Outside-in and inside-out are two ways of entering the systems that are studied at Challenge Lab, where outside-in is meant to capture "knowledge, methods and tools to understand and deal with the requirements global sustainability will put on the system", while inside-out captures "knowledge, methods and tools to understand and cope with the students' own values, strengths and visions as well as to understand and manage the interaction with and between the different stakeholders within the system" (Holmberg, 2014, p. 98). At the Lab, it is argued that both is needed in order to bring about transformative and integrative change.

Connected to the ambition to bring about transformative and integrative change, guiding transition processes in the region, the students at Challenge Lab are encouraged to not only to design sustainability solutions but also to connect them to existing transition processes during their thesis work. In addition, apart from the standard intended learning outcomes (ILO's) subscribed to all master's theses, Challenge Lab aims to foster additional skills in their students, such as the ability to "apply a systems perspective on sustainability challenges" and "apply relevant frameworks and methods for sustainable development, from a challenge driven approach" (Malmqvist et al., 2015). The extended ambitions of Challenge Lab resulted in a non-compulsory preparatory course (*Leadership for Sustainable Transitions*) being established the second year the Lab was running, introducing the theoretical and methodological frameworks used in the master's thesis work.

Seeing as Challenge Lab is a novel way of organizing education at Chalmers, a study of learning at the Lab, based on self-assessment, has already been made (Kohn Rådberg et al., 2015). Kohn Rådberg et al. investigated to what extent the students perceived they met the intended learning outcomes subscribed to all master's thesis courses (such as *ability to contribute to research*), and to what extent the students self-assessed learning and the results of their master's thesis relate to the specific ambitions of Challenge Lab. The study showed that the students perceived they had developed all skills subscribed to Chalmers master's thesis at least to some extent, and specifically the ILO's reflecting the specific ambitions of Challenge Lab were developed significantly.

Summarizing these remarks on Challenge Lab, it can be noted that "[t]he power of C-Lab lies in its potential to bring people together for co-creation in processes where existing mental models and beliefs of how systems work and should work are challenges" (Holmberg, 2014, p.98) and that C-Lab consequently aims to act as a "'bonding agent' for the various stakeholders and a natural vehicle for transformative learning, leadership and change" (ibid., p.91). However, it should also be noted that it is not Challenge Lab in itself that is the object of study in this thesis, but rather the competences that students might develop as a result of partaking in the learning experience. As such, Challenge Lab lends a context and forms a case in the study, potentially providing examples that can shed some additional light on the actual object of study: sustainability competences.

3. Method

As was stated in the introduction, the aim of this study is to investigate sustainability competences found in research on *education and sustainability*, *leadership and sustainability* and *transition management* (RQ1). Moreover, Chalmers Challenge Lab will be studied as a case which could potentially be used to identify areas of development in earlier research on sustainability competences in the three fields (RQ2). Starting from this secondary aim, the study will conceptually take on the notion of *learning*, i.e. trying to find what earlier research, imagined as an entity, could 'learn' from the case of Challenge Lab.

The framework for this metaphorical learning will be constructivistic. Learning, as it is seen in constructivism, is the process of an individual building internal cognitive structures holding knowledge procured by experiencing interaction with the world (Phillips and Soltis, p. 70-71). This study takes on a constructivistic approach to learning for two main reasons. Firstly, this enables the notion of building 'knowledge structures' that can be used to present and to hold the information procured in the study. Secondly, the field of sustainability competences is relatively young, and this opens up for symbolic parable with the learning of children, a phenomenon around which much research has been done with a constructivistic approach.

Constructivism, as discussed by Piaget, stems from the concept of evolution, and the manner in which living beings adopt to their environment by using and changing their biological structures (Phillips and Soltis, p. 69). In the building of cognitive structures, Piaget hypothesized that this adoption could be broken down into two processes, *assimilation* and *accommodation* (Phillips and Soltis, p. 73). When interacting with an object of study, an experience can be assimilated into the existing cognitive structure if it is consistent with earlier knowledge of this object. However, if the experience is inconsistent with previous knowledge, the cognitive structure is put out of its state of equilibrium. In order to shift back in to equilibrium, the cognitive structure must be accommodated, in order to harbor the new experience.

In the context of this study, cognitive structures will correspond to frameworks used to hold and present information on the sustainability competences studied, constructed through simple approaches such as clustering and categorization. Generally, earlier research will be seen as an entity (or learner) interacting with Challenge Lab, a new experience in its environment. Accordingly, the relation between earlier research and the case of Challenge Lab will be studied through identification of aspects of Challenge Lab (the new experience) that are consistent with and aspects that are inconsistent with the cognitive structure representing the knowledge held in earlier research. In other words, aspects of Challenge Lab that can be assimilated and aspects that causes a need for accommodation will be identified. A graphical representation of the conceptual methodology is shown in Figure 2.

The process of this study of sustainability competences and adaption, trying to capture Challenge Lab's contribution to earlier research, will be divided into three steps, each step entailing different research methodologies.
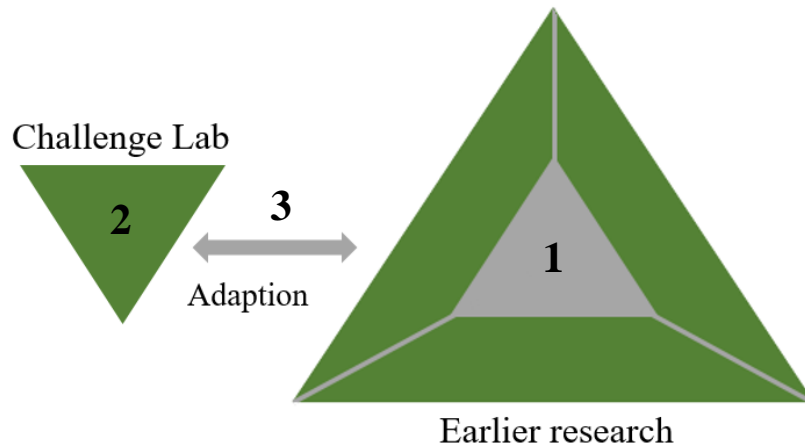
Figure 2: A conceptual representation of the method used in order to combine earlier research on sustainability competences with the knowledge potentially accessible in Challenge Lab. The steps 1-3 are described further below.

❖ Firstly, earlier research on sustainability competences is investigated through literature review. Using the gathered information on sustainability competences, a basic framework is constructed, using clustering and categorization of competences. This first step corresponds to the first research question of this thesis (i.e. "*What is the current view in research on sustainability competences in the areas of education and sustainability, leadership and sustainability and transition management?*"). Accordingly, the framework developed, i.e. the set of competence categories, corresponds to a metaphorical cognitive structure holding the previous knowledge on sustainability competences. This part of the study will henceforth be referred to as *Step 1*.

❖ Secondly, Challenge Lab is studied as a case. To this end, two sub-questions are developed, namely "*What competences does Challenge Lab aim to foster in their students?*" (RQ2.1) and "*What are some common examples of competences that the students at Challenge Lab perceive to have developed?*" (RQ2.2). These questions are investigated using mainly interviews, combined with observations and a survey undertaken with the Challenge Lab students. Accordingly, this step enables the investigation of RQ2 ("*What areas of development in sustainability competence theory can be identified through studying Challenge Lab using earlier research on sustainability competences as a theoretical lens?*"), through procuring accessible information about the object of study, i.e. Challenge Lab. This part of the study will henceforth be referred to as *Step 2*.

❖ Lastly, Challenge Lab's contribution to the furthering of the understanding of sustainability competences (RQ2) is investigated by studying the potential for adaption of the information procured in the two first steps, i.e. the injection of the Challenge Lab-case into the framework holding knowledge from earlier research on sustainability competences. This is done by identifying aspects of Challenge Lab that are consistent with and aspects that are inconsistent with earlier research on sustainability competences, i.e. potential for assimilation and accommodation is studied. This part of the study will henceforth be referred to as *Step 3*.

3.1. Analysis procedure

Before describing the data gathering methods used in the three steps above, a general note needs to be made regarding analysis methodology. The main tool for analysis used in this study is a basic version of 'general inductive analysis', as described by Thomas (2006). According to Thomas (2006, p. 237), the approach "provides an easily used and systemic set of procedures for analyzing qualitative data". Although stated to be "not as strong as some other analytical strategies for theory or model development" (Thomas, 2006, p. 237), this method was chosen on the merit of its simplicity, starting from the large amount of data to be processed in this study, stemming from mainly literature review and interviews. In addition, the method seems relatively widely used, seeing as the article in which it is presented is well-cited.

Generally, the purpose of an inductive analysis is to "allow research findings to emerge from the frequent, dominant, or significant themes inherent in raw data" (Thomas, 2006, p. 238). In this study, the aim of the analysis is to make these dominant themes accessible, to enable comparison between earlier research and Challenge Lab, but also in order to present the information gathered in a comprehensible way to the reader of this thesis. The principles of the general inductive analysis presented by Thomas (2006, p. 239) state that "[d]ata analysis is guided by the evaluation objective, which identify domains and topics to be identified", in this case sustainability competences. Further, the "primary mode for analysis is the development of categories from the raw data into a model or framework" (Thomas, 2006, p. 240). In this case, the set of 'categories' identified in the raw data, makes up metaphorical cognitive structures or frameworks used to hold and present the information extracted.

The analysis procedure used consists of three steps, aiming towards the development of basic frameworks holding the information found in raw data (i.e. articles from literature review and transcripts of interviews):

- ❖ Firstly, the raw data is read, marking references to the object of study, i.e. sustainability competences. The references to competences is compiled in tables in Microsoft Excel. This process will henceforth be referred to as *extraction* of competences.
- ❖ Secondly, the references to competences are *clustered*, linking similar occurrences together. In this study, most clusters were constructed starting from competences aimed at the same object or task.
- ❖ Lastly, starting from these clusters, categories with labels are developed using references to or quotes from the raw material to form a description of the cluster(s) which the category in question aims to capture. This process will henceforth be referred to as *categorization* of competences.

In this study, these established categories were used as frameworks holding the information procured in the data gathering process.

Before returning to *Step 1-3* (describing the overarching method for the study), a note needs to be made regarding preconceptions of the researcher. Since the role of the researcher or evaluator is to interpret the data, and prioritize what could be seen as important and unimportant, any general inductive analysis procedure is subjected to the preconceptions of the researcher

(Thomas, 2006). In this case, perceptions of what might be considered a competence impacts the extraction. Further, perceptions of what competences might be linked impacts the clustering. Moreover, perceptions of what is central to the clusters impacts the choice of categories, and the manner in which they are labeled and described. These perceptions are based on how the researcher have conceptualized competences. Relating to this, in the context of learning, the 'post-Piaget' constructivistic thinker von Glaserfeld argues that we cannot assume that two individuals' cognitive structures representing a concept (such as sustainability competences) are similar in any way, since they might have been constructed diametrically different (Phillips and Soltis, p. 81). The implication for this study is that bringing in many ways to conceptualize sustainability competences seems favorable. For example, interviews were consequently seen as a favored methodology in studying Challenge Lab as a case, since this brings a larger number of ways to conceptualize sustainability competences in to the data. Although not erasing the impact of the preconceptions of the researcher, this gives more opportunities to reflect upon the conceptualization during analysis than would have been possible using only observation or tests of some sort.

Returning to the overarching method used in this study including both the data gathering and analysis, as conceptualized in Figure 2, *Step 1-Step 3* will be described in further detail in the sections below.

3.2. Step 1: Investigating earlier research

The method used for investigating earlier research on sustainability competences is literature review, mainly using articles published in scientific journals, since many such articles are easily accessible online. A description of the manner in which this literature review was undertaken can be found in Section 3.2.1. Using the gathered literature, a framework for sustainability competences is constructed using extraction, clustering and categorization, as described in Section 3.2.2. This step aims towards the investigation of RQ1, i.e. "*What is the current view in research on sustainability competences in the areas of education and sustainability, leadership and sustainability and transition management?*".

Figure 3: Graphical representation of the literature study undertaken, where the construct holding sustainability competences is shaded in grey.

3.2.1. Gathering of literature

The articles used were gathered using a combination of two scientific search engines: Google Scholar (which gave easily accessible information about number of citations) and Chalmers Summon (which gave access to some specific literature that Google Scholar did not). Search words used include:

- ❖ for sustainability and education, e.g. "education for sustainable development", "sustainability competences", "sustainability education"
- ❖ for leadership and sustainability, e.g. "sustainability leadership", "leadership for sustainability", "sustainability and management"
- ❖ for transition management, e.g. "transition management", "sustainability transition"

When studying these three mostly separated areas of research, a massive amount of articles on sustainability with relevant competences could be identified. A selection was therefore necessary. This was mainly done by choosing sources that explicitly aims at identifying competences for sustainability, rather than more generally suggesting certain behaviors that could lead to sustainability. In addition, sources with a larger number of citations were chosen,

particularly in the area of leadership. In searching for literature on competences in transition management, the demands had to be lowered, since there are few articles explicitly considering competences in this area. Seeing as competences for sustainability has not converged in an established field, what was considered "well-cited" articles in this context ranged from having 30 to 1500 citations. In addition, since there was not many well-cited, qualitatively different meta-studies to be found, both articles starting from larger literature review and more applied articles stemming from a given example of a course in sustainability were included. Accordingly, some articles presented more or less structured lists of competences or discussed competences in more general terms, while others presented frameworks developed to be more full representations of needed competences.

In Section 4.1.1., the gathered literature on sustainability competences is presented.

3.2.2. Synthesis of gathered competences

Out of the articles presenting frameworks for sustainability competences identified, one was chosen to use as a benchmark, proposed by Wiek et al. (2011). In short, Wiek et al. (2011) develop a framework for sustainability competences using literature review, and identify five "key competences for sustainability". A more detailed description of the framework can be found in Section 4.1.1.1. Wiek et al. (2011) were deemed to be the most relevant framework, including competences from all three areas studied (education, leadership, transition management). In addition, Wiek et al. (2011) seemed to be one of the most contemporary and most well-used[2].

The gathered articles were analyzed using the general process of extraction, clustering and categorization described in Section 3.1. For example, the identified competences *capability to deal with change* and *capability to embrace change* were grouped together in a cluster called *dealing emotionally with change*. This cluster shared traits with another identified group, *self-reflection*, since they are both directed towards oneself. Therefore, these clusters together with other similar ones were categorized as *intrapersonal competences*, i.e. competences that are directed towards oneself.

The key competences identified by Wiek et al. (2011) were used as pre-existing categories. Accordingly, categories were only developed for competences not included in Wiek et al., i.e. the categories constructed in this study could be said to complement the framework developed by Wiek et al. (2011).

The result of the synthesis of the gathered literature, i.e. the constructed categories, is presented in Section 4.1.2. These categories aim to shed light on RQ1, i.e. "*What is the current view in research on sustainability competences in the areas of education and sustainability, leadership and sustainability and transition management?*".

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[2]For example by SWEDESD, a center for learning for sustainable development, see http://swedesd.uu.se/

3.3. Step 2: Investigating Challenge Lab

The aim of the study of Challenge Lab is to investigate its contribution to the furthering of the understanding of sustainability competences (RQ2), through identifying areas in need of theory development. Since competences are abstract in general, difficult to measure and in this context difficult to test, interacting with people at the Lab and inquiring into perspectives on sustainability competences was deemed to be a preferable method for investigation. In addition, since any larger group interacting during a longer period of time can be seen as a complex phenomenon, using multiple methods of data collection seemed favorable. Consequently, the study of sustainability competences at Challenge Lab was divided in to two sub-questions, aimed at the two main groups of people involved – the

Figure 4: The second part of the study investigates sustainability competences at Challenge Lab, through observations and interviews

personnel and the students. Subsequently, the following sub-questions were developed, aiming to capture information on sustainability competences at the Lab:

RQ2.1: What competences does Challenge Lab aim to foster in their students?

RQ2.2: What are some common examples of competences that the students at Challenge Lab perceive to have developed?

Accordingly, the aim of the investigation of these two questions is to enable the identification of aspects of sustainability competences at Challenge Lab that is consistent with or inconsistent with that of earlier research. Again, this is done in order to try to capture Challenge Lab's contribution to earlier research, by studying what can be assimilated and what calls for accommodation, thereby potentially identifying areas in the theory of sustainability competences in need of development. It needs to be noted that RQ2.2 does not aim to get a full understanding of all students perceived competence development, but rather to procure some examples of competences they feel they have developed.

In order to investigate the two research questions above, a multi-dimensional study was undertaken, given the collective name *case study*. The name case study is simply given as a label to simplify referencing in the thesis. The study fulfills some of the conditions often subscribed to the term, for example being a study of a phenomenon in a real-life context and relying on multiple data sources (Yin, 1994) however, it does not inherit any particular similarities with the specific ways to conduct case study research.

The methods used for data collection are divided in to three subsections below, 3.3.1-3.3.3. Section 3.3.1 describes a pre-study undertaken through observation at Challenge Lab, Section 3.3.2 describes a group interview with Challenge Lab personnel aimed at investigation of RQ2.1 (*What competences does Challenge Lab aim to foster?*) and Section 3.3.3 describes interviews with students, aimed at investigation of RQ2.2 (*What are some common examples of competences that the students at Challenge Lab perceive to have developed?*).

3.3.1. Pre-study of Challenge Lab

The aim of the pre-study was twofold. First, to enable subsequent investigation and analysis, a valid understanding of the context and the discourse at the Lab was needed. In addition, access to the environment and familiarity with the personnel and students was deemed important, to ensure cooperation and make practicalities such as getting hold of people to interview easier.

