ID 039: Challenge Lab – Learning by Engaging in Society's Sustainability Transitions

Holmberg, John, Johan **Larson** *(Chalmers University of Technology)*

Abstract

The United Nations (UN) 2030 Agenda for Sustainable Development with its 17 Sustainable Development Goals devotes goal 4 specifically to education, but sustainable development is altogether a large societal learning process. Education with its institutions therefore have a key role to play. The different aspects of this role are discussed within education for sustainable development (ESD) and several interesting examples of real-world ESD learning initiatives have been developed and realized. Yet, they are rarely evaluated in depth to understand why, how and what kind of learning that occurs. In this paper, Challenge Lab (C-Lab) is analysed, where students are provided support and space to engage with complex real-world sustainability challenges in society. The results indicate that C-Lab is in line with the ESD ambition, but is more explicit on: perspective awareness, experimentation, leadership and the unique role students can play in society's transition. The results also indicate that C-Lab relates to education and learning concepts of *expansion, dialogue, values, authenticity, scaffolding, reflection*. The backcasting process used at C-Lab gives the expansion a direction toward sustainability, which is also the ambition of ESD.

Introduction

Sustainable development has been recognized by the United Nations (2015) as a challenge of transformation and integration. Transformation in the meaning that marginal changes are not sufficient, it is a question of systemic change to shift the world towards a sustainable path. Integration in the meaning that all dimensions of sustainability have to be considered simultaneously, and that we have to work together across sectors and scales.

'Education for Sustainable Development' (ESD) seeks to integrate sustainability challenges into teaching and learning and empower learners to take action for sustainable development (UNESCO, 2014b). ESD challenge the very way educational institutions are structured (Cortese, 2003; Lozano, 2006), and in teaching and learning transformative pedagogies are sought after that engage the learner in inter- and transdisciplinary processes and practices (Cortese, 2003; Sterling, 2011; Lotz-Sisitka, Wals, Kronlid, & McGarry, 2015). The Global Action Programme (UNESCO, 2014a) further recognize the necessity and value of deep student engagement.

In a review by Tilbury (2011) central ESD learning ambitions were identified (see Table 1) followed by a set of proposed educational shifts (Table 2).

Table 1: Learning for ESD (Tilbury, 2011)

ESD refers to learning about sustainable development, and:
Learning to ask critical questions
Learning to clarify one's own values
Learning to envision more positive and sustainable futures
Learning to think systematically
Learning to respond through applied learning
Learning to explore the dialectic between tradition and innovation

Table 2: Educational shifts proposed by ESD (Tilbury, 2011)

From	To
Passing on knowledge	Understanding and getting to the root of issues
Teaching attitudes and values	Encouraging values clarification
Seeing people as the problem	Seeing people as facilitators of change
Sending messages	Dialogue, negotiation and action
Behaving as expert – formal & authoritarian	Acting as a partner – informal & egalitarian
Raising awareness	Changing the mental models which influence decisions & actions
Changing behavior	More focus on structural and institutional change

In ESD, sustainability is to be seen less about something pre-determined to be learnt, and more about open-ended learning processes coping with complex and uncertain futures (Vare & Scott, 2007).

Several education initiatives seeking to address sustainability challenges exist, only mentioning a few: problem- and project-based learning (Brundiers & Wiek, 2013; Brunetti, Petrell, & Sawada, 2003), service-learning (Bodorkós & Pataki, 2009; Barth, Adomßent, Fischer, Richter, & Rieckmann, 2014), transdisciplinary case studies (Scholz, Lang, Wiek, Walter, & Stauffacher, 2006), experiential learning (Jiusto, McCauley, & Stephens, 2013).

In a review, Tilbury (2016) has identified that most ESD initiatives see students as knowledge receivers, rather than as knowledge producers. Further, transformative learning ambitions seeking to empower and engage students in real-world issues have not translated well into empirical research work. Instead, studies have been made measuring student satisfaction levels rather than seeking to address questions on how to improve participation levels or outcomes.

Demand for more comprehensive evaluation of sustainability-related work from a learning and education perspective is further underpinned by the observation that there is little support among learning scientists that it is enough to bring together individuals who care deeply about authentic problems and then expect transformative learning to happen (Budwig, 2015). Budwig also state that:

> *"much of the work in the sustainability literature that talks about transformative learning*

looks at the general role others play in student learning. What could use more attention is careful study of whether and how scaffolding actually takes place." (p. 101)

In this study we present, analyse and evaluate the Challenge Lab (C-Lab) approach, where students engage with complex real-world sustainability challenges in society. C-Lab seeks to respond to the ESD ambition with a view of students as knowledge producers. This paper (and its further extension) seeks to evaluate C-Lab in-depth to understand mechanisms of what kind of, how and why learning occurs among the students engaged at C-Lab.