To that end[3], unstructured observations were conducted, since this enabled presence at the Lab, understanding of the educational design and experience of the manner in which personnel and students interacted. Eleven such observations were made, during the five first weeks of the Challenge Lab master's thesis course. Ten out of these were non-participative. These observations were done by simply being present at the lab and quietly and discreetly taking down notes on what happened and personal thoughts about the events. One observation was made through participation in a workshop, and less detailed notes were taken during this session. The observational notes were put down in coherent text as soon as possible following the observations. The resulting transcripts held more or less detailed descriptions of the events with reflections added in hard brackets.

The results of these observations are largely intangible, and any analysis of the transcripts will therefore not be presented in this thesis. However, as was intended, the pre-study at least enabled the feeling of being able to understand the educational context and interact in a relevant way.

3.3.2. Group interview with Challenge Lab personnel

The second part of the case study is aimed towards the investigation of RQ2.1, i.e. "*What competences does Challenge Lab aim to foster?*". In order to shed light on what competences Challenge Lab aims to foster in their students, a group interview was undertaken with Challenge Lab personnel.

A group interview was chosen on two grounds. First, competences are abstract and an investigation could therefore benefit from natural opportunities for clarification and reconciling of a common view. Secondly, a group interview enabled discussion of competences starting from the preliminary findings made through literature study (which was finished before conducting the interview). Both these aspects are captured by Frey and Fontana (1991, p. 182), stating that group interviews can "serve as a testing ground for hypotheses or analytical suggestions, and expand the depth and variation in response or description of relevant social events".

3.3.2.1. Devising interview and selection of respondents

Generally, the interview was structured in such a way that the respondents were encouraged to discuss and talk amongst each other, with some questions being posed as facilitation of the

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[3] Apart from briefly studying earlier publications on Challenge Lab, the Challenge Lab webpage, course documents and literature used at the Lab.

session. The interaction served the purpose of enabling natural clarification amongst the respondents, lowering the risk of misinterpretation in analysis or answers that could be looked upon as non-representative for Challenge Lab. This was deemed especially important when inquiring into competences, since these are abstract and can be verbalized in many ways.

The interview was divided in to three parts.

- ❖ First, in order to get information on what competences Challenge Lab aim to foster in their students, three open and general questions were posed in the beginning of the interview, in attempt to procure data which had not been steered in any particular direction. The questions were broad in the meaning that almost every competence could be included in their answer, hopefully enabling a good coverage of competences, lowering the risk of some competence getting accidentally forgotten. The three questions were *"Why was Challenge Lab initiated?"*, *"What competences does Challenge Lab aim to foster?"* and *"What competences do you need in order to be skilled at working with Backcasting?"*.
- ❖ The second part aimed towards clarification of competences, trying to go deeper in to how Challenge Lab interprets the competences they aim to foster. Accordingly, the second part of the interview consisted of inquiry into certain competences that had been mentioned. The questions used were constructed beforehand out of hypotheses formed about the outcome of the three first questions, starting from the understanding of the Challenge Lab discourse procured through observations, see Section 3.3.1. The following questions were included: *"What competences are in systems-thinking?"*, *"What competences are in design thinking?"*, *"What competences in self-leadership do you aim to foster at Challenge Lab?"* and *"What competences are important for being skilled in dialoguing?"*.
- ❖ Lastly, an open discussion was held starting from the categorization of sustainability competences in earlier research constructed from literature review, see Section 3.2.2. The purpose was to get further information on the competence that Challenge Lab aims to foster through contrasting the respondent's view of sustainability competences with the categories constructed from earlier research. The categories were visualized using mind-mapping and presented to the respondents. The respondents were asked to study the categories and share their thoughts on how these relate to the competences that Challenge Lab aims to foster.

Starting from von Glasersfeld's aforementioned argument about the possibility of very different conceptualizations of an object or concept (Phillips and Soltis, p. 81), all five facilitators were invited to take part in the group interview, and all participated This way, more perspectives on sustainability competences could be represented in the study.

The respondents have different history with Challenge Lab. One is the founder of the Lab, forming the ambitions, structure and processes. One was deeply involved with the operations at the time, running the Lab on a day-to-day basis and representing the entrepreneurial dimensions of the Lab. One was a, at the time, less involved facilitator. Two respondents are former students of Challenge Lab, who were involved in facilitation and administration of the

Lab's activities at the time. Starting from these diverse background and relations to Challenge Lab, the respondents' individual accounts for what competences Challenge Lab aims to foster could differ substantially. In addition, one could argue that since it is the *ambitions* of Challenge Lab that is studied (not what they actually do), the view of the respondent who founded the Lab holds some additional legitimacy. In a group interview, these different views can be collectively examined, hopefully rendering a more robust account of what Challenge Lab is and which competences for sustainability are intended.

Frey and Fontana (1991, p. 175) state that the "background of members (e.g. Leadership style) can impact the interaction and response patterns within the group". In trying to overcome some potential power relations between the respondent, the discussion was actively facilitated. In addition, all respondents were prompted, by e-mail, to answer a basic question about competences at Challenge Lab before the interview. That way, the process of reflection of all respondents had started before the interview, and a tool for facilitation was enabled (i.e. referencing the answers when conducting the interview). Unfortunately, only one respondent answered the question before the interview.

The interview was audio-recorded and transcribed. The length was approximately 70 minutes.

3.3.2.2. Analysis

The aim of the analysis is to make accessible the information in the transcription of the group interview, determining the key themes, and subsequently trying to capture the sustainability competences Challenge Lab aim to foster (RQ2.1). This analysis is made following the general procedure for analysis described in Section 3.1, i.e. in a manner similar to the analysis of the literature review made in study of earlier research (RQ1). This analysis is made on the competences discussed in response to the open questions in the first part of the interview. Descriptions of competences are then clarified using additional competences discussed in response to the aimed questions of the interview.

Following the procedure described in Section 3.1, competences were extracted and clustered, and categories were developed, starting from the transcripts. Some pre-labeled competences were evident in the Challenge Lab discourse (e.g. *self-leadership*), similar as in the case of analyzing gathered literature. These competences were treated as pre-formed categories, in a similar manner to the competences identified by Wiek et al. (2011) in the analysis of earlier research. However, after categorization it was evident that the combination of pre-formed categories and categories developed through analysis showed significant overlap. Therefore, aiming towards minimization of this overlap, the categories were divided in to a set of 'basic' categories and a set of 'aimed' categories. The goal was to procure a set with minimum amount of categories, which includes all competences – these are the 'basic' categories. The 'aimed' categories, subsequently, only hold competences that can be constructed as a combination of a number of 'basic' categories. Even though the aimed categories do not hold any unique competences (at least not in this representation) they are included since the combination of competences in itself could be important for the understanding of sustainability competences.

Descriptions of all categories were developed using relevant quotes from the interview. The result of the analysis, i.e. the key themes in the interview presented as categories with

descriptions, can be found in Section 4.2.1. Accordingly, Section 4.2.1 is aimed at shedding light on RQ2.1, i.e. *"What competences does Challenge Lab aim to foster?"*.

3.3.3. Interviews with Challenge Lab students

In order to further investigate Challenge Lab's contribution to sustainability competences, student interviews were conducted. The aim of these was to investigate RQ2.2, i.e. *"What are some common examples of competences that the students at Challenge Lab perceive to have developed?"*. Since the development of competences is hard to observe, or even test (at least when it comes to competences such as self-leadership), interviews were chosen as the tool for investigation. Accordingly, the aim of the student interviews is to exemplify how a student can perceive the development of the sustainability competences identified in this study. Specifically, the goal was to get a better understanding of the competences identified through literature review, not included in Wiek et al. (2011), since these categories are to be established in this study. Therefore, the goal could be seen as threefold:

- ❖ Investigate what competences the respondent perceive s/he has developed.
- ❖ For competences referred to by the respondent and qualifying as sustainability competences, investigate how the respondent feel that these competences were developed, to procure some additional understanding.
- ❖ Investigate further whether the students feel they have developed the specific competences not included in Wiek et al. (2011), and if so – how these competences were developed.

3.3.3.1. Devising interviews

Since the aim was to capture the respondents perceived competence development, the interviews were done individually. A semi-structured interview was chosen, in order to provide flexibility and enable further questioning into any competence potentially referenced. The interview was constructed following the three goals described above.

Initially, some warm-up question was posed, in order to get the respondent comfortable with talking, i.e. *"How are you?"* and *"How do you feel about doing your master's thesis at Challenge Lab so far?"*.

Secondly, aiming towards the investigation of what competences the respondent perceived to have developed, and in order not to steer the conversation towards any specific competences, open questions were posed regarding development and learning, namely *"Doing your thesis at Challenge Lab, what impact has it had on you?"*, *"What have you learned during this experience?"* and *"What competences do you feel you have developed?"*

Further, competences or learnings linking to any of the sustainability competences identified in this study were inquired into. These follow-up question were formulated during the interview, using mainly the wording of the respondent, in order not to steer the response, and to give flow to the conversation. In order to procure examples of how the respondent felt s/he had developed the aforementioned competences, the respondents were asked to elaborate and exemplify.

Finally, in order to ascertain that the sustainability competences not included in Wiek et al. (2011) were covered to some extent, some questions where posed aimed at these specific areas of competences, namely "*Do you feel you have developed any competences aimed at handling yourself in some way?*", "*Do you feel that your willingness to contribute to sustainability have changed?*" and "*Do you feel that you have developed any competences that can complement rational thinking in working with sustainability? For example 'feeling' or 'sensing' in to sustainability systems?*". Since these questions are aimed, they were not used to determine categories of competences that the students perceived they had developed, but rather to strengthen the understanding of categories developed through analysis of literature, group interview and open questions in the student interviews.

In order to not to miss out on general reflections, the interview ended by asking the respondent whether s/he wanted to add or ask something.

The interviews was audio-recorded and transcribed. The length varied between 35 and 50 minutes.

3.3.3.2. Preparation

In order to improve comprehensibility of the questions, and provide familiarity with the interviewing situation, a preparatory interview was conducted with a former student of Challenge Lab. After this preparation, the wording of some questions were changed, the structure of the interview was slightly changed and questions were added (final result is shown above). In addition, new ways to inquire in to competences were unveiled, for example asking for a specific situation in which a competence came in to play. Moreover, some extra descriptions were prepared, for example for the term 'competence', to be used if a respondent did not feel comfortable with the concept.

3.3.3.3. Selection

The aim of the selection was to potentiate variation in perceived development. To that end, three respondents were chosen using a survey as a base for selection. The aim was to include students who had different competence backgrounds, who perceived their competences differently when entering the Challenge Lab master's thesis.

The survey was done by each student in the beginning of the Challenge Lab experience, based on self-assessment of the students' competences in the area of sustainability[4]. Analysis of the survey rendered a basic simplified 'competence profile' for each student, in form of scores for each of the competence categories identified in this study. The selection of students to interview was aimed at giving some variation in these competence profiles, i.e. enabling interviews with students that perceived their competences differently in the beginning of the Challenge Lab

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[4] Initially, the aim of the survey was to 'measure' the students' development by conducting the survey before and after the Challenge Lab experience. This endeavor was later abandoned mainly due to time constraints and shifted focus of the study.

experience. More details on the survey and how it was used as a basis for selection can be found in Appendix B.

To potentially enable further understanding of competences identified with relatively weak support in earlier research, a fourth student was chosen based on the fact that during observations in the Lab, s/he focused on and talked about such competences. Accordingly, this student was chosen to potentially provide examples of how the particular competences can be interpreted, and how a student can perceive the development of such competences.

Apart from showing variation in self-assessed competence, the students chosen also had different nationalities spanning three continents, and represented both female and male genders. In addition, two had participated in the preparatory course at Challenge Lab and two had not.

3.3.3.4. Analysis

As in the analysis of gathered articles (in Step 1) and of the group interview with Challenge Lab personnel (RQ2.1), the aim of the analysis of the student interviews is to procure a framework for the key themes present in the data, in relation to RQ2.2 (*What are some common examples of competences that the students at Challenge Lab perceive to have developed?*). Accordingly, the same method of analysis is used, i.e. the process of extraction, clustering and categorization described in Section 3.1. This analysis is made on the competences discussed in response to the open questions. Descriptions of competences are then clarified using additional competences discussed in response to the aimed questions of the interview.

The result of the analysis, i.e. examples of the respondents' perceived development of sustainability competences (RQ2.2), is presented in Section 4.2.2.

3.4. Step 3: Adaption

Finally, in order to try to capture Challenge Lab's contribution to the furthering of understanding of sustainability competences (RQ2), the concept of adaption through the two simultaneous processes of assimilation and accommodation is simulated, in order to potentially identify areas of theory in need for development. This is done very basically, since the aim simply is to identify aspects of sustainability competences at Challenge Lab that are consistent with or inconsistent with earlier research on sustainability competence. Accordingly, to this end, the results from the case study of Challenge Lab (procured in Step 2, i.e. RQ2.1 and RQ2.2.) were read using the framework for sustainability competences constructed through study of earlier research (procured in Step 1) as a theoretical lens, continuously evaluating the consistency of the two.
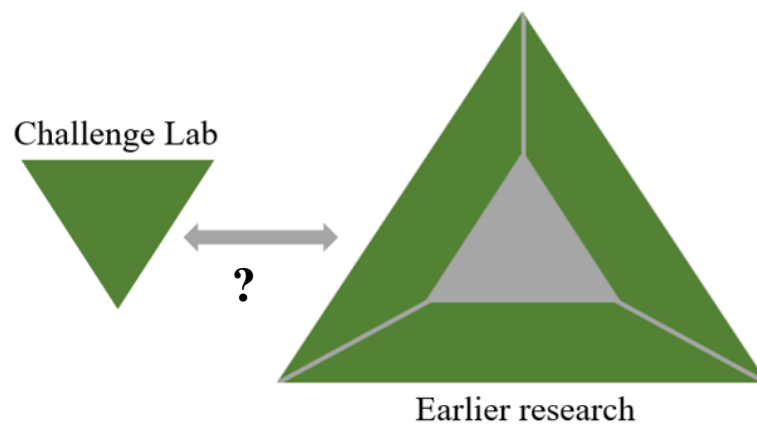
Figure 5: The third part of the study identifies aspects of sustainability competences at Challenge Lab that are consistent or inconsistent with earlier research, trying to capture Challenge Lab's contribution to the understanding of sustainability competences

The result of this analysis, i.e. the identified aspects of Challenge Lab potentially contributing to the understanding of sustainability competences, is shown is Section 4.3. Accordingly, Section 4.3 aims to shed light on RQ2, i.e. "*What areas of development in sustainability competence theory can be identified through studying Challenge Lab using earlier research on sustainability competences as a theoretical lens?*".

4. Results

In this section, the results from the data gathering and analysis in Step 1-3, described in Section 3, are presented. The section is structured following the research questions investigated in this study, i.e. Section 4.1 aims to shed light on RQ1 (*What is the current view in research on sustainability competences in the areas of education and sustainability*, *leadership and sustainability* and *transition management?*), in Section 4.2 results from the investigation of RQ2.1 (*What competences does Challenge Lab aim to foster?*) and RQ2.2 (*What are some common examples of competences that the students at Challenge Lab perceive to have developed?*) are presented, and lastly, results aiming to unveil RQ2 (*What areas of development in sustainability competence theory can be identified through studying Challenge Lab using earlier research on sustainability competences as a theoretical lens?*) are presented in Section 4.3.

4.1. Results from Step 1 – Investigation of earlier research

This section present results aimed at shedding light on RQ1 (*What is the current view in research on sustainability competences in the areas of education and sustainability*, *leadership and sustainability* and *transition management?*). To this end, the gathered literature on sustainability competences is presented in Section 4.1.1 and the developed categorization of competences is presented in Section 4.1.2.

4.1.1. Presentation of gathered literature

The gathered literature on sustainability competences is divided into three parts, depending on the field of research the articles represent, i.e. the context in which they were written. Accordingly, competences identified in three different areas will be discussed, namely: *education* (Section 4.1.1.1)*, leadership/organizational research* (Section 4.1.1.2), and *transition management* (Section 4.1.1.3).

4.1.1.1. Competences in sustainability education:

A framework for sustainability competences that draws from different views on how to understand and work with sustainability in education was developed by Wiek et al. (2011). The starting point of the framework is ability to "develop, test and implement strategies for sustainable urban development". Five over-arching 'key competencies in sustainability' were identified through literature review, namely; *system-thinking competence, anticipatory competence, normative competence, strategic competence,* and *interpersonal competence* (Wiek et al., 2011). More explicitly:

Figure 6: The first part of the literature study investigates sustainability competences found in research on sustainability education

- ❖ system-thinking competence is described as the "ability to collectively analyze complex systems across different domains [...] and across different scales" (Wiek el al., 2011, p. 207);
- ❖ anticipatory competence is described as the "ability to collectively analyze, evaluate, and craft rich "pictures" of the future" (Wiek el al., 2011, p. 207-209);
- ❖ normative competence is described as the ability to "map, specify, apply, reconcile, and negotiate sustainability values, principles, goals, and targets" (Wiek el al., 2011, p. 209);
- ❖ strategic competence is described as the ability to "design and implement interventions, transitions, and transformative governance strategies" (Wiek el al., 2011, p. 210); and
- ❖ interpersonal competence is described as the ability to "motivate, enable, and facilitate collaborative and participatory sustainability research and problem solving" (Wiek el al., 2011, p. 211).
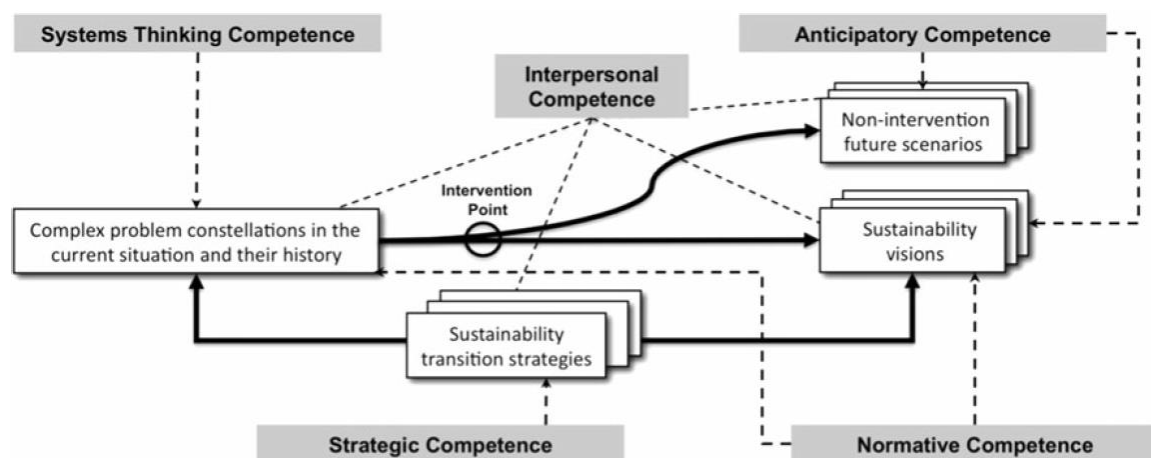
Figure 7: A competence framework for working with sustainable transitions, developed by Wiek et al. (2011), reproduced with permission. The dashed arrows indicates in what step(s) of the problem solving framework the competences come into play.

Since the framework developed by Wiek et al. (2011), see Figure 7, is highly relevant in the context of this study, including competences inherent to all three areas of research, and developed through extensive literature review of articles on sustainability education, it is used as a key framework for sustainability competences in this study. Moreover, since Wiek et al. (2011) provides an extensive framework for competences, the rest of the literature reviewed in this section on sustainability education will only be discussed in the manner in which they contribute additional knowledge, skills and attitudes.

In reviewing the articles that are cited in Wiek et al. (2011), it becomes apparent that the competences presented by Wiek et al. mostly focus on skills, and few attitudinal aspects of competences are presented (for example willingness to contribute to sustainability). Wiek et al. (2011) point out that there are divergent opinions presented in literature regarding whether sustainability education requires the acquisition of certain values, or if it suffices to give insight into different value concepts in order for the students to be able to facilitate dialogue or negotiation rather than to take a position. In another review (of intended learning outcomes of

sustainability education) by Svanström et al. (2008 p. 347) it is suggested that "in order to be successful sustainability change agent, an individual must have [...] a value system and self-concept to support and under gird the actions of a change agent". Wiek et al. (2011) points towards at least six articles that discuss such affective aspects: Kearins and Springett (2003), Sterling and Thomas (2006), Svanström et al. (2008), Segalàs et al. (2009), de Haan (2006) and Sipos et al. (2008).

Kearins and Springett (2003) discuss how critical theory could contribute to sustainability education in a management context. The authors discuss some of the problems with the classic approach to managing, and how it could be hard to combine with strong sustainability since sustainability necessities change and management is classically rooted in control. Three skillsets needed for bridging from classical management to more radical paradigm are identified, "reflexivity, critique and social action/engagement" (Kearins and Springett, 2003). Reflexivity and critique are mostly covered by the competences discussed by Wiek et al. (2011). The term social action/engagement is interpreted in Kearins and Springett (p. 194) as the ability to "resolve tensions between the collectivity and the individual in ways that support both" and "a level of ease with more inclusive approaches". It is suggested that students should build the ability to reflect on what they as individuals can do to be change agents for sustainability and assess their environmental awareness.

Sterling and Thomas (2006) state that the transformation to sustainability education necessitates a shift from only using cognitive learning objectives to including affective and skills-related learning objectives as well. In discussing capabilities, and the learning outcomes that ESD should strive to achieve, Sterling and Thomas (2006) reviews (for example) qualities of a global citizen presented in Parker et al. (2004). Such a global citizen:

- ❖ respects and values diversity;
- ❖ are outraged by social injustice;
- ❖ participates in and contributes to local and global community;
- ❖ is willing to act for a more equitable and sustainable world; and
- ❖ takes responsibility for his or her actions (Parker et al., 2004).

Further, capability requirements for education for sustainability from Parker et al. (2004) is presented by Sterling and Thomas (2006), including certain values and attitudes, such as:

- ❖ "sense of identity and self-esteem";
- ❖ "commitment to social justice and equity";
- ❖ "concern for the environment and commitment to sustainable development"; and
- ❖ "belief that people can make a difference" (Parker et al., 2004, p. 69).

Svanström et al. (2008) review ILOs in higher education, and discusses some initiatives for ESD (e.g. the UN Decade of Education for Sustainable Development). Most competences presented are included in Wiek et al. (2011), but some additional competences can be found, e.g.:

- ability to cope with uncertainty and ambiguity;
- understanding of their own personal and professional responsibility;
- ability to implement sustainable actions in their personal and professional lives;

Specifically, competences needed for acting as a change agent, which are not included in Wiek et al. (2011), are discussed. These are presented with reference to College Students Educators International (ACPA)[5] and include a number of personal traits (e.g. resilience, optimism, commitment, patience) and skills, such as (the ability to):

- listen to others and incorporate their perspectives;
- engage in "self-assessment, self-reflection, and analysis";
- reflect on current events in order to further sense-making;
- "engage in civil discourse and debate";
- recongnize global implications of one's own actions;
- "challenge the *status quo* effectively when appropriate";
- network and form alliances and teams;
- adjust to the need of society and of others;
- "be both a leader and a follower";
- "analyze and influence group dynamics"; and,
- make decision based on ethics and responsibility (Svanström et al., 2008 p. 347-348).

In addition, change agents are said to have:

- commitment to solving societal problems;
- the belief that their thoughts and personal and professional actions are important;
- integrity; and,
- courage (Svanström et al., 2008).

Starting from a comparison between three technical universities, Segalàs et al. (2009) describes desired sustainability competences for engineers. Some minor convergence is found in learning outcomes regarding the area of attitudinal aspects. The only clear consensus found was in attaining "a certain level of concern or awareness of risks" and in "Responsibility/commitment/SD challenge acknowledge" (Segalàs et al., 2009, p. 22, 25). It is stated that the lack of convergence stem from different ways of describing intended learning outcomes, and it is also hypothesized that cultural differences might hinder convergence in desired attitudinal outcomes (Segalàs et al., 2009).

de Haan (2006, p. 22) presents an educational design based on the German concept "Gestaltungskompetenz" ('shaping competence'), i.e. "the specific capacity to act and solve problems". Two specific competences not included in Wiek et al. (2011) are presented, namely: "[t]he capacity for empathy, compassion and solidarity" and "[c]ompetence in self-motivation" (de Haan, 2006, p. 24).

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[5]www.myacpa.org

Sipos et al. (2008) discusses the notion of *transformative sustainability learning*, which aims at affecting change in students' perspectives in the context of sustainability. The authors mostly discusses educational practices, and develops an evaluation framework for sustainability education. However, two competences not included in Wiek et al. (2011) can be found: *ability to acknowledge one's responsibility as global citizens*, and *ability to reflect on one's experiences*.

Starting from the educational approach of action competences (discussed in Section 2.2.2) Jensen and Schnack (1997) identifies certain competences that are important for sustainability education. In general, some components of such competences are presented:

- ❖ "knowledge/insight;
- ❖ commitment;
- ❖ visions;
- ❖ action experiences" (Jensen and Schnack, 1997, p. 173).

Jensen and Schnack (1997) further state that the aim of environmental education should be to "make present and future citizens capable of acting on a societal as well as a personal level", and some additional competences are presented:

- ❖ ability to envision new trajectories and ability to work towards the fulfillment of these trajectories;
- ❖ coping with anxiety and uncertainty;
- ❖ courage;
- ❖ collaborating;

This concludes the review of competences for sustainability in educational research. In general, it can be noted that Wiek et al. (2011) includes most competences to be found in the area of education and sustainability, apart from specific attitudinal aspects and skills aimed at the individual possessing the competence in question. In order to complement this field, sustainability competences stemming from leadership and management research is reviewed in the following section.

In searching for sustainability competences in leadership literature, two barriers soon become apparent. Firstly, contemporary research on leadership is somewhat more process-oriented than person-oriented (see for example Avolio et al., (2009) for a review of current developing leadership concepts). This makes the occurrence of specific competences relatively rare. In addition, the focus on leadership competences is criticized (e.g. by Bolden and Gosling, 2006) because it tends to over-simplify the concept of leadership. Secondly, it is evident that there is no well-established leadership concept corresponding to ESD or similar concepts in the

Sustainability leadership

Figure 8: The second part of the literature study investigates sustainability competences found in research on sustainability leadership

domain of education. Accordingly, there is no clear concept on the lines of 'leadership for sustainable development' or 'leadership for sustainability'. One somewhat established term is 'sustainability leadership', rendering three times the amount of results when using Google Scholar[6]. In general, Brown (2011, p. 3) states that "there is very little robust research on the intersection of sustainability and leadership".

Ferdig (2007) discusses *sustainability leadership* as naturally inherent to the challenges of an increasingly complex world. Adopting a contemporary view of leadership (e.g. transcending leadership found only in formal position), Ferdig (2007, p.27) states that sustainability leadership includes "anyone who seeks sustainable change regardless of role or position". Among other characteristics, s*ustainability leaders*:

- ❖ take "responsibility for fostering sustainable conditions in the workplace" (p. 27);
- ❖ are leaders "'with' others instead of […] 'over' others" (p. 27);
- ❖ and adopts a holistic view of the interconnections existing between people and natural systems;
- ❖ create opportunities for co-creation, collaboration, exploration and learning;
- ❖ address sustainability challenges through realistic strategies, embrace change, and recognize dissonance as a driver for new thinking (Ferdig, 2007).

Moreover, sustainability leaders are said to be grounded in a personal sustainable ethic "that reaches beyond self-interest", open to learning and inquiry, and "informed, aware, realistic, courageous, and personally hopeful" (Ferdig, 2007, p. 32). In addition, they have traditional

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[6]The concept sustainable leadership is also found in research, but does not seem specific enough since it is denoted in some of the most well-cited sources as a leadership style aiming towards sustainable change in education (e.g. Hargreaves and Fink (2012)), i.e. change that *lasts* rather than change aimed at environmental, social and economic sustainability.

leadership (management) skills in areas such as strategic thinking, communication and mobilization of action (Ferdig, 2007).

Brown (2011) argues for the importance of advanced skills in meaning-making in order to work successfully with designing and implementing sustainability initiatives, under the term *conscious leadership for sustainability*. Through interviews with leaders occupying formal position to work with sustainability in organizations, Brown identified 15 competences that sustainability leaders display. Eight of these competences are presented as especially important for sustainability leaders who are developing their meaning-making:

  ❖ knowledge of and ability to use the basics of *systems theory*, to "better understand sustainability issues and support the development of systems" through systems thinking;
  ❖ knowledge of and ability to use the basics of *complexity theory*, to "better understand sustainability issues and support the development of complex adaptive systems";
  ❖ knowledge of and ability to use the basics of *integral theory*, to use in diagnosing sustainability issues, designing interventions, tailoring communications, and support development of self, others and systems;
  ❖ ability to "*ground their sustainability work in deep meaning*" (e.g. in order to battle burnout);
  ❖ ability to use "*intuitive decision-making and harvesting*" to supplement rational thinking;
  ❖ ability to "*scan and engage one's internal environment*" to strengthen self-awareness;
  ❖ ability to "*dialogue with the system*" by sensing needs in the system, testing interventions, analyzing system response and iterating;
  ❖ ability to "*create developmental conditions*" to foster development of both individuals and collectives (Brown, 2011, p. 233-237).

Other competences presented in the study include, for example:

  ❖ capacity to embrace uncertainty and trust "oneself, co-designers, and the process";
  ❖ ability to hold multiple perspectives;
  ❖ ability to "take advantage of openings and opportunities for system changes" by "going with the energy";
  ❖ ability to help others to question their assumptions; and
  ❖ ability to use fundamentals of polarity management (Brown, 2011, p. 213-214).

Another attempt to deduce what is core in leadership and sustainability, under the term *leading for sustainability*, was made by Quinn and Dalton (2009), by interviewing senior leaders holding some authority in organization which have formally adopted sustainability principles. Although the focus is not on discussing traits or skills of the leaders, some competences are mentioned or could be considered to be implied. The interviewees state that in order to motivate employees to engage in sustainability issues it is important to:

  ❖ focus on positive aspects of sustainability in framing the endeavor;

- ❖ be enthusiastic;
- ❖ frame the idea of sustainability in a way that is appropriate to the context;
- ❖ use vivid examples and emotions in communication about sustainability;
- ❖ use the language of business;
- ❖ be attentive to timing, to know when to act;
- ❖ set up goals that can be implemented in day-to-day activity;
- ❖ engage external stakeholders in the sustainability of their joint business;
- ❖ treat employees well and give recognition
- ❖ recognize that ideas for acting on sustainability does not only come from people with formal authority in an organization;
- ❖ encourage the sharing of ideas and knowledge;
- ❖ build networks for communication and sharing of ideas and practices

Metcalf and Benn (2013), in yet another attempt to unravel some of the confusion regarding leadership styles related to successfulness in the endeavor to implement sustainability in corporations, posits that the issues in finding a theoretical framework stems from the complexity of interpreting organizational sustainability itself. However, Metcalf and Benn (2013) do identify three leadership concepts that have been associated with corporate social responsibility (CSR), *authentic, transformational[7],* and *ethical/moral leadership.* These concepts are reviewed briefly below.

In reviewing contemporary leadership theories, Avolio (2009, p. 423) state that authentic leadership is a product of research on transformational leadership, forming a categorization between "pseudo versus authentic transformational leaders". Transformational leadership in turn is defined in contrast with transactional leadership (Bass, 1991), and describes a leader who is:

- ❖ *charismatic*, providing vision, gaining respect and trust;
- ❖ *inspiring,* communicating high expectations and purpose in simple ways;
- ❖ gives *intellectual stimulation,* promoting rationality; and,
- ❖ gives *individual consideration,* giving individual attention, coaching and advice.

Bass (1991, p. 21) states that such leaders "generate awareness and acceptance of the purpose and mission of the group" and "stir their employees to look beyond their own self-interests". Further, following critique of the concept on the base of it opening towards manipulation of followers, Bass and Steidlmeier (1999, p. 211) argue that *authentic* transformational leaders does so while aiming "towards noble ends, legitimate means, and fair consequences". Metcalf and Benn (2013, p. 374) further states that authentic and ethical leaders are similar in the sense that they "share an emphasis on honesty, openness and integrity as well as a desire to do what is right". In addition, Walumbwa et al. (2008, p. 90) state that authentic leaders show awareness of their own values and motivators and that the core of authentic leadership is being "true to

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[7]Also identified by Galpin and Whittington (2012) as a tool for workforce engagement in sustainability.

oneself". In clarification of the concept of ethical leadership, Brown and Trevino (2006, p. 597) state that ethical leaders are "honest, caring, and principled individuals who make fair and balanced decisions".

Ferdig (2007), Avolio (2009) and Metcalf and Benn (2013) mention and point towards complexity science as an avenue for development of leadership theory, inherent to the growing complexity of organizations, of the world and consequently of sustainability. In trying to resolve the meaning of leadership in what is denoted as the "Knowledge Era", Uhl-Bien et al. (2007) propose the use of a framework for leadership based on complexity theory. Drawing on research on the dynamics of complex adaptive systems (CAS), Uhl-Bien et al. (2007) develop a three part model building on the concepts of *administrative, adaptive* and *enabling* leadership. Leadership itself in this context is interpreted as "an emergent, interactive dynamic"; as a *process*, rather than the actions of a sole leader (Uhl-Bien et al., 2007, p. 299). In short, *administrative leadership* holds much of the classical notions of organizational leadership, based on formal managerial roles, referring to the "actions of individuals and groups […] who plan and coordinate activities to accomplish organizationally-prescribed outcomes in an efficient and effective manner" (Uhl-Bien et al., 2007, p. 305). The use of a*daptive leadership* refers to "adaptive, creative, and learning actions that emerge from the interactions of CAS as they strive to adjust to tension" (Uhl-Bien et al., 2007, p. 305). *Enabling leadership* refers to actions that catalyze appropriate conditions under which adaptive leadership emerge, and actions aiming at management of the interaction between "the bureaucratic (administrative leadership) and the emergent (adaptive leadership) functions of the organization" (Uhl-Bien et al., 2007, p. 305). Although leadership is discussed mostly at a process level, some individual competences are discussed. An effective administrative leader needs to be skilled in for example:

❖ structuring tasks, planning, building vision, resource-acquisition, goal-achievement;
❖ crisis management and resolving conflict; and
❖ managing organizational strategy (Uhl-Bien et al., 2007).

Enabling leaders foster conditions that catalyze adaptive leadership and the complex self-organizing networks it appears in, by "(1) fostering interaction, (2) fostering interdependency, and (3) injecting adaptive tension to help motivate and coordinate the interactive dynamic" (Uhl-Bien et al., 2007, p. 309). Ways of acting as an enabling leader include

❖ enlarging personal networks in order to "increase the amount of access and network resources they can bring to the table";
❖ being informed on relevant issues and framing them with respect to "the perspectives of the others with whom they are interacting" in order to improve information flow in the organization; and,
❖ monitoring the external context in which the organization operates in order to understand what might be influencing their adaptive dynamic (Uhl-Bien et al., 2007, p. 310).