This paper addresses the following research questions:
- What are key concepts from sustainability, learning and education research that can be useful for evaluating real-world ESD learning initiatives?
- How does C-Lab relate to ESD intentions and pedagogies, and key concepts from learning and education research?
- What is the relation between C-Lab's learning intention and actual experiences/actions from the learners? (extended in a future version of this paper)

Method
This study seeks to analyse on the one hand the intention of the C-Lab approach and on the other hand the experiences from and actions taken by the students. The method is divided into two parts: analysis of the C-Lab design in relation to ESD intentions and pedagogies (see Tabe 1), pedagogical shifts (Table 2) and in relation to C-Lab-relevant concepts in learning and education research; and, evaluation of the C-Lab process as experienced by the students.

To identify C-Lab relevant concepts in learning and education research a set of 'sensitizing concepts' (Bowen, 2006) were derived: *expansion, values, dialogue, authenticity, scaffolding, reflection.*

To evaluate the process from the students' perspective a qualitative inductive approach was followed. The sensitizing concepts guided collection of data, in a first version of this paper consisting of data being observations, surveys, interviews and reports from previous work on C-Lab. The data was analysed in relation to the initial sensitizing concepts.

The results are presented in the form of a C-Lab process description, where key design components are in *italic*, and some illustrative student quotes inserted where appropriate.

In a further development of this paper, the data is to be further analysed and new data to be collected, possibly leading to a categorization different from what the initial sensitizing concepts propose.

Challenge Lab

The C-Lab approach was first initiated as an arena hosted by Chalmers University of Technology, located at a science park in Gothenburg, Sweden. This is the Lab studied in this paper. C-Lab creates space for *students with different educational and cultural backgrounds* to address *real-world complex sustainability challenges in society*. The students are *guided by* a *sustainability-driven backcasting process* as an overarching framework. *Teachers guide the students learning of the process and associated theories and tools and then give space to the students to be in charge*. The teachers are then active through guiding and facilitating (Holmberg, 2014). The authors of this paper play roles at C-Lab as founder, developer, teacher and facilitator. A student voice:

> *"Applying the different tools to a real-world-real-industry setting will serve me as an important skill for future tasks"*

One core idea with C-Lab is that *students have unique capabilities to bring multi-stakeholders together, create openness, build trust and guide sustainability-driven innovation processes*. Students are provided support and space to explore a challenge from various perspectives, and from this analysis formulate questions. By spending time to *formulate questions rather than starting from pre-defined questions*, students can play a role in sustainability transitions: they are perceived as neutral and unthreatening and thereby create openness, making it possible to in dialogue with societal stakeholders address the more fundamental questions and identify leverage points. The students can thereby take *ownership of questions that often fall between* what the respective individual actors can govern through their own activity. The students are often enthusiastic and curious, which spreads through the group and to the other actors. Previous work has concluded that the students at C-Lab develop unique capabilities while also creating value for others (Larsson & Holmberg, 2017).

C-Lab is divided into a 7.5 ECTS preparatory course "Leadership for sustainability transitions", where the students learn the theories and tools through literature and lectures, through applying them in real-world cases and through reflection upon their experience. The students who are interested can then conduct their master's thesis, in a master thesis lab, where they bring together researchers with actors from the private and the public sector and civil society, to address society's complex sustainability challenges in thematic areas.