In addition, enabling leaders recognizes tension related to differences of opinions regarding task performance as a driver for creativity and contributes with conflicting or contrasting ideas in order to break groups out of non-generative consensus (Uhl-Bien et al., 2007).

In discussing the need for companies to develop new ways of action facing the challenges of a changing world, another take on adaptive leadership is given by Heifetz and Laurie (1997) and Heifetz et al. (2009). In *The Work of Leadership* (Heifetz and Laurie, 1997) mobilizing action towards change and helping employees in coping with change are seen as two key tasks for an adaptive leader, who in this context is mostly depicted as someone holding a higher formal position in the organization. Guidelines on how to succeed in coping with adaptive challenges is given. An adaptive leader should:

- ❖ use the collective intelligence in the organization, not solely focusing on solutions coming 'from above';
- ❖ observe the operations holistically and not get too caught up in the field of action;
- ❖ analyze the organization (including the leaders own behaviors) and the adaptive challenges it faces;
- ❖ regulate the distress of change by pacing the work and creating spaces for diverse groups to talk about the challenges they are facing;
- ❖ recognize conflict as a driver for creativity and learning and challenge polarized or superficial arguments with tough questions;
- ❖ have emotional capacity to tolerate ambiguity and frustration;
- ❖ support other people to take initiative and responsibility;
- ❖ listen to and provide cover for voices 'from below';
- ❖ recognize the need for learning in the organization, in order to face adaptive challenges (Heifetz, 1997).

In *Leadership in a (Permanent) Crisis* (Heifetz et al., 2009) the description is elaborated, additionally stating that adaptive leaders should:

- ❖ be empathic;
- ❖ depersonalize conflict and "create a culture of courageous conversations" in order to make more out of disequilibrium;
- ❖ generate leadership throughout the organizations by distributing responsibility and mobilize all staff members to generate solutions;
- ❖ take care of themselves by being both optimistic and realistic, by finding special places to rejuvenate, by reaching out and confiding in people outside of the organization, by showing more (appropriate) emotion in the workplace and by finding other sources of fulfillment than ones job (Heifetz, 2009).

A recent attempt to define a leadership style that is effectively aiding the work towards the solving of today's systemic challenges is given by Senge et al. (2015)[8], in their discussion of *system leadership*[9]. A system leader is described as any person in an organization who catalyzes and bring about collective leadership (Senge et al., 2015). Three core capabilities of a system leader are identified, namely the abilities to *i)* see (and help others see) the larger system, *ii)* to foster reflection and more generative conversations and *iii)* shift the "collective focus from reactive problem solving to co-creating the future" (Senge et al., 2015, p. 29). Moreover, a system leader is said to be skilled in for example:

- ❖ adopting others' perspectives;
- ❖ deep listening;
- ❖ building networks of trust;
- ❖ fostering reflection;
- ❖ "building positive visions for the future";
- ❖ using the tension between current and desired states (Senge et al., 2015, p. 29).

Seeing as the endeavor to make organizations more sustainable is inevitably a process of change, inclusion of a well-used framework from change management seems appropriate in order to identify other potentially important competences for sustainability. In a classic article on the subject, Kotter (1995) discusses the failure and success of change efforts, and proposes an eight step model for organizational transformations. Competences are not presented explicitly, but some could be considered to be implicitly present in the transformation steps that are presented. Some of these are (the ability to):

- ❖ create a sense of urgency, that change is needed;
- ❖ have patience;
- ❖ facilitate a frank discussion;
- ❖ build coalitions;
- ❖ create trust;
- ❖ create clear pictures of the future that can easily be communicated;
- ❖ communicate in a way that captures the heart and minds of employees;
- ❖ live up to the demands the change puts on the individuals in the organization, i.e. to be a role model for others;
- ❖ see potential obstacles and barriers that hinder the transformation;
- ❖ see potential for short-term gains of long-term transformations and capitalizing on such gains (Kotter, 1995).

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[8]Not a well-cited article, but is included since it was only recently published and because Senge is more or less a guru on the subject of organizational research.
[9]The term system leadership, not well-established, seems to otherwise most often denote leadership aimed at improvement in schools, see for example Hopkins and Higham (2007).

This concludes the literature review in the context of sustainability and leadership[10]. Complementing the competences identified this far, the field of transition management is briefly reviewed in the next section.

4.1.1.3. Competences in transition management:

In the sections above, sustainability competences found in leadership literature have been reviewed. These stem from organizational research and could therefore be seen as valid in all organizations, from profit-seeking companies, NGOs, universities and other publically managed institutions. However, in the context of sustainability and public policy, a particular field of research, *transition management,* have emerged during the early 21st century, as discussed in Section 2. Transitions are, according

Figure 9: The third part of the literature study investigates sustainability competences found in research on transition management

to Loorbach (2007, p. 17), "transformation processes in which existing structures, institutions, culture and practices are broken down and new ones are established". Transition management is a rather new area of research, and consequently there are only a few articles discussing specific competences in this area.

Raven et al. (2010) discuss competences that are needed in working with transition management, building on the work of Andringa and Weterings (2006). Six clusters of competences are presented: *system analysis and problem structuring, reorientation and visioning, establishing and executing transition experiments, broadening and scaling up transition experiments, monitoring, evaluating and learning,* and *transition management* (a synthesis of all competences, that enable appropriate action) (Raven et al., 2010). Further details are given in Jansen et al. (2008), who state that a condition for system change is individuals with open mind and a willingness to listen and to co-operate. Competences that are needed in a transition management team are presented, such as:

❖ frankly interviewing;
❖ integral thinking;
❖ visioning;
❖ 'guts';
❖ entrepreneurship;
❖ networking skills;
❖ reflections skills;

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[10]A noteworthy exclusion from the review of leadership and sustainability is the work done by Doppelt (see for example *Leading Change for Toward Sustainability* (Doppelt, 2009)). This was not included as Doppelt discusses much of what needs to be done in order to lead change towards sustainability in organizations but mentions few specific competences.

- ❖ self-consciousness;
- ❖ system thinking; and
- ❖ timing (Jansen et al., 2008).

Wals and Schwarzin (2012) identify dialogue as an important tool for working towards sustainability transitions in people, in organizations and in society. Further, 'sustainability competence' is defined, as "capacities and qualities that people, and the organizations and communities of which they are part, need in order to address (un)sustainability" (Wals and Schwarzin, 2012, p. 11). Addressing (un)sustainability requires competences to deal with complexity and uncertainty, and some such competences are presented, e.g.:

- ❖ ability to facilitate dialogue;
- ❖ a disposition to be aware of and open to others perspectives;
- ❖ ability to trust others;
- ❖ willingness to engage in dialogue;
- ❖ willingness to engage in personal growth;
- ❖ patience;
- ❖ ability to listen empathetically;
- ❖ ability to adopt other people's perspectives, fundamentally different to one's own;
- ❖ ability to withhold judgment and automatic emotional reactions;
- ❖ ability to represent one's own perspective;
- ❖ ability to critically examine one's own perspective;
- ❖ ability to deal constructively with differences in opinions;
- ❖ ability to use dissonance constructively, as an opportunity for re-consideration;
- ❖ ability to adopt different mindsets and perspectives e.g. "local-global, past-present-future, anthropocentric-biocentric" (p. 21); and,
- ❖ anticipatory (forward) thinking (Wals and Schwarzin, 2012).

This concludes the review of sustainability competences in transition management, and subsequently the review of earlier research. The categories developed to hold the competences presented in the sections above, aiming towards the unveiling of RQ1 (*What is the current view in research on sustainability competences in the areas of education and sustainability, leadership and sustainability and transition management?*) are presented in the following section.

4.1.2. Developed competence categories

Through analysis of the gathered literature presented above in Section 4.1.1.1-4.1.1.3, using the analysis procedure described in Section 3.1, categories representing the competences identified in the study of earlier research were developed. Five categories were treated as pre-existing, i.e. the five competences identified by Wiek et al. (2011). Generally it was noted that the competences identified by Wiek et al. were supported not only in research on sustainability education, but also in both sustainability leadership and transition management. However, complementing the framework developed by Wiek et al. four additional categories were developed. These categories are presented below.

Figure 10: The nine competence categories presented in Section 4.1.2 aim to capture the sustainability competences found in the areas of sustainability education, sustainability leadership and transition management.

❖ *Intrapersonal competence*: the ability to lead oneself and cope with the challenges that working with sustainability can entail. This category includes reflecting upon one's own thinking and challenging one's own assumptions, being self-aware, open and willing to learn, grow and change. In addition, this competence category include the capacity to embrace change and deal emotionally with uncertainty and adopting patience, perseverance and resilience. Moreover, the category includes ability in self-motivation and supporting one's own development. Further, dealing with the challenges of sustainability necessitates an ability to rejuvenate, by finding safe spaces and people to confide in. Aspects of this competence category was found in Kearins and Springett (2003), Svanström et al. (2008), de Haan (2006), Jensen and Schnack (1997), Ferdig (2007), Brown (2011), Walumbwa et al. (2008), Heifetz (2009), Senge et al. (2015), Kotter (1995), Jansen et al. (2008) and Wals and Schwarzin (2012). This category complements the interpersonal competence identified by Wiek et al. (2011) with competences aimed at handling oneself.

❖ *Being and owning*: this category includes the ability to recognize and assume one's responsibility for the furthering of sustainability, contributing to sustainability in both professional and personal life, being committed to social and environmental sustainability and courageously taking on the challenges of sustainability. This competence category could alternatively be described as *embodying the cause*. Furthermore, this includes being optimistic, advocating sustainability and inspiring others, by power of persuasion and through being a role model. Aspects of this category can be found in Parker (2004), Svanström (2008), Segalàs et al. (2009), Sipos et al. (2008), Jensen and Schnack (1997), Ferdig (2007), Brown (2011), Quinn and Dalton (2009), Bass and Steidlmeier (1999), Metcalf and Benn (2013), Senge et al. (2015), Kotter (1995), Jansen et al. (2008), Wals and Schwarzin (2012). This category holds

many of the attitudinal dimensions of competences that are not included in Wiek et al. (2011).

❖ ***Trans-rational thinking****:* this category includes the ability to move beyond the rational reasoning of weighing facts or sustainability principles and values and "sense" into socio-ecological systems, by looking for energy telling of potential for change, and understanding sustainability issues through adopting and inhabiting multiple perspectives, seeing the system through the eyes of others. Further, this competence category includes the ability to see dissonance between two perspectives (e.g. personal opinions, conflicting scenarios) or polarities as a driver for change and a tool for analysis of systems. Aspects of this category can be found in Svanström et al. (2008), Ferdig (2007), Brown (2011), Quinn and Dalton (2009), Uhl-Bien et al. (2007), Heifetz (1997), Senge et al. (2015) and Wals and Schwarzin (2012). This category relate strongly to systems-thinking competence identified by Wiek et al. (2011), but complements with more non-tangible dimensions.

❖ ***Leading with others****:* this category includes the ability to foster collective action towards sustainability. This means supporting the emergence of networks for communication and the development of mutual trust in organizations and collaborations. Furthermore, this category includes the ability to support the development of colleagues, by helping others examine their assumptions, supporting them to take initiative and responsibility, coaching and creating space for and culture of courageous conversations. This competence category also includes involving internal and external stakeholders in working with sustainability and the ability to facilitate dialogue between different actors. Aspects of this competence category can be found in Svanström et al. (2008), Ferdig (2007), Brown (2011), Quinn and Dalton (2009), Bass (1991), Uhl-Bien et al. (2007), Heifetz (1997, 2009), Senge et al. (2015), Kotter (1995), Jansen et al. (2008), and Wals and Schwarzin (2012). This category is closely related to the interpersonal and strategic competence identified by Wiek et al. (2011) but provides more detail and understanding of what leadership competences might be relevant for sustainability.

The nine categories identified and developed, (i.e. *systems thinking, anticipatory competence, normative competence, strategic competence, interpersonal competence, intrapersonal competence, being and owning, trans-rational thinking* and *leading with others*) are henceforth used as a framework holding the information to be found on sustainability competences in earlier research, i.e. this study's answer to RQ1 (*What is the current view in research on sustainability competences in the areas of education and sustainability, leadership and sustainability* and *transition management*?). A summary of all nine categories can be found in Table 1. Looking upon this framework as a metaphorical cognitive structure belonging to earlier research as an entity, these categories are used to simulate the potential learning in an interaction between earlier research and Challenge Lab as an object of study, in an attempt to capture Challenge Lab's contribution to the furthering of understanding of sustainability competences (RQ2), through identification of areas of theory in need for development. This metaphorical learning is presented in Section 4.3.

Category	Description
Systems thinking	"ability to collectively analyze complex systems across different domains [...] and across different scales"*
Trans-rational thinking	the ability to move beyond the rational reasoning of weighing facts and "sense" into socio-ecological systems, by looking for energy and seeing the system through the eyes of others
Anticipatory	"ability to collectively analyze, evaluate, and craft rich "pictures" of the future"*
Normative	"ability to collectively map, specify, apply, reconcile, and negotiate sustainability values, principles, goals, and targets"*
Being and owning	the ability to recognize and assume one's responsibility for the furthering of sustainability, contributing to sustainability in both professional and personal life, being optimistic and brave
Strategic	"ability to collectively design and implement interventions, transitions, and transformative governance strategies"*
Leading with others	ability to foster collective action towards sustainability, e.g. by supporting the development of others and networks of communication and mutual trust, and by connecting with internal and external stakeholders
Interpersonal	"ability to motivate, enable, and facilitate collaborative and participatory sustainability research and problem solving"*
Intrapersonal	the ability to lead oneself and cope with the challenges that working with sustainability can entail, e.g. through self-reflection and embracing change and uncertainty

4.2. Results from Step 2 – Investigation of Challenge Lab

Before moving on to the investigation of RQ2 (*What areas of development in sustainability competence theory can be identified through studying Challenge Lab using earlier research on sustainability competences as a theoretical lens?*), the results of the sub-questions RQ2.1 (*What competences does Challenge Lab aim to foster?*) and RQ2.2 (*What are some common examples of competences that the students at Challenge Lab perceive to have developed?*) investigated in Step 2 of the study are presented in Section 4.2.1 and 4.2.2 respectively.

Figure 11: The results presented in Section 4.2 aim to capture aspects of sustainability competences at Challenge Lab, representing the study's answer to RQ2.1 and RQ2.2

4.2.1. Challenge Lab's intentions

Through the interview with Challenge Lab personnel, ten competence categories could be identified using the analysis procedure described in Section 3.1 for the open questions. The categories were divided in to six basic and four aimed ones. As described in Section 3.3.2, this division was made to minimize overlap between the basic categories, and subsequently so that most competences in the four aimed categories could be found in the basic categories. The aimed categories are not attached to one specific basic category, but rather draws competences from two or more basic categories. The basic categories are: *understanding and linking to sustainability, systems-thinking, self-leadership, collaborating, doing good/contributing* and *mentality/presence*. These are presented in Table 2. The four aimed categories are: *dialoguing, design thinking, entrepreneurial thinking* and *transformative thinking*. These are presented in Table 3, with support of the competences discussed in response to the aimed questions of the group interview. More detailed descriptions of these competence categories and supporting quotes from the interview can be found in Appendix A.

In the interview it was evident that most competences had already been formed, discussed and put in to labeled clusters by the respondents. Subsequently, these have been given the names that the respondents already had attached to them. Two categories, *doing good/contributing* and *mentality/presence*, could be looked upon as emergent, as these competences never occurred under a specific label and were not extensively discussed during the interview. Consequently, these categories are less evident in the transcript, but is nevertheless present, and constitutes basic categories since this division minimizes overlap between the basic categories. It should be noted, however, that Challenge Lab does not aim towards competences that exist in isolation, all competences are looked upon as strongly interlinked, as highlighted in the following quote:

"…it is the interconnections that is making the Challenge Lab, and the skills for the students to connect design thinking with the bigger picture, to connect different things. To use self-leadership in a dialogue process. That is very much the Challenge Lab. It is not separate things, it is a web of skills"

Category	Description	Example quote
Understanding and linking to sustainability	Ability to understand sustainability principles, create sustainability criteria for the future and link all other competences and activities to sustainability	*"It is not okay just to say "this is fun" or "this is effective", but how does it link to social, ecological, economical dimensions of sustainability?"*
Systems-thinking	Ability to analyze systems, causality, interconnections, to analyze in short term and long term, local and global, to understand something from different perspectives and adopt a holistic view	*"So there is a time dimension in this systems-thinking, it is a scale dimension in this system thinking, there is a knowledge dimension, a cultural dimension in systems thinking, there is a causal dimension in systems-thinking"*
Self-leadership	Understanding of and ability to reflect upon one's values and strengths, one's driving forces, ability to be pro-active and have confidence and courage	*"To be actively looking you have to understand yourself, to know what you want, what you want to do, and what you want for the world, and for yourself."*
Collaborating	Ability and willingness to work together and take part in co-creation and dialogue, understanding of group dynamics, and ability to communicate and network	*"every engineer do work in a group of persons and has to be quite communicative, and so we talk a lot about how it affects others, the planet, other persons, how we can connect with other persons"*
Doing good, contributing	Ability to bring one's knowledge/power to something good for other people, to have empathy and care for others, take responsibility for one's actions and acknowledge that one's contribution is important	*"it kind of comes down to that you care for your fellow beings, some kind of empathy. It's not just about innovating stuff, because it's actually about taking care of the planet and the other persons"*
Mentality, presence	Ability to adopt a state of mind relevant for working with sustainability challenges, having patience, being able to stay in a question or a complex problem without rushing to solutions, being curious and able to cope with uncertainty, having mental space for working with others, an ability to be open and willingness to trust and actively listen to others.	*"To be really skilled in this Backcasting, they need to be patient, and stay in the question, to really stay there, before they run in to solution"*

Aimed category	Description	Example quote
Dialoguing	Understanding of the concept dialogue, being able to work together by talking and active listening, being able to learn about others' perspectives, thereby extracting information about a system or sustainability issue, being able to foster and find inspiration, innovation and creativity through dialogue. This category draws competences mainly from *understanding and linking to sustainability, systems thinking, collaborating* and *mentality/presence*.	*"A dialogue is mainly about learning and understanding more about others perspectives on a certain thing. It is a learning process, not a convincing process. To learn more about the system."*
Design thinking	Includes curiosity and not taking anything for granted, understanding the effect of an action, multilevel-thinking, ability to design starting from criteria for sustainability, taking responsibility for one's actions, and ability to frame and visualize. Draws competences mainly from *Understanding and linking to sustainability, Systems-thinking, Doing good/contributing* and *Mentality/Presence*.	*"Curiosity, it's the first thing. And not taking anything for certain. But then also to understand that there is a person somewhere that will be effected by what you do"*
Entrepreneurial thinking	Ability to make an intervention happen.	*"then you need entrepreneurial thinking, in order to make it happen"*
Transformative thinking	Understanding of change, transitions and transition systems, multilevel thinking, and ability to create an intervention that can bring about transformative change	*"then you need thinking about transition. How can this actually change the system, what is a transition, how can we understand that? With multilevel perspective and transitions system."*

4.2.2. The students' perceived development

In this section, the result and analysis of interviews conducted with four Challenge Lab students are presented, i.e. this study's answer to RQ2.2 (*What are some common examples of competences that the students at Challenge Lab perceive to have developed?*)[11]. In Section 4.2.2.1., the developed competences are presented, and in Section 4.2.2.2., developmentary conditions are discussed.

4.2.2.1. Developed competences

Through analysis of the key themes in the open questions of the student interviews, four categories of competences were developed, namely: *relating to others, relating to oneself, understanding sustainability and the world* and *doing*. The categories are interlinked, with some specific competences existing in the interface between two categories, see Figure 12.
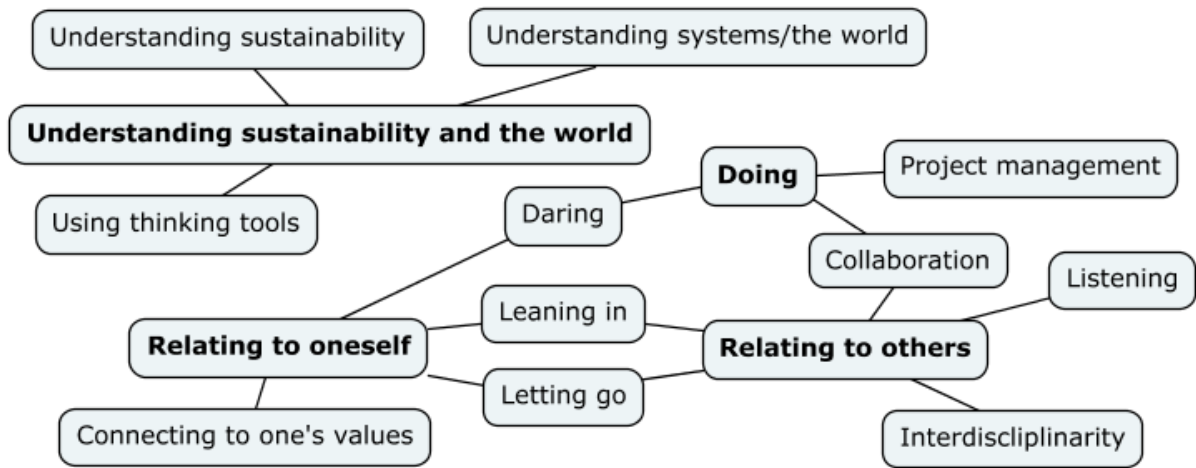
Figure 12: A graphical representation of the categories of competences which the four students perceive they have developed.

The categories, described with support of additional competences discussed in response to the aimed questions of the student interviews, are presented in Table 4. Further description and justification of the categories is given in Appendix C.

Generally, it was noted that the connections between all competences, which were discussed frequently by Challenge Lab personnel (see Section 4.2.1), were also represented in the student interviews, as exemplified by the following quote:

"*I think I could develop more of the technical skills here, but also soft skills by just working and doing the thesis. But connecting that to my thinking of the cultural and social change that needs*

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[11] Again, it needs to be noted that this study does not aim to cover the competence development of all students, but rather to procure some examples of competences that students perceive that they have developed.

to happen among society [...] I think the great thing here for me is that I can now combine all of this and understand how it all integrates with one another."

Table 4: Four categories capturing the type of competences the four Challenge Lab students perceived that they had developed.

Name of category	Description	Example quote
relating to others	through interdisciplinarity, collaboration, listening without judging, asking for help, trusting and stepping back to let others take the reins	*"I think I increased the level of being more open and to accept different ways or points of view [...]. And to not prejudge, before knowing someone."*
relating to oneself	through self-reflection, connecting to oneself, one's values and motivations, handling one's emotions through sharing and letting go of need for control	*"I am more able to step back and understand, to look at myself from a third perspective"*
understanding sustainability and the world	through theoretical frameworks, thinking tools and experience, with a broad perspective on sustainability	*"Viewing sustainability from the ecological constraint, with individual well-being at the top, but then having your social and economic pillars [...]. That framework has been very central, and it makes me then understand society, like in better context"*
doing	developing solutions taking different perspectives in to account, daring to explore and connect with stakeholders, management of oneself and one's team	*"Good experience of how to connect the stakeholders, how you contact the stakeholders, how you expose or talk about your project, and how to connect different and bring together to find a solution."*

In response to the aimed questions, all students also discussed the way in which they relate to sustainability personally. A clear transition that seems to have happened for most students is shifting their personal focus of sustainability to be more on social dimensions. This is exemplified below:

"I think [my view of engaging in sustainability] has changed or shifted, that the focus needs to be more on social sustainability and individual well-being, that it has shifted towards that much more. And it has probably gotten me more interested and motivated to work with things on that side of the spectrum."

Moreover, two students talked about being more motivated to engage in sustainability, as exemplified below:

"Now I know how to make a change, it will be an omission not to do it, at least not to try."

In this section, advantageous conditions for development mentioned in the student interviews are presented.

The most prevailing source of competence development referred to in the interviews are learning from interacting and working with the others students in the Lab. For example, this is referred to as a source of understanding of sustainability issues:

"Here you have the chance to talk about many different sustainability issues, and you're maybe not interested in half of them, but you still get to understand and learn about them by talking to and co-working with each other. I think that is very valuable, because then you get more input. […] Even though someone else does something completely different, you can share knowledge and perspective that you can then incorporate in your own project."

In addition, the diversity of the group of students, and stakeholders invited to the Lab, is referenced in the following quote:

"This is a very interactive environment. You get inspiration from so many different countries, from so many different disciplines, from companies and organizations."

Mental and physical space are also mentioned as a developmentary conditions:

"They give this space for us, very neutral and compassionate […]. Definitively a neutral, safe space, non-judging space, that comes with freedom to explore"

Another developmentary condition is the combination of theory and practice, illustrated in the following quote. The student talks about things that have helped to develop a sensitivity and awareness to ways of approaching collaboration, first mentioning theoretical frameworks introduced in Challenge Lab. *"And then also, from learning about that, and then seeing it in practice and experience in the Challenge Lab"*, referring to the manner in which the facilitators interact with the students.

4.3. Results from Step 3 – Adaption

In this section, identified differences and similarities (i.e. potential causes for learning through assimilation or accommodation) between earlier research and aspects of sustainability competences at Challenge Lab are presented, in order to identify areas of theory in need for development. Accordingly, this section aims to shed light on RQ2 "*What areas of development in sustainability competence theory can be identified through studying Challenge Lab using earlier research on sustainability competences as a theoretical lens?*". The conceptual analogy of Challenge Lab's contribution conceptually imagined as learning through adaption is shown in Figure 13 below.
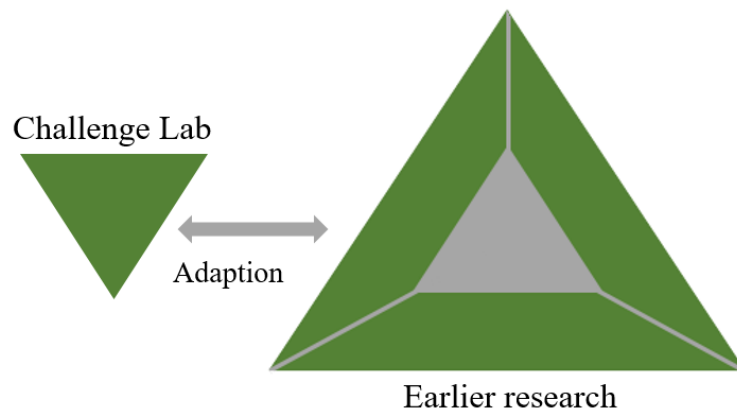
Figure 13: The results presented in Section 4.3 aim to capture Challenge Lab's contribution to furthering the understanding of sustainability competences (RQ2), i.e. the potential adaption of the metaphorical cognitive structure representing the understanding of sustainability competences held in earlier research (RQ1).

Generally it can be noted that there are major similarities between the view in earlier research and the perspectives on sustainability competences found at Challenge Lab. However, there are some differences in focus, and how competences are linked together. The importance of interlinkage in itself is supported in both earlier research (Wiek et al., 2011) and in the study of Challenge Lab.

Specifically, the differences and similarities between earlier research and aspects of sustainability competence at Challenge Lab are presented below for each of the competence category developed through literature review and subsequent analysis in Step 1 of the study.

4.3.1. Systems thinking

> *"ability to collectively analyze complex systems across different domains [...] and across different scales"*
> – Wiek et al. (2011, p. 207)

Although articulated differently, the systems-thinking competence described in earlier research (Wiek et al., 2011) and in the interview with Challenge Lab personnel show major similarities. Both are aimed at the analysis of systems, using causal, scalar, temporal and perspective or cultural dimensions. In the student interviews, although not explicitly mentioning ability to analyze complex systems, the most prominent reference to learnings related to systems thinking competence is the notion of using theoretical framework and thinking tools to better understand of how societal systems 'work'. Also, the respondents frequently mention developing a broader

perspective on sustainability. This could be interpreted as an ability to adopt a holistic view, and could therefore be a part of systems-thinking. One student references systems thinking explicitly, and states that it is a useful thinking tool in understanding why today's situation is not sustainable.

4.3.2. Trans-rational thinking

"ability to move beyond the rational reasoning of weighing facts and "sense" into socio-ecological systems, by looking for energy and seeing the system through the eyes of others"

Neither the personnel nor the students discussed any ability to 'sense' or 'feel' into systems or *actively* adopting others' perspectives[12]. However, potentially related to the concept of trans-rationality, some competences discussed at Challenge Lab revolves around being able to 'let go' and let things 'emerge'. In the interview with Challenge Lab personnel this was interpreted by the researcher as a certain mentality or presence, which includes adopting patience and being able to stay in complexity without rushing to solutions, being curious, able to handle uncertainty, having mental space to work with others and a willingness to trust and be open towards others[13]. In the student interviews, this was discussed together with the notion of 'stepping back', as a capacity to trust each other and let go of control. Also, this was related to the ability to 'let go' of one's own way of working. In addition, active listening, without judging, was discussed in all interviews, which could also build towards the notion of a certain needed presence. Accordingly, the manner in which the trans-rational competences was interpreted and conceptualized in this study was not represented at Challenge Lab. However, there are similar competences discussed at the Lab that might be aimed at trying to capture a similar dimension of sustainability competences.

4.3.3. Anticipatory competence

"ability to collectively analyze, evaluate, and craft rich "pictures" of the future"
– Wiek et al. (2011, p. 207, 209)

Since envisioning future solutions is the third step of the Backcasting process used at Challenge Lab, thinking into and analyzing the future was discussed in general terms, however not crafting and analyzing particular scenarios. Moreover, belonging to the first step of the Backcasting process, a need for an ability to identify criteria for what a sustainable future might be was stated, but doing this was described as necessitating a combination of systems thinking and understanding sustainability. Accordingly, it was unclear whether anticipatory competence could be looked upon as a basic category of competences in the context of the Challenge Lab. Moreover, the students made very few references to skills that are included in anticipatory competence as it was described by Wiek et al. (2011). Only some references to creativity and visualizing was made.

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[12] However, taking others perspectives into account was discussed, but rather as a rational (or logical) tool for analysis, or to be able to work together.
[13] However, it needs to be noted that "looking for energy" is a part of the Challenge Lab discourse, even though it was not referenced as a competence during the interviews.

4.3.4. Normative competence

"ability to collectively map, specify, apply, reconcile, and negotiate sustainability values,
principles, goals, and targets"
– Wiek et al. (2011, p. 209)

Although the definition of this competence found in Wiek et al. (2011) is rather specific, it could in broader terms be interpreted as an ability to deeply understand and analyze sustainability. There is much support for such competences in the study of Challenge Lab and understanding sustainability is represented as a key theme for both the interview with personnel and with students. When it comes to the dimensions of sustainability, the students at Challenge Lab all stated that they had gone from a narrow to a broad view of sustainability, particularly expanding their understanding of social sustainability.

4.3.5. Being and owning

"ability to recognize and assume one's responsibility for the furthering of sustainability,
contributing to sustainability in both professional and personal life, being optimistic and
brave"

Competences in this category were supported both in the group interview with Challenge Lab personnel (in the key theme *doing good/contributing*) and in the student interviews (only in response to aimed questions). Although, it needs to be noted that such aspects of sustainability competences were not discussed to the same extent as others. The ambition of Challenge Lab does not seem to be to develop certain values or attitudes in their students, but rather for the students to connect to their own values. However, having empathy and wanting to do something good for other people was discussed. Moreover, willingness to change personal life choices, and wanting to impact sustainability through one's professional life was referenced in the student interviews. In addition, developing courage and confidence was referred to both by personnel and students, and being more optimistic was discussed in the student interviews.

4.3.6. Strategic competence

"ability to collectively design and implement interventions, transitions, and transformative
governance strategies"
– Wiek et al. (2011, p. 210)

Since developing strategies and solutions to engage in transition processes is the focal point of doing a master's thesis at Challenge Lab it could be argued that strategic competences are automatically implied, and that the competences discussed in the interviews are all aimed at being successful in one's endeavor to design and implement transition initiatives. In addition, design thinking was a preformed category from the group interview with the Challenge Lab personnel, including skills that is stated to be important when designing in this sustainability context. Moreover, entrepreneurial skills were discussed, as an ability to get things done. In the student interviews, competences in *doing* are represented in a key theme, including skills in developing concepts taking human perspectives into account, daring to explore, connecting with external stakeholders and organizing oneself and one's team.

4.3.7. Leading with others

"ability to foster collective action towards sustainability, e.g. by supporting the development of others and networks of communication and mutual trust, and by connecting with internal and external stakeholders"

When it comes to supporting the development of others, the development of different aspects of group dynamics was discussed frequently in the student interviews (in the key theme *relating to others*). For example, ability to step back and let others lead was mentioned as an important part of working in teams. Moreover, giving and receiving feedback and support through asking for help and sharing fear and anxiety was discussed. Listening without judging was also referred to as an important ability, in both student interviews and the interview with Challenge Lab personnel. These aspects were often mentioned together with building trust. In addition, ability to network and connect with stakeholders was discussed. Generally, most referenced competences supporting the existence of this category could also fall in under *interpersonal skills*, as seen in the following section.

4.3.8. Interpersonal competence

"ability to motivate, enable, and facilitate collaborative and participatory sustainability research and problem solving"
– Wiek et al. (2011, p. 211)

Competences in this category was supported in the interview with Challenge Lab personnel (in the key theme *collaborating*) through the discussed ability and willingness to work together and take part in co-creation and dialogue (which is given extra focus), understanding of group dynamics, and ability to communicate and network. Moreover, support can also be found in student interview (in the key theme *relating to others*) through interdisciplinarity, collaboration, listening without judging, asking for help, trusting and stepping back to let others take the reins. Accordingly, mostly similarities can be found between the view in earlier research and the view at Challenge Lab when investigating interpersonal skills. However, particular skills such as dialoguing, active listening and trusting receives stronger focus at Challenge Lab than in the framework developed by Wiek et al. (2011).

4.3.9. Intrapersonal competence

"the ability to lead oneself and cope with the challenges that working with sustainability can entail, e.g. through self-reflection and embracing change and uncertainty"

Support for this category of competences can be found in both the Challenge Lab's ambitions (in the key theme *self-leadership*) and the students' perceived development (in the key theme *relating to oneself*). However, at Challenge there is a larger focus (in relation to earlier research) on the ability to connect to and reflect upon one's values and motivations, and ability to use this connection to guide decisions about one's projects and future. Ability to handle change and uncertainty was referenced in student interviews, mainly through sharing emotions in the group, and personnel interviews, mainly through enlarging one's understanding of the world and seeing that changes actually can be made with the right tools.

This concludes the presentation of results procured in the study. It needs to be noted that since answering RQ2 (identifying areas of development) necessitates argumentative text, this is done in the following section, Discussion.