The 30 ECTS master thesis lab is divided into two phases: phase 1 and phase 2. During phase 1 the students work together in a group of 15-20 to explore the thematic areas. This is to a large extent done in dialogue with societal actors and lead to the identification of 'leverage points', around which the students form pairs and formulate a research question, brought forward to phase 2. During both the course and the thesis lab weekly check-in and check-outs have been important for the reflection. A student voice:
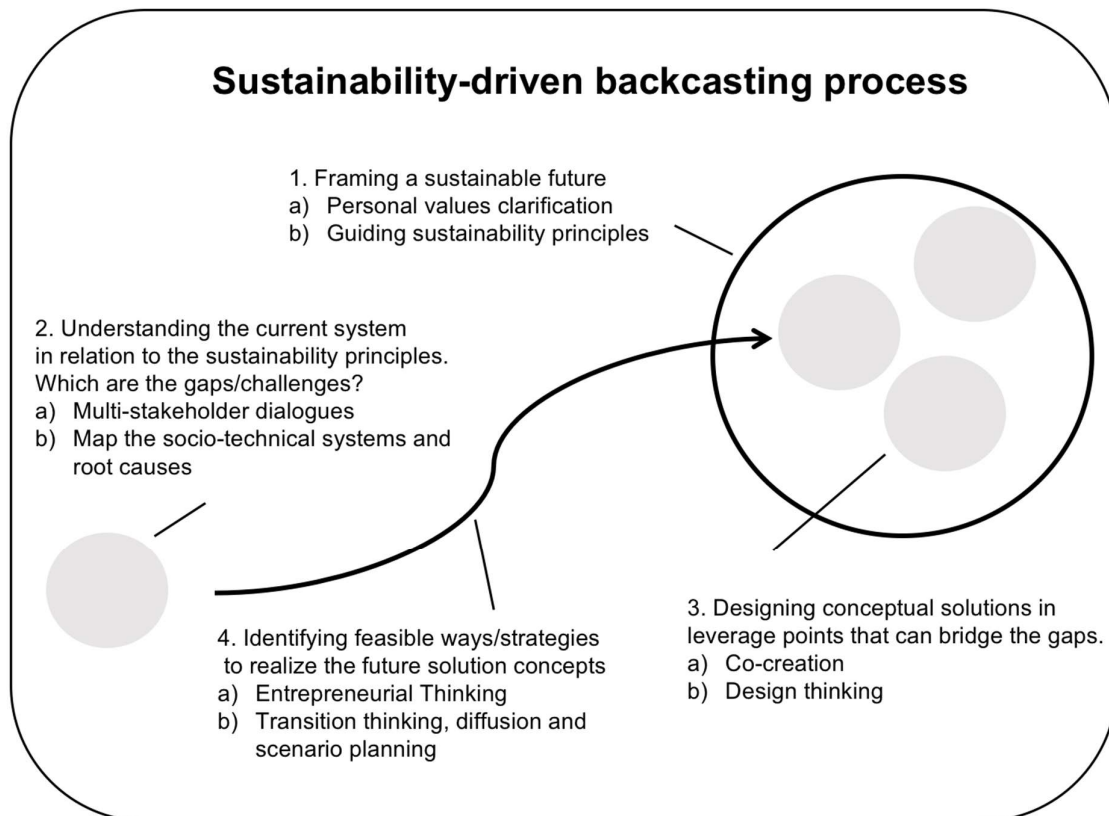
> *"However, the dialogue sessions with external partners /…/ highlighted an understanding of sustainability restricted to an industrial-ecologist perspective, which appeared to overlook social and wellbeing aspects. The reflection time after the dialogue allowed us to lift these two aspects up."*

The four steps in the sustainability-driven backcasting process at C-Lab

The idea with a structured step-wise approach at C-Lab is to reduce uncertainties that are not of central importance for the C-Lab ambition, instead focusing on maintaining uncertainty regarding the complexity of sustainability challenges. An observation is that that without teacher-induced support the groups end up in confusion and frustration eventually hindering collaboration and creation.

Figure 1 illustrates the sustainability-driven backcasting process, which guides the students as an overarching framework throughout C-Lab. The process consists of four steps and each step is approached from an inside-out and an outside-in perspective. The inside-out perspective is a more subjective perspective where the students reflect upon themselves or their surroundings. In the outside-in perspective the students use more objective theories and tools. A student voice:

"The backcasting process offers a more in-depth approach in analyzing and processing the problem at hand. Sustainability being a complex, and multidimensional subject to comprehend, backcasting afforded us a systematic way to look into the future by the facts we gather in the present."

Sustainability-driven backcasting process

1. Framing a sustainable future
   a) Personal values clarification
   b) Guiding sustainability principles

2. Understanding the current system in relation to the sustainability principles. Which are the gaps/challenges?
   a) Multi-stakeholder dialogues
   b) Map the socio-technical systems and root causes

4. Identifying feasible ways/strategies to realize the future solution concepts
   a) Entrepreneurial Thinking
   b) Transition thinking, diffusion and scenario planning

3. Designing conceptual solutions in leverage points that can bridge the gaps.
   a) Co-creation
   b) Design thinking

Figure 1: The sustainability-driven backcasting process. The four steps in the process are presented together with the (a) inside-out and (b) outside-in perspective for each step (based on Holmberg (1998)).

The first step focuses on framing a sustainable future. In the inside-out perspective *personal values are clarified*. This activity is designed to create openness between the participants and are built on active listening, which is important for creating intrinsic motivation and trust between the members

of the group and thereby prepare for deeper learning throughout the lab. Two student voices:

> *"When you put something under a vision. Phase 1 was the glue. Facilitated my trust in NN and his intentions. Space. Bring together. No trust in skills or competence because I didn't know. But in intention. Connected with the values on deeper level. The setup of phase 1 was opening up."*

> *"From number to person in academic system. New way of academic life. Best experience. As a human value for the system."*

In the outside-in perspective guiding principles/questions are formulated for all dimensions of sustainable development. This activity aims at challenging existing mental models and escape unsustainable path-dependent trends. It creates a "why" for transitions and provides direction for later activities. This activity seeks to balance the tendency to run for solutions and divide complex challenges into pieces, by *staying in the question* and consider the system as a whole. At C-lab there is a motto: *to solve a big problem - make it bigger!*

The second step focuses on the current system and tries to identify the gaps/challenges between the current system and the sustainability principles/questions formulated in the first step. In the inside-out perspective the students use their *unique capabilities to bring multi-stakeholders together, create openness and build trust* in *multi-stakeholder dialogues*. This activity is also important to build *perspective awareness*. The students are trained in deep democracy in order to also invite the "no-voice" (Lewis, 2008) into the dialogue. These characteristics make it natural for the students to take on an ownership of aspects that falls *in-between* stakeholders in these dialogues. A student voice:

> *"The dialogues we had with various stakeholders gave us many more insights that no other media would be able to give us.*

In the outside-in perspective the students use tools like causal loop diagrams and the multi-level perspective (e.g. Geels, 2002) to map the current *socio-technical system and tries to identify root-causes* to problems. *Zooming* between scales and levels is key here. The second step results with an identification of important gaps/challenges between the current system and the sustainability principles/questions.

The third step focuses on future solutions/possibilities and starts by identifying leverage points in the gap/challenges identified in the previous step. In the inside-out perspective the students work with *co-creation and co-experimentation*. They practice teambuilding based on combining strengths and perspectives. They train to iterate often seeing failure as an opportunity for learning. In the outside-in perspective the students use a design thinking approach to interact with stakeholders and develop conceptual solutions in the identified leverage points.

The fourth step focuses on pathways between future possible solutions/possibilities and the present situation. In the inside-out perspective the students develop their *entrepreneurial thinking* to be able to engage with sustainability transitions in reality. In the outside-in perspective the students apply transition theories to identify feasible ways/strategies to realize the future options, which were developed in the previous step. Scenario planning is used to analyse the robustness of the different

options under critical uncertainties.

In step 3 as well as step 4 *iteration* and *experiential learning-by-doing* is a key component, where students take deliberate action to enter "in-between" issues where they seek to broaden the object for the involved activities. Student interventions are of lower risk and thus have a potential to bring issues to the table that at first were not in the activity of the actors. Three such student interventions have been studied in depth by Larsson and Holmberg (2017). A C-Lab motto here is: *think big, start small and act now!*

Altogether, a central aim with C-Lab is to create an opportunity for the students to develop their *leadership capabilities*; both their capability to lead themselves as well as their capability to lead together with others.

Relation to concepts in sustainability, learning and education research

Error! Reference source not found. presents the relations between C-Lab, ESD ambitions and concepts from learning and education research. The key components of C-Lab cover the central concepts from Tilbury (2011). Apart from Tilbury's review results, C-Lab is also explicit on the student's role in building trust, the value of perspective awareness, leadership capabilities and the emphasis on experimentation. Similar aspects have also been highlighted by others (e.g. Wals & Jickling, 2002; Dale & Newman, 2005; Wals, 2009; Kahu, 2013)

The intention of the backcasting approach is to guide thinking beyond what currently is, by envisioning the future with an abstract representation by a set of sustainability principles. This relates to the concept of **expansion** — the learner engages in a process of 'learning what is not yet there', entering uncertain terrains in open-ended processes where qualitatively new concepts or objects are created for collective activities (Engeström, 1987).

The personal value clarification in the first step relates to the concept of **values** — the learner's values are made explicit. Values may provide guidance for decisions and actions, that are also intrinsically motivating (Ryan & Deci, 2000). Further, values clarification in a group create trust and openness: essential for taking upon complex challenges together (Wendelheim, 1997).

The multi-stakeholder dialogues in step two relates to the concept of **dialogue** — the learner engages in processes of dialoguing, where complementary and conflicting voices, meanings and expressions are shared and explored (Bakhtin, 1981) around common issues. Dialogue can be seen as the act of thinking together (Isaacs, 1993), fosters perspective awareness (Jordan, 2011), and is considered central in building trust for social collaboration (Sandow & Allen, 2005).

C-Lab addresses complex real-world sustainability challenges in society. It relates to the concept of **authenticity** – the learner creates meaning and identity in relation to existing communities of practice by addressing authentic problems in authentic, outside school, contexts (Lave & Wenger, 1991; Wenger, 1998; Barab & Duffy, 2000).