5. Discussion

The discussion is divided in to three major parts, discussion of findings, discussion of research methodology and limitations and discussion of implications for and future research in the field of sustainability competences.

5.1. Discussion of findings

In this section, the results of this study is discussed and related to the context in which the study was undertaken. This discussion aims at summarizing the findings and their potential implication in relation to RQ1 (*What is the current view in research on sustainability competences in the areas of education and sustainability, leadership and sustainability* and *transition management?*) and RQ2 (*What areas of development in sustainability competence theory can be identified through studying Challenge Lab using earlier research on sustainability competences as a theoretical lens?*).

5.1.1. Findings on sustainability competences in earlier research and at Challenge Lab

This study found support in literature for nine categories of sustainability competences, namely *systems-thinking, anticipatory competence, normative competence, strategic competence, interpersonal competence* (Wiek et al., 2011)*, intrapersonal competence*, *being and owning, trans-rational thinking* and *leading with others.* Generally, sustainability competences seem to be discussed as *interlinked* sets or complexes of knowledge, skills and attitudes. These interconnections were discussed both in earlier research (e.g. Wiek et al., 2011) and at Challenge Lab (in both personnel and student interviews).

The five competence categories proposed by Wiek et al. (2011) (*systems-thinking, anticipatory competence, normative competence, strategic competence, interpersonal competence*) are presented as 'key' competences for sustainability. The distinction made in Wiek et al. (2011, p. 204) is that 'key' competences are "critically important for *sustainability* efforts, distinguishing them for those of other professions and academic programs", and basic skills such as critical thinking is therefore not included. Further, Wiek et al. (2011, p. 204) state that the division "emphasizes the competencies considered essential for sustainability that have not been the focus of traditional education and therefore require special attention". Through the choice of five 'key' competences, Wiek et al. (2011) propose such a division, but also recognize that further justification is needed in order to determine whether these competences actually help sustainability graduates to contribute to sustainability. Specifically, more empirical studies are needed in order to investigate this. Evidently, the same argument needs to be made regarding the four additional competence categories identified in this study (*intrapersonal competence, being and owning, trans-rational thinking* and *leading with others*), since only two of the articles reviewed in this study are based upon formal empirical research (Brown (2011) and Quinn and Dalton (2009)). Starting from the different criteria identified by Wiek et al. (2011) and the results in this study, some questions can and should be posed in regard to the nine developed competence categories in order to initiate the investigation to determine whether they can be looked upon as 'key' competences for sustainability:

❖ Are the competences in the category well-understood?
❖ Are they supported in key themes of the interviews conducted at Challenge Lab? If not, are there diverging conceptualizations that might be aimed at similar dimensions of sustainability competences?
❖ Are the competences in the category critical for sustainability?
❖ Are they different from general skills such as communication and critical thinking?
❖ Are they fostered by higher education in general?

In this study there are not grounds on which to answer or even to speculate in all questions regarding all nine competence categories, but some initial insights and potential for further investigation are discussed in the Sections 5.1.1.1-5.1.1.5 below, for five of the nine competences. In Section 5.1.1.6, a classification of the categories identified in earlier research is made in to three groups, starting from how well-understood and well-justified the competences are.

Four of the categories of competences proposed by Wiek et al. (2011) (*systems thinking, normative competence, strategic competence* and *interpersonal competence*) were clearly supported through the study of Challenge Lab undertaken in this thesis. Therefore, using the current findings, there is no evident ground on which to question these competences' importance for sustainability and their proposed status as 'key' competences. Moreover, they are well-structured and well-justified. Accordingly, these will not be discussed. Regarding the five remaining categories of competences (*anticipatory competence, intrapersonal competence, being and owning, leading with others* and *trans-rational thinking*), some further investigation or clarification is needed. This is especially true for *trans-rational thinking* and *leading with others* – the understanding of which are still tentative, seeing as no robust attempt to structure them in a well-defined model or framework was found in the literature review undertaken in this study.

5.1.1.1. Anticipatory competence

The fifth category of competence proposed by Wiek et al. (2011), anticipatory competence, was not supported in any of the key themes of the interviews conducted at Challenge Lab, and explicitly an instance of future-thinking discussed was expressed as a combination of systems thinking and understanding sustainability in the group interview. It should be noted however, that the Challenge Lab facilitation team did talk about thinking into the future and that the Backcasting process entails both identifying sustainability criteria situated in the future and envisioning future solutions. Consequently, it could be argued that anticipatory competences are implied, even if they are not verbalized as specific competences. Another note that needs to be made is that a common phrase in the Challenge Lab discourse is working with "painting the frame, not the picture". This refers to the impossibility and undesirability of describing the future in detail (Holmberg, 1998), and a consequent focus at Challenge Lab on thinking in broad terms about the future. This focus could explain the lack of discussion of learnings that relate to analyzing or crafting pictures of the future. In any case, the lack of references to anticipatory competences at Challenge Lab could call for further work with the conceptualization of anticipatory competence, trying to determine whether it is a critical competence to be able to "craft rich "pictures" of the future", as proposed by Wiek et al. (2011, p. 207, 209), or if it

suffices to "paint the frame, not the picture". Such an investigation is a potential area of development for the theory on sustainability competences.

5.1.1.2. Intrapersonal competence

Intrapersonal competences clearly differs from the five 'key' competences proposed by Wiek et al. (2011) since they are aimed at the individual possessing the competences, rather than the task at hand or the whole team that will carry it out. Therefore, most of the included competences falls only under this category, making such a category relevant for a framework for competences. However, more work needs to be done in determining whether such competences could be looked upon as 'key' competences for sustainability – if they are crucial for successfully contributing to sustainability. Starting from this study, very solid support for intrapersonal competences was found in both earlier publications on sustainability competences – where such skills were referenced for example in the context of being able to cope with uncertainty – and at Challenge Lab, where self-leadership is seen as a condition to be able to be actively looking, to take part and connect with others and to understand driving forces into the future among other things. Intrapersonal competences could possibly be classified as general skills relevant for all professionals, but one could hardly argue that such competences are generally fostered by regular higher education. Accordingly, expanding the understanding of intrapersonal competences in the sustainability context is a clear area of development for the field of sustainability competences. A relevant first step could be to investigate questions on the lines of "What are the core intrapersonal competences relevant for sustainability?" and "Does designing and implementing strategies for sustainability transitions always call for such intrapersonal competences?".

5.1.1.3. Being and owning

Being and owning also centers on the individual, but is directly aimed at the individual's relationship to sustainability. This category differs from the competences proposed by Wiek et al. (2011) since it is solely focused on attitudinal dimensions, such as willingness to engage in sustainability. Such competences were supported in both earlier research and at Challenge Lab. However, there is not a clear consensus whether education should strive to foster certain affective outcomes, as discussed by Shephard (2008) and Jickling (1992). Moreover, at Challenge Lab there is a large emphasis on connecting to one's values rather than to develop specific attitudes or values. Using this conceptualization, such competences might rather fall in under intrapersonal competences. In addition, only two of the four interviewed students talked about developing competences included in being and owning, one of which emphasized the importance of sharing and discussing personal life choices with one's team or other peers. This could mean that these competences belong together with interpersonal skills or leading with others. Accordingly, unraveling some of these details and subsequently determining whether there is justification for such competences being 'key' for sustainability could be a potential area of development for the field of sustainability competences.

5.1.1.4. Leading with others

Not being as clearly defined, many of the competences in this category could be seen as included in interpersonal competence, as proposed by Wiek et al. (2011). However, most of the competences in leading with others have higher claims than "ability to motivate, enable, and facilitate collaborative and participatory sustainability research and problem solving" (Wiek et al., 2011), for example *ability to foster trust* or *ability to support the development of others*. A separating aspect could be that the competences in leading with others have a different time scale, looking at leadership and development over longer time periods. Another potential separating aspect could be the object of study, viewing leadership on individual level versus at a collective or process level, as discussed in Section 4.1.1.2 guided for example by complexity leadership (Uhl-Bien et al., 2007). In any case, competences included in leading with others were supported at Challenge Lab, in both personnel and student interviews. At the Lab, active listening is often mentioned as a way to build trust. However, the competences in this category is often described in rather general terms in earlier research. For example, the authors seldom come all the way to describing the dynamics of building trust and what capabilities are needed to do so. Specifically, there is very little research done in this area from an educational point of view. This could imply that such competences constitutes an area of development for the theory on sustainability competences.

5.1.1.5. Trans-rational thinking

When investigating sustainability competences at Challenge Lab through individual and group interviews, no support could be found for competences in trans-rational thinking, at least with the conceptualization the category was given in this study. However, this category of competences, laying close to spirituality and other kinds of non-technical ways of understanding the world, is largely unchartered by research on sustainability competences. Moreover, the intangible quality which they aim to capture makes them difficult to verbalize, leading to figurative descriptions (such as the 'sensing', proposed by Brown (2011)) and subsequent difficulties in evaluating the consistency of two different conceptualizations. Additionally, competences in this area are very far from being included in classical engineering education, and are probably very foreign to the average engineer, potentially explaining the lack of references to such skills. The competences discussed at the Lab and interpreted by the author of this thesis as a certain mentality or presence might be aimed at trying to capture the same dimension of sustainability competences as the competences included in trans-rational thinking.

This competence category was developed mainly guided by Brown's (2011) concept of intuitive decision-making and 'getting out of the way' in order to 'harvest' insights that one could use to supplement rational thinking. This could be interpreted as a competence one could actively invoke in order to understand a challenge or procure additional information. In contrast, at Challenge Lab 'letting go' was discussed to a large extent, which seems to rather describe a state of mind which is important in order not to miss out on the signals, opportunities or information emanating from the system or from a situation. The manner in which the competence is conceptualized by Brown (2011) resembles expert decision making (see for example Shanteau (1988)), while the conceptualization at Challenge Lab rather seems built upon theories of emergence (see for example Lichtenstein and Plowman (2009)).

Regardless of conceptualization used, less deterministic and technical approaches and competences could be relevant in order to handle the complex dynamic and wickedness of sustainability challenges. Since the systems in themselves cannot be properly defined without reducing their complexity, the same might be true for the solutions. Consequently, solutions or insights which are not 'only' based upon explainable rationale might be needed in response to certain sustainability challenges. Accordingly, investigating this possibility, trying to reconcile the views of 'harvesting' and 'letting go' , investigating further the role of expert decision making in sustainability, particularly in a collaborative setting, could be potential areas of development for the theory on sustainability competences.

5.1.1.6. Classification of categories

To summarize the discussion of findings, starting from the questions specified in Section 5.1.1 and the arguments made in Sections 5.1.1.1-5.1.1.5, the categories identified in earlier research can be classified in to three groups, aiming to capture how well-understood and well-justified they are. The three groups are:

- ❖ *solid*, i.e. categories that are well-supported in earlier research and at Challenge Lab and well-understood, in relation to which there is no information in this study that questions their status as 'key' competences for sustainability;
- ❖ *strong*, i.e. categories that are well-supported in earlier research and at Challenge Lab, but are in need of some further clarification in regards to conceptualization or justification; and.
- ❖ *unclear*, i.e. categories that might be well-supported in this study, but are not well-understood and need further investigation before arguments can be properly made regarding their status as 'key' competences.

The classification of the categories into these three groups is shown below in Table 5.

Table 5: A classification of the nine categories identified in earlier research into three groups, aiming to capture how well-understood and well-justified they are

Solid categories	Strong categories	Unclear categories
Systems-thinking	Anticipatory competence	Trans-rational thinking
Normative competence	Being and owning	Leading with others
Strategic competence	Intrapersonal competence	
Interpersonal competence		

5.2. Methodological discussion

In this section, the research methodology used to undertake this study will be discussed. First, the research approach is discussed in relation to the study conducted by Wiek et al. (2011). Then, implications of the methods used are examined followed by discussion of the analysis procedure.

5.2.1. Research approach

When initiating this thesis, the aim of the study was to find a framework for sustainability competences and subsequently to "measure" the extent to which the Challenge Lab students perceived they had developed these competences. A trace of this ambition can be found in Appendix B, describing a survey undertaken in the beginning of the Challenge Lab master thesis course. Later on, it became apparent that this task was far too great, mostly stemming from difficulties is procuring reliable measures of level of competence. Moreover, the areas of competences in themselves needed, and still needs, further understanding.

The aim of the study undertaken by Wiek et al. (2011) was to find a synthesis of contemporary discussions of competences in sustainability education. The main method in finding this synthesis was literature review, and simple methods for categorization. In these regards, the study undertaken by Wiek et al. (2011) is rather similar to this study. However, there are two major and interlinked differences in the carrying out of the study. Firstly, where Wiek et al. (2011) focuses on finding a well-defined, well-justified and structured set of competences using literature on education and sustainability, this study takes on a broader scope and includes two other fields of research, leadership and transition management, settling for a more loosely defined set of competences, and linking to a particular educational context, Challenge Lab, in order to procure some further understanding of how these competences might be conceptualized in a real-world setting. This choice might reduce the validity of the competence categories. However, it also build towards more flexibility and rather to set in stone certain key competences, instead points towards potential areas of competences that might be relevant for sustainability. Secondly, this study was undertaken by one person, while the study presented in Wiek et al. (2011) was conducted by three researchers, with guidance from "continuous exchange with colleagues engaged in sustainability programs around the world" (Wiek et al., 2011, p. 206). As discussed in Section 3.1 and Section 5.2.3, the analysis procedure used in this study is highly subjected to the researcher's decisions and understanding. Accordingly, in order to procure a relevant more structured framework for sustainability competences, it was deemed that this study would need to have involved many other researchers. Since this did not seem feasible, seeing as it would demand many workhours from people who could not be formally accredited the publication of this study (since the study was undertaken as a master's thesis), the study focused on identifying competence categories, rather than developing a structured and well-justified framework. To capture the difference in research approach, one could visualize the study done by Wiek et al. (2011) as zooming-in on a closed set of sustainability competences, while this study starts from the position specified by Wiek et al. and zooms out again, trying to determine if there are more areas of competences that could and should be included.

Using a mixed methodology approach, studying both earlier publications and a specific educational context, Challenge Lab, rendered some needed clarity in response to the abstract nature of sustainability competences. In addition, since Challenge Lab could be seen as a novel educational initiative, a strategic sustainability tool for Chalmers and a regional transition arena, this environment gave relevant insights into contemporary views on sustainability competences.

5.2.2. Methods used

In this section, the methods used for gathering of data is briefly discussed. Since the observations and survey used in the study do not build towards any specific conclusions, these will not be examined in this discussion.

5.2.2.1. Literature review

As was stated in the beginning of Sections 4.1.1.1-4.1.1.3, the literature review on the areas of education and sustainability, leadership and sustainability and transition management was not entirely straightforward. Three main obstacles were encountered, described in the sections below.

Firstly, in the field of education and sustainability there are massive amounts of publications on specific competences for sustainability (e.g. interdiscliplinarity), intended learning outcomes for sustainability courses, approaches to learning for sustainability and frameworks for sustainability competences. The abundance of articles, and the existence of a framework based upon a relatively recent literature review in education and sustainability guided the decision to adopt Wiek et al. (2011) as a key framework, and a starting point for the literature review. Accordingly, Wiek et al. (2011) was chosen to represent the most part of earlier knowledge held in the field of sustainability and education. Of course, it might had been beneficial to repeat the literature review and analysis conducted by Wiek et al. (2011). However, this was deemed to be too time consuming.

Secondly, in the field of leadership and sustainability, there is no clearly established 'sustainability leadership' concept. Accordingly, reviewing the area of sustainability and leadership could have been a study in itself. Although making the task at hand more difficult, it also highlights the need for studies such as this one. The lack of convergence in this field led to a necessity of picking and choosing publications with perceived relevance. These choices could have been more systematic, and potentially relevant publications might have been omitted. Moreover, when it comes to articles explicitly specifying sustainability competences (rather than behaviors or approaches), not many publications were found. Accordingly, finding relevant, well-cited literature was rather difficult. This necessitated some use of less cited literature (e.g. Senge et al., 2015) and articles where the competences were mentioned more implicitly (e.g. Kotter, 1995).

Thirdly, the field of transition management is rather young, and consequently very little have been written in this area on sustainability competences. Also, the two articles found and used (Jansen et al., 2008; Wals and Schwarzin, 2012) had few citations, and subsequently, their relevance might be questionable.

Generally, it needs to be noted that in the preparatory course, Challenge Lab uses a set of articles, some of which are related to sustainability competences. Only one of these articles overlap with the publications reviewed in this study. Accordingly, more support and interpretation for the competences suggested in this thesis could probably be found in those articles. Moreover, had there been significant overlap with the articles used at Challenge Lab, one could question if studying Challenge Lab would have rendered any new information.

5.2.2.2. Interviews

Interviews were chosen as the main method for gathering of data on sustainability competences at Challenge Lab, using arguments presented in Sections 3.3.2 and 3.3.3. Through the interviews, many perspectives on competences could be inquired into and many interpretations could subsequently help guide the analysis of areas of development for sustainability theory. Numerous examples of these interpretations are shown in Section 4.2, and in Appendix A and C. Apart from rendering many interpretations, the interviews also provided opportunities for Challenge Lab personnel and students to reflect upon what might be important sustainability competences.

Since competences are abstract, it was not evident that the students and the facilitation team would be able to verbalize their thoughts and experiences in relation to this subject. However, all respondents seemed comfortable with both reflecting upon themselves, explaining, exemplifying and elaborating their statements. The facilitation team had evidently discussed competences before the interview since there were pre-formed competence concepts in the discourse at the Lab. Moreover, two of the interviewed student had participated in the preparatory course, which includes literature on sustainability competences and an assignment on reflection upon one's own competences. Accordingly, this study was helped by the fact that Challenge Lab is an environment that supports self-reflection and awareness of competences. If the study were to be repeated in a different educational context, more consideration of interview design might be necessary in order to enable a successful data gathering. For example, the interviewer would potentially have to go for a more structured approach. Generally, an advantage of a more structured approach (for example asking more and more specific questions, e.g. specifically about ability to analyze complex systems) could be the procurement of data that is easier to relate to the earlier research which was used to construct the interviews. However, this could entail steering the conversation too much in a particular direction, thereby affecting the results in a potentially unwanted manner.

In the group interview with Challenge Lab personnel, some competence areas were discussed using labeled concepts (e.g. self-leadership), i.e. there was pre-formed conceptualizations of competences categories. Since these concepts had been used at the Lab beforehand, observed in the discourse at the Lab, these could be inquired into during the interview, rendering a way to attain deeper understanding of the competences that Challenge Lab aim to foster. On the other hand, the origin of the concepts was not investigated, and it is unclear how they might affect the manner in which other sustainability competences are discussed at the Lab. It is also possible that, when undertaking the analysis, the existence of pre-formed categories obscured other dominant themes discussed in the interview.

5.2.3. Analysis procedure

As pointed out by Thomas (2006) and discussed in Section 3.1, the analysis procedure used in developing the categories out of gathered competences from literature and interviews is highly subjected to the preconceptions of the researcher. Accordingly, some notes need to be made on how these might have influenced the result of the study. In order to facilitate this discussion without having to use overly cumbersome language, this will be discussed in first person.

My view of competences may be less focused on activity, in relation to the view of certain other researchers. I find myself looking upon competences in their truest form as pre-requisites, something that an individual need to have, that one can acquire and that lay dormant inside the individual, and that are largely context independent. When undertaking a task, I believe that a specific permutation of these competences is activated and directed at the task. Accordingly, I do not always perceive the ability to complete a certain task (e.g. ability to design a strategy) as a competence, but rather the skills or knowledge needed (e.g. analytical and strategic thinking). This pursuit to find 'the basic components', might be hopeless, and might obscure patterns in data that would be evident to another researcher.

Another potential effect of perceptions of sustainability competences is that early findings in the study might have guided later findings. For example, the key theme *mentality/presence* competence category developed from the Challenge Lab interview might not have been identified if *trans-rational* competence had not been identified through literature study. Being guided by earlier research in analyzing data is of course natural, but since a comparison were to be made between the two sources (earlier research and Challenge Lab), it would have been beneficial if both could have been been analyzed initially without guidance from the other.

Starting from the limitations of individually conducting a study built upon general inductive analysis, measures could have been taken in order to make the study more systematic and more easily reproducible. For example, when conducting the literature study, interviews and analysis, distinct criteria to use in order to identify competences from the texts and transcripts had not been specified. This could have helped to make the analysis more robust, and to procure a better understanding of the concept of competence. The view of competences evolved during the undertaking of the study and if it had been conducted again, the results would probably have differed somewhat to the current study. Also, defining criteria on how to identify competences could have made the study more repeatable for others.

5.3 Looking forward

In this final section of the discussion, future research will be discussed. However, firstly a short discussion of Challenge Lab in itself will be presented.

5.3.1. Challenge Lab as an educational initiative

Even though this study does not aim to provide any evaluation of Challenge Lab or specifically investigate educational praxis used to foster sustainability competences, it does seem proper to shortly discuss such aspects here, in order to potentially motivate and guide further studies on Challenge Lab.

First and foremost, all four students interviewed in this study were very satisfied with the choice of doing their master thesis at Challenge Lab. The impression was that the experience and the facilitation team had met and gone beyond the expectations of the students. The students talked about feeling heard, important, empowered. In addition, after partaking in the Challenge Lab experience, they perceived to have developed many of the competences that the Challenge Lab team aimed to foster, which in turn are very similar to the sustainability competences identified in this study through review of earlier research. Accordingly, Challenge Lab seems to aiming towards and managing to help their students in developing relevant, contemporary sustainability competences. Accordingly, investigating the impact on the students further, and the justifications used to motivate the choice of intended competence development at Challenge Lab could help guide research on sustainability competences.

Moreover, starting from major similarities with the key learning processes for education for sustainable development identified by Tilbury (2011) (see Section 2.2), i.e. "processes of collaboration and dialogue", "processes which engage the 'whole system'", "processes which stimulate innovation within curricula as well as through teaching and learning experiences" and "processes of active and participatory learning" (Tilbury, 2011, p. 39), the educational approach used in Challenge Lab seems to hold many merits. Additionally, the students mention several beneficial developmentary conditions, presented in Section 4.2.2.2, such as interacting in a heterogeneous group, getting mental and physical space, and learning from a combination of theory and practice. Accordingly, future research on the subject of Challenge Lab in itself could be relevant for the field of education and sustainability, in order to determine what aspects of the learning experience are crucial for developing relevant sustainability competences and subsequently guiding other courses. In addition, since the Challenge Lab students actually are working in transition processes, well-needed empirical research could be done at Challenge Lab in order to determine what competences contribute to the success of transitions.

5.3.2. Moving onward with sustainability competences

There are, naturally, many areas not chartered by this study. For example, there are major research done into specific competence areas that is omitted (e.g. transdisciplinarity competences, transboundary competences), modes of learning not discussed (e.g. transgressive learning, transformational learning) and justifications for sustainability competences not specified. So, to claim that this study has answered its first research question, i.e. "*What is the current view in research on sustainability competences in the areas of education and*

sustainability, leadership and sustainability and transition management?", would probably seem like an exaggeration. However, some understanding of the predominantly discussed competences have been procured (RQ1), and further, potential areas of development for sustainability competence theory have been identified (RQ2). Investigating these areas could subsequently contribute to convergence into an established field, moving towards discussion of a common set of sustainability competences in the fields of education, leadership and transition management.

In order to achieve this, and find a well-defined and well-justified set of sustainability competences that can help sustainability graduates handle sustainability challenges and design and implement strategies for sustainable transitions, more empirical research is needed, investigating what competences actually are correlated with being successful in sustainability endeavors. At the moment, most publications to be found are based on curricula designs or simply on the authors' own view. Their views are presumably built upon experience of the field, but empirical research could give more legitimacy, and could possibly help the field to stay away from only continuously expanding the range of competences to include. Also, in order to contribute to convergence, this research needs to be done in close collaboration between researchers on education and sustainability, leadership and sustainability and transition management (and other potentially relevant fields), in order to incorporate many perspectives and battle the effects of subjectivity inherent to the study of competences.

Finding a set of sustainability competences might not be enough. Further, to operationalize the competences, intended learning outcomes might need to be formulated, in order to guide higher education[14]. At least, that would be the business as usual approach to developing curricula. However, a necessary aspect of integration to be taken into account in the work is the interconnectivity of sustainability competences. There is not enough information in this study to draw any solid conclusion from the interconnections between competence areas, however it seems clear that the competences does not exist in isolation. This could potentially indicate that in order to be successful in fostering sustainability competences, higher education needs to adopt a holistic view of competences, not reducing their complexity by seeing them as simply a sum of separate parts. Accordingly, there might be a need to balance clear guidance though the concreteness of intended learning outcomes, and clear communication of the importance of interconnectivity of competences.

What seems certain is that university praxis might need to be transformed in order to enable more educational initiative like Challenge Lab, where students get to engage personally in sustainability, meet real-life challenges and cooperate with other students and external stakeholders. If this is achieved, then higher education could be able to provide students with the opportunity to develop the "awareness, knowledge, skills and values needed to create a just and sustainable future" (Cortese, 2003, p. 17). If this is achieved, then higher education institutions might be able to fulfill their profound moral responsibility.

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[14] A process which has already been initiated, for example in Wiek et al. (2015)

6. Conclusion

Starting from the areas of education and sustainability, leadership and sustainability and transition management, this study shows support in earlier research for at least nine categories of competences relevant for working with sustainability, namely *systems-thinking, anticipatory competence, normative competence, strategic competence, interpersonal competence* (Wiek et al., 2011)*, intrapersonal competence*, *being and owning, trans-rational thinking* and *leading with others*. These seem to be intricately interlinked. However, it remains to be determined which of the categories can be looked upon as 'key' competences for sustainability.

The study also shows major similarities in the competence categories identified from earlier research, the competences that Challenge Lab aim to foster and the perceived competence development of the Challenge Lab students. Moreover, differences and similarities between earlier research and perspectives on sustainability competences at Challenge Lab point towards further clarification and justification of *anticipatory competences, intrapersonal competences* and specific attitudinal aspects (*being and owning*), as well as further investigation of less tangible ways of understanding systems and challenges (*trans-rational thinking*), and collective leadership competences guided by theories of emergence and complexity (*leading with others*) as potential areas of development for sustainability competence theory.

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Appendices

Appendix A – Key themes from interview with Challenge Lab personnel

In this appendix, the ten categories used to describe the key themes discussed in the interview with Challenge Lab personnel are presented in further detail. Note that these represent this study's answer to RQ2.1 (*What competences does Challenge Lab aim to foster?*).

Understanding and linking to sustainability

The first identified basic category is the ability to understand and link all activities and other competences to sustainability, coupled with the ability to understand sustainability principles, create sustainability criteria for the future. This was mentioned numerous times during the interview, illustrated by the quotes below.

"*In order to work with Backcasting, first you have to have competences related to how to identify criteria for the future, that means systems thinking and understanding sustainability*"

"*We go all the way to "why is this a problem" with the basic criteria for sustainability, instead of reducing problems to parts*"

"*And in our case, we also need good competence in linking the 'why' issue all the way up to some criteria for sustainability. [...] It is not okay just to say "this is fun" or "this is effective", but how does it link to social, ecological, economical dimensions of sustainability?*"

The focus on sustainability is further illuminated by the following:

"*We have to understand and stay in the question, and the global perspective, humanity perspective. What space of change do we have in the global society, into the future, how can we understand that from different perspectives? From the societal perspective – how can we live on earth together? From natural perspective – how can we fit within the natural boundaries? And economical perspective – how can we safeguard resources in to the future. But also well-being, what is good life, what is a good society?*"

Systems-thinking

The second competence category identified is systems-thinking – the ability to analyze systems, see causality, interconnections, to analyze in short term and long term, local and global, to understand something from different perspectives and adopt a holistic view. The components of this category is illustrated by the following quotes answering the question "*What competences are in systems-thinking?*":

"*To see the connections. Cause and effects*"

"*Another important part is to zoom-in and zoom-out. To iterate in time, long-term, short-term. To see it from different perspectives, different disciplinary perspective, knowledge-perspective. Maybe culture perspective, is a way of systems thinking, to look at the same thing from different*

perspectives. So there is a time dimension in this systems-thinking, it is a scale dimension in this system thinking, there is a knowledge dimension, a cultural dimension in systems thinking, there is a causal dimension in systems-thinking"

"*It also prevents something that is always taught and it's in our paradigm right now, the reductionistic thinking*"

The use of systems-thinking is exemplified below:

"*In order to work with Backcasting, first you have to have competences related to how to identify criteria for the future, that means systems thinking and understanding sustainability*"

"*And then you need competences to analyze today's situation – that means systems thinking*"

"*And then you have an idea about the gap between the two, and when you have that you need to have some systems thinking, in analyzing leverage points*"

Self-leadership

This category includes understanding of and ability to reflect upon one's values and strengths, one's driving forces, ability to be pro-active and have confidence and courage. The components of self-leadership is illustrated by the following quotes:

"*The idea with self-leadership are many, but one is to really take the students seriously. As individuals. […] That is the starting point for them to understand that they are important, their life and their contribution, their knowledge and their background in their countries is important*"

"*More than that if it also helps them to identify and reflect on their values and their strengths*"

"*So this self-leadership is also there to […] create some courage*"

The stated need for self-leadership is expressed below:

"*…and then we a space on personal level. How can I challenge my own assumptions, my own willingness to collaborate? […] also braveness, to take a step outside the comfort zone? And then we need some self-leadership and maybe some entrepreneurial skills in doing that.*"

"*And you also need to have an understanding of your own values, and strength, that is related to this driving force in the future*"

"*And then, on the personal level, in order to take part in all this – what are my own values, how can I actually contribute to this? How can I test ideas, how do I dare to take part in things?*"

"*To be actively looking you have to understand yourself, to know what you want, what you want to do, and what you want for the world, and for yourself. I think that this is an important part of being a self-leader, to be more pro-active. But also, you need the confidence, and to know that you're important*"

Collaborative skills includes ability and willingness to work together and take part in co-creation, understanding of group dynamics, ability to communicate and network. Such skills were mentioned numerous times, however not under a specific label:

"*we have to work with more than one issue at a time, and together.*"

"*every engineer do work in a group of persons and has to be quite communicative, and so we talk a lot about how it affects others, the planet, other persons, how we can connect with other persons*"

"*How can I challenge my own assumptions, my own willingness to collaborate?*"

An additional major part of this competence category is the ability to dialogue, including competences that are described in the section 'Dialoguing' below.

Doing good/contributing

This emergent competence category includes the ability to bring knowledge to something good for other people, to use one's power to make good, to have empathy and care for others, take responsibility for one's actions and acknowledge that one's contribution is important. These competences are illustrated by the following quotes:

"*So it's a lot about people, how to take all this knowledge that they have and bring it to something good, for other people*"

"*It is very important that […] they learn to use that power to make good*"

"*it kind of comes down to that you care for your fellow beings, some kind of empathy. It's not just about innovating stuff, it's actually about taking care of the planet and the other persons*"

"*You should take responsibility for what you do. And then you understand 'What is the outcome if I do something here – if I go up and mess around with this system?' Something will happen*"

Mentality/presence

The second emerging category describes a state of mind that is relevant for working with sustainability. This includes having patience, being able to stay in a question or a complex problem without rushing to solutions, being curious and able to cope with uncertainty, having a mental space for working with others, an ability to be open and willingness to trust and actively listen to others. Such competences are highlighted below:

"*To be really skilled in this Backcasting, they need to be patient, and stay in the question, to really stay there, before they run in to solution*"

"*And that means that we have to work together, we have to create some space to work together, and we have to have the mental space to take part in that meeting*"

"what it also brings is a new way for students to psychologically cope with the situation that they stand in front of"

"you have to be, curious about it, you have to understand it, it is a bigger picture, you always have to take a look around, not think that you have everything certain"

Dialoguing

This competence category was one of the most discussed since dialogue is central to the Challenge Lab methodology, and forms an aimed category since dialoguing ultimately can be looked upon as a kind of collaboration. Hence, this aimed category is mainly a subset of the category *collaborating*, but also includes aspects of all other basic competence categories. This competence includes understanding of the concept dialogue, being able to work together by talking and active listening, being able to learn about others' perspectives, thereby extracting information about a system or issue, being able foster and find inspiration, innovation and be creativity through dialogue. The category is illustrated by the following quotes answering the question "*What competences do you need to be skilled at dialoguing?*":

"…understand what the dialogue is, it is not debate, it's something else"

"It is a way of working together by talking"

"A dialogue is mainly about learning and understanding more about others perspectives on a certain thing. It is a learning process, not a convincing process. To learn more about the system."

"…there is also creativity and innovation in the dialogue"

The interconnectivity of the competences in general, and dialoguing in particular is illustrated by the following quote:

"The dialogue in C-Lab means that you also have an understanding of the big picture, in order to relate to those criteria and to link to that. It also relates to design processes, and it relates to everything. For us, dialogue is not inseperate, self-leadership is not inseperate. Systems-thinking and so on. They are interlinked, so you need to have experience and knowledge about the outer system, in order to have good dialogue. Otherwise it is not a challenge lab dialogue, otherwise it is a dialogue anywhere."

Design thinking

This aimed category mainly draws competences from *Understanding and linking to sustainability, Systems-thinking, Doing good/contributing* and *Mentality/presence*. The category includes competences such as curiosity and not taking anything for granted, understanding the effect of an action, multilevel-thinking, ability to design starting from criteria for sustainability, taking responsibility for one's actions, and ability to frame and visualize. The components are illustrated in the following quotes, answering the question "What competences are in 'design-thinking'?":

"Curiosity, it's the first thing. And not taking anything for certain. But then also to understand that there is a person somewhere that will be effected by what you do"

"And in our case, we also need good competence in linking the 'why' issue all the way up to some criteria for sustainability"

"You should take responsibility for what you do, and then you understand what is the outcome if I do something here If I go up and mess around with this system, something will happen and I need to find out what is happening"

"It is a multilevel thinking in the way that we talk about designing for those needs that the system have, or the boundaries that the Earth have"

The use of design thinking can be exemplified with following quote:

"...when you have that [an analysis of leverage points in a transition process], you have a need, that is entering the design process. Then you need competence to do design thinking, going from need to something that is a concept"

Entrepreneurial skills

This category was not well-established during the interview, but was mentioned explicitly twice. This competence was described briefly as the ability to make an intervention actually happen, to get it done. Consequently, in this context and analysis, this category was deemed an aimed category formed by a combination of mainly competences in *Self-leadership, Collaborating* and *Doing good/contributing*. References to the competence are shown below:

"How can I challenge my own assumptions, my own willingness to collaborate? [...] also braveness, to take a step outside the comfort zone? And then we need some self-leadership and maybe some entrepreneurial skills in doing that, to be able to do that"

"then you need entrepreneurial thinking, in order to make it happen"

Transformative thinking

This competence includes understanding of change, transitions and transition systems, multilevel thinking, and ability to create an intervention that could bring about transformative change. This category draws competences mainly from *Understanding and linking to sustainability* and *Systems-thinking*. The competence is exemplified below:

"...then you have a research question, [...] and then you need thinking about transition. How can this actually change the system, what is a transition, how can we understand that? With multilevel perspective and transitions system."

"...you need a Backcasting process to make it transformative in that that you have to go into the future, starting with principles, in order to challenge the existing system."

Appendix B – Survey with Challenge Lab students

A survey investigating how students perceived their level of competence in the area of sustainable development was conducted in the beginning of this study, in the first week of the Challenge Lab process, i.e. during the four week start-up phase. The aim was, originally, to enable a 'before' and 'after' comparison of how the students at the Lab perceived their competences. However, as the study progressed, the aim of the study shifted from trying to 'measure' impact on students to shedding some light on how the competences identified in this study could be interpreted, and in what way the students felt they had developed these competences. Therefore, the survey was instead used as a basis for selection when choosing which students to interview (see Section 3.3.3.3), enabling different perspectives on the competences studied.

The survey consisted of 79 items, divided into three main areas: *knowledge, skills* and *attitudes*. All items were statements. The respondents were prompted to rate the extent to which they agreed with the statements presented, on a scale from **1 = disagree completely** to **7 = agree completely**.   A small, modified excerpt from the survey is presented below in Table 6.

Table 6: A modified excerpt from the survey used as a basis for selection of Challenge Lab students to interview. The first item aims to capture an attitudinal aspect, the second an understanding and the third a skill.

	1	2	3	4	5	6	7	I cannot assess
I believe that society can transition into a sustainable state								
I have understanding of the principles of a sustainable state								
I have the ability to participate in collaborative sustainability problem solving								

Constructing the survey

Since the survey was constructed very early in the process, only a minor part of the literature reviewed in this study was used in constructing the items. The sources used were Jordan (2011), Kearins and Springett (2003), Kelly (2006), Parker et al. (2004), Segalàs et al. (2009), Senge (2015), Sterling and Thomas (2006), Svanström et al. (2008) and Wiek et al. (2011). The construction was made using guidelines set up by Braun et al. (2012), resulting in the following considerations:

- ❖ the research intention was not included in the questionnaire, as it could influence the information provided by the respondents;
- ❖ the only demographic question (*Did you participate in the preparatory course?*) was put last, since it might impact the respondents' perceived competence;
- ❖ social desirability was counteracted, by making the surveys anonymous, stressing the fact that the answers will not affect the students, and that honest answers might help Challenge Lab, when introducing the questionnaire;
- ❖ statements were worded in a manner consistent with the discourse at the Lab, using similar terms and concepts;

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- agreement items, since they are less vulnerable to different interpretations than frequency scales; and,
- only positive numbers was used on the response scale, because this increases the likelihood of respondents using the entire scale (Braun et al., 2012)

Analysis

The aim of the survey analysis was to find three respondents showing variety in perceived competence in the beginning of the Challenge Lab experience. To aid this analysis, a spatial analogy was made, illustrating the nine competences studied as a number of dimensions in a multi-dimensional space S_C. This analogy is based upon the fact that even though the competences are closely intertwined, they were constructed so that there would not be significant overlap in their content. Accordingly, it could be stated that none of them could be constructed solely by a combination of the others[15], therefore qualifying them to be a set of *basis vectors* spanning a nine-dimensional room. This analogy enabled a study of 'distance' between respondents' self-assessed competences. Before the analogy is described, a number of definitions needs to be made:

- R_j, where $j = 1, \dots, 12$, is each respondent to the survey
- Q_k, where $k = 1, \dots, 77$, is each item (i.e. questions and statements) in the survey
- q_{jk} is R_j:s response to Q_k, (accordingly $q_{jk} \in \{1,2,3,4,5,6,7\} \, \forall \, j, k$)
- C_i, where $i = 1, \dots, 9$, is the nine competences that was identified in this study
- S_C, is a nine dimensional 'competence room' spanned by $\{C_i\}$
- x_{ij}, is 'competence-coordinates' in the vector X_j, describing R_j:s position in S_C

Each competence C_i, where $i = 1, \dots, 9$, represent one dimension of S_C, which could therefore be looked upon as a nine-dimensional 'competence room'. The respondents R_j had a certain position in S_C at the beginning of the Challenge Lab experience. This position was estimated by self-assessment in the survey. The estimated position of respondent R_j is described by the set of coordinates x_{ij}, in the vector X_j, for each respondent.

To be able to calculate the estimated coordinates, every competence C_i were assigned a subset of the items (i.e. questions and statements) in the survey, Q_k, where $k = 1, \dots, 77$. Naturally, these items were those that captured some aspect of the competence category C_i. For example, the item I_{37} – "I have the ability to analyze complex systems across different domains (society, environment, economy, etc.)" – was assigned to the competence C_1, *Systems thinking*. Similarly, I_4 – "I have a willingness to act for a more sustainable future in my professional life" – was assigned to C_7, *Being and owning*. Accordingly, each competence C_i included a number of items Q_k. The number of items assigned to each competence varied from 0 to 11. For each respondent R_j, the answers to each item Q_k were denoted q_{jk}.

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[15]Compare with the concept of *linear independence*

The position of R_j in S_C (the coordinates x_{ij}) could then be calculated by summing all answers q_{jk}, divided by the maximum score possible (7), for all items Q_k assigned to each competence C_i respectively, i.e.

$$x_{ij} = \sum \frac{q_{jk}}{7}, \text{ for } k \text{ such that } Q_k \in C_i.$$

This was calculated for all respondents. The coordinates assigned to a respondents was named the 'competence profile' X_j of the respondent R_j, since the coordinates also denotes the percentage of maximum score for each competence for each respondent. X_j, the position of R_j in S_C, gives a picture of what competences R_j perceived having. In order to relate the positions to each other, a mean position was calculated, and denote the mean 'competence profile', M. The coordinates of M, m_i, were calculated by taking the mean for all coordinates assigned to a specific competence, i.e.

$$m_i = \sum_{j=1}^{12} \frac{x_{ij}}{12}.$$

At this stage, 13 positions in S_C is specified, the 'competence profiles' of the 12 respondents, X_j, where $j = 1, \dots, 12$, and the mean 'competence profile' M. In order to find respondents R_j with as different perceived competences as possible, each respondents distance from the mean 'competence profile' d_j was studied, i.e.

$$d_j = \sqrt{\sum_{i=1}^{9}(x_{ij} - m_i)^2}.$$

Starting from this distance from the mean 'competence profile', respondents representing a variation in perceived competence at the beginning of the Challenge Lab experience could be identified.

Results

Through analysis of the survey data, two main findings could be made. Firstly, a 'competency profile' could be calculated, giving an indication of the students' perceived competence at the beginning of the Challenge Lab experience. This 'competence profile' is essentially the percentages of the maximum points available in the survey for each competence. Accordingly, a score of 1 on a certain competence means that the student rated all items assigned to the specific competence with the highest possible answer. A score of 0,71 means that a student rated the items assigned to the specific competence in such a way that the sum was equal to 71 % of all the available points for that competence. The result is shown below in Table 7, together with the mean score for each competence.

Table 7: Calculated competence profiles for the 12 respondents. Note that no items representing trans-rational competence was included in the questionnaire.

	Respondents												
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
Systems think	0,67	0,62	0,67	0,64	0,71	0,76	0,69	0,57	0,89	0,71	0,90	0,60	0,70
Anticipatory	0,74	0,71	0,77	0,64	0,77	0,83	0,83	0,63	0,83	0,71	0,71	0,63	0,73
Normative	0,86	0,76	0,94	0,71	0,88	0,90	0,80	0,71	0,84	0,80	0,69	0,55	0,78
Strategic	0,81	0,62	0,76	0,67	0,81	0,86	0,76	0,48	0,71	0,62	0,81	0,48	0,69
Interpersonal	0,94	0,80	0,66	0,66	1,00	0,89	0,86	0,77	0,80	0,86	0,74	0,69	0,79
Intrapersonal	0,91	0,80	0,87	0,80	0,74	0,87	0,70	0,83	0,77	0,71	0,64	0,67	0,77
Being/owning	0,99	0,70	0,81	0,90	0,83	0,90	0,65	0,80	0,93	0,81	0,81	0,89	0,82
Transrational	-	-	-	-	-	-	-	-	-	-	-	-	-
Leading with	0,91	0,89	0,69	0,83	0,83	0,83	0,83	0,74	0,71	0,71	0,80	0,69	0,78
Total score	6,83	5,90	6,17	5,95	6,57	6,84	6,12	5,53	6,47	5,93	6,10	5,20	6,07

Using a spatial analogy, each respondents 'distance' from the mean score could be calculated. The result is shown below in Table 8.

Table 8: Distance from the respondents' competence profiles to the mean competence profile, all shown in Table 7.

Respondent	1	2	3	4	5	6	7	8	9	10	11	12
Distance from mean	0,302	0,207	0,262	0,245	0,253	0,268	0,244	0,298	0,244	0,149	0,296	0,405

From the distances shown in Table 8, it can be concluded that respondent #10 lay closest to the mean score, while respondent #1 and #12 lay farthest away. In addition, #1 and #12 represents two ends of the competence scale, since #1 had one of the highest total scores (6,83), while # 12 had the lowest (5,20), see Table 7, i.e. assessed their competences as generally higher and generally lower respectively. This indicates that these three respondents could potentially occupy mutually contrasting perspectives on competences, making them relevant for further study. Therefore, these three were selected for the interviews.

Appendix C – Key themes from interviews with Challenge Lab students

In this appendix, the result from student interview will be presented with more detail. Note that this represents results regarding RQ2.2, i.e. "*What are some common examples of competences that the students at Challenge Lab perceive to have developed?*".

Through analysis of interviews, four competence categories were developed. These are presented in the sections below. Lastly, some notes are made on willingness to engage and contribute to sustainability are made.

Relating to others

Competences included in this category was referenced frequently. All are in some way related to working together with others, with an emphasis on ability to work in international teams, between disciplines, ability to give and ask for support, to listen and be open, willingness to trust and step back from control.

Collaborative skills were mentioned several times. For example, one student perceived having developed better understanding of:

"*How to discuss, how to collaborate, more on group dynamics*"

Interdisciplinarity and working in international teams are specifically referenced by several respondents:

"*You are taught a certain way of doing things […] "This is the way the world works". That's how you grow up, and that is how you perceive the world […]. And in an international team, there is no one way. There are nine ways, because I think we're representing nine different countries.*"

"*Ability to collaborate in different disciplines, without thinking 'I am right and you are wrong'.*"

Related to this last quote is the ability to listen without judging, referenced by several respondents:

"*Active listening, that has been really important. […] It's kind of just always in the back of my head. […] And to be really conscious of not putting judging or those kind of statements in place with people, to make them feel like their voices are being heard.*"

"*I think I increased the level of being more open and to accept different ways or points of view […]. And to not prejudge, before knowing someone.*"

Moving towards the interface with the category *relating to oneself*, one frequently referenced competence was the ability to step back from control and trust others:

"*For me to be able to let go of something, believing that you can do it just as good, that I can trust that*"

Another was ability to adopt a less driving role when appropriate, adopting calmness and patience:

"And also when working together as a team, I think I try to be more – not a passive member – but more trying to observe the reactions of the others and the interaction. […] This part, this kind of interaction has been about learning how to be more patient […], to be more relaxed and to wait, and discuss every aspect of a decision."

"To more be stepping back […]. Try to see different perspectives, try to see what's happening. A little bit of calmness."

Relating to oneself

A key factor of this category is the ability to reflect upon oneself:

"I am more able to step back and understand, to look at myself from a third perspective"

Handling one's own uncertainty and worries by sharing fear

"And sharing fear, […] we've tried to be very open, and create an environment where everybody can actually raise their concerns […] It helps you to reduce this [anxiety], by just simply talking and understanding and acknowledging that other people have it to."

Asking for help

"I know now that it's actually okay to ask for help, actually okay to say that I don't know, or am not able, and ask someone else."

Moving towards the interface with the category *relating to sustainability*, one frequently referenced competence is the ability connect to one's values and motivations.

"I think I've learned how to connect what I really want, what vision of future I have, what I want to do in my professional life."

"For me, this has been a personal journey, identifying my values and what I believe is important, how I see my future, what I think is important in an organization."

Understanding sustainability and the world

As implied by the label, the competences in this category aim at understanding sustainability and understanding the world. This is mostly develop through the use of thinking tools introduced at Challenge Lab, and the experience the students get during undertaking their theses.

All respondents references an increased ability to understand sustainability. In addition, all respondents state that they have gone from having a narrow perspective on sustainability to a broader one, specifically shifting towards thinking more about the social aspect of sustainability issues, as discussed above.

"I was very much in my own box [...]. But then came the whole development here, especially the first month when we really examined our values and our view of sustainability, leadership and change agency [...] We also talked about sustainability being more than just environmental aspects, it also is social, well-being, economy, societal aspects."

It is also apparent that the respondents' understanding of sustainability have extended in different areas, depending on their background. For example, the account of respondent coming from an economic background:

"The more mechanical aspect has helped me a lot, because before I had this environmental, economical perspective on sustainability. Now I'm getting that from this more technical and mechanical perspective on sustainability"

The students also referred to use of theoretical frameworks and thinking tools such as systems thinking and multilevel perspective as ways to better understand sustainability and the world:

"Viewing sustainability from the ecological constraint, with individual well-being at the top, but then having your social and economic pillars [...]. That framework has been very central, and it makes me then understand society, like in better context. [...] It's given me a framework to better understand the world."

"Because it's a big topic, big challenge, we need thinking tools to understand that. And I think that the guys from the C-Lab team have done a good job in selecting good thinking tools that help you understand what's going on. It can be very overwhelming and confusing a lot of times, putting things in to place, and some of the methodologies that they have provided us with is really good in that regard. [For example] systems thinking, I like that, and the multilevel perspective that we are using here. [...] That is also what I hoped to gain, because I'm coming with an economical background and I'm going to go to a technical university, so I was very eager to understand how they perceived the whole issue."

Getting opportunities to experience and discuss many the system:

"Here you have the chance to talk about many different sustainability issues, and you're maybe not interested in half of them, but you still get to understand and learn about them by talking to and co-working with each other. I think that is very valuable, because then you get more input."

"Also, there are all these concrete things we have learned – how Gothenburg works, and what is happening in [an area where respondent implements project]"

Doing

Especially two respondents referenced competences in this category explicitly, namely ability to develop concepts taking in to account different perspectives, connecting with stakeholders, daring to explore and take initiative and management of self and one's project or team

On designing and developing concepts:

"And with the knowledge that I have in the Challenge Lab, and in the course before, I think that I more understanding of when or where in the system I can have an impact."

"You need to see the data and you need to see the logic, but also you need to see the human perspective, of how you will impact and how other people will perceive this – whatever you are doing – based on their backgrounds. And also, that teaches you try be more empathic and how to build your solutions or your concepts, taking different backgrounds in to account"

On implementing through connecting with stakeholders and daring to explore:

"I think when it comes to engaging third parties, people that come to C-Lab [...]. There I have gained some competences."

"Taking initiative, that is another skills. Not being afraid to take the first step, to go out in the world and explore. Maybe just ask a dumb question to an expert. [...] That is important to understand where you are and it can lead you on the right track"

"Being braver also. [...] [We] have been very practical in our research, going out talking to people and networking. That has brought with it some personal growth, getting to be more independent in that way. And always daring to ask, that is in itself pretty brave"

"Good experience of how to connect the stakeholders, how you contact the stakeholders, how you expose or talk about your project, and how to connect different and bring together to find a solution. Even if you don't find a solution, you contribute to making these stakeholders have a meeting."

On management of oneself and one's team:

"To be a better planner, to schedule better, all the activities that we need to do. At least with my partner. It would be like 'project management' I would say."

"… now that we are the two of us, a lot of time I also had to manage – when it comes to team-management, administration of things, organizing things. So, because I had to – it was a necessity to do it – I think it helped me improve these skills."

Willingness to engage in and contribute to sustainability

Not forming a category of competences, attitudinal dimensions of sustainability competences were discussed during the interviews. Three of the respondents mentioned such competences, for examples wanting to have an impact and create a more sustainable future:

"Now, I feel that if I really want to contribute to my area, my country, my society [...] I need to do something. Now I know how to make a change, it will be an omission not to do it, at least not to try. [...] If you don't know, if you don't have the knowledge, it's ok. But if you have the knowledge, and you know how to make a change, even if it is a little. You should do it."

"Everyone here wants to create a better world, and no one is satisfied with what is happening here and now."

Moreover, one respondent discusses changing habits and making certain life choices as inherent to working with sustainability:

"I find myself a lot in this: I am conscious about it and I am willing to adjust my consumptions patterns for example, but I am still not where I want to be – this transition still has to happen. […] But the Challenge Lab is a continuation from where I have left in [home country] when it comes to my personal life decisions."

A clear transitions that seems to have happened for most students is shifting their personal focus of sustainability to be more on social dimensions. This is exemplified below:

"I think [my view of engaging in sustainability] has changed or shifted, that the focus needs to be more on social sustainability and individual well-being, that it has shifted towards that much more. And it has probably gotten me more interested and motivated to work with things on that side of the spectrum."

"Now I'm looking more at the social aspects of sustainability, and that is absolutely what I want to work with. […] I am so glad that my perspective have been broadened this much."

Trying to explain why this transition might have happened, one students says the following:

"Now we are more aware of the climate change. And we are more aware of that if we don't change the way the system is working, maybe we don't have a very good future. And we have been bombing about the recycling and the environment – but not about the other part of how to see society, to see how people react and everything, and in the Challenge Lab we discuss about this."