The backcasting process with its consecutive steps intends to provide an overarching structure and primarily metacognitive support for the student. The process relates to the concept of **scaffolding** –

the learner is provided contingent support and guidance in the learning activities: metacognitive, cognitive and affective. The support should fade over time and responsibility transferred to the learner (van de Pol, Volman, & Beishuizen, 2010)

Reflection is considered central for the learning at C-Lab, following double-loop schemes. It relates to the concept of **reflection** – the learner reflects upon one's actions to turn experience into learning (Schön, 1983), and critically examines underlying assumptions, beliefs, takes new action and assesses (Argyris & Schön, 1978; Mezirow, 1991).

ESD intentions and pedagogies

Learning to:

- Ask critical questions
- Clarify one's own values
- Envisioning more positive and sustainable future
- Think systematically
- Respond through applied learning
- Explore the dialectic between tradition and innovation

Educational shifts:

- Understand and getting to the root of issues
- Encourage values clarification
- Seeing people as facilitators of change
- Dialogue, negotiation and action
- Acting as a partner; informal and egalitarian
- Changing the mental models which influence decisions and actions
- More focus on structural and institutional change

Key components in Challenge lab

- C-Lab is built around a sustainability-driven backcasting process
- Real-world complex challenges in society
- Students with different educational and cultural backgrounds
- Students are in charge and take ownership. Analyse systems and formulate questions rather than starting from pre-defined problems
- Recognize students unique role for creating openness and building trust
- Teachers guide the students learning of the process and associated theories and tools and then give space to students to be in charge
- Personal values clarification, reflection and double-loop learning, check-in/check-out
- Principles covering all dimensions of sustainability. Make big problems bigger
- Systems thinking, root causes and zooming
- Multi-stakeholder dialogue
- Perspective awareness
- Design- and Entrepreneurial thinking Iteration, co-creation and co-experimentation, learning-by-doing Think big, start small, act now!
- Leadership capabilities to lead oneself and lead together with others

Links to almost all components of C-Lab

Concepts in learning and education research

- Expansion
- Values
- Dialogue
- Authenticity
- Scaffolding
- Reflection

Figure 2 - The relations between key components of Challenge Lab (centre), ESD intentions and pedagogies (left) and concepts from learning and education research (right)

Concluding discussion

In this study no consideration has been taken to 'sustainability competencies' frameworks (e.g. Wiek, Withycombe, & Redman, 2011). However, a previous study on Challenge Lab by Hagvall-Svensson (2016) concluded that sustainability competency frameworks lack leadership capabilities, which are of central importance at C-Lab. Leadership was also stressed in recent work by Senge, Hamilton, and Kania (2015) who sees leadership, and especially the ability to foster collective leadership, as key to take upon common challenges.

ESD initiatives that engage with real-world challenges in society create outcomes beyond student learning. Sustainable development in its whole can be considered a societal learning process (Holmberg, 1995; Wals, 2009). Larsson and Holmberg (2017) concluded that value creation beyond student learning is an effect of C-Lab, and students' unique capacities to induce societal transitions deserve further attention.

C-Lab is part of a broader context: whole-institution approaches to sustainability (Mcmillin & Dyball, 2009) also brought up by UNESCO (2014a) as a key approach to build capacity for ESD at universities. C-Lab's ambition in this context has been studied elsewhere (Holmberg, Lundqvist, Svanström, & Arehag, 2012; Holmberg, 2014).

Working with complex (or wicked) challenges are inherently about engaging in ambiguous processes where no definite solutions exist. Engineering students may be especially uncomfortable in this context and further studies are needed (Lönngren, 2017). An idea is that values clarification at C-Lab play an important role in guiding decisions and actions in complex and uncertain circumstances.

Finally, of special interest is whether and how backcasting-from-principles approaches can facilitate expansive (social) learning processes with explicit purpose and direction. The principles address fundamental questions of "where to?" and "why?", guiding abstract-to-concrete processes of creation. This is in close resemblance to what Engeström (2016) refers to as 'the future-making potential' of expansion. In this context, directionality and purpose of the expansion is first made explicit through a joint formulation of sustainability principles, which then serve as a basis for the questioning. This means that potential backcasting-from-principles evoked expansive cycles not necessarily start from contradiction and tension, but may as well be initiated from a motivating and shared challenge or purpose, as is often the ambition in ESD processes.

Acknowledgements

References

Argyris, C., & Schön, D. A. (1978). Organizational learning: A theory of action perspective (Vol. 173). Addison-Wesley Reading, MA.

Bakhtin, M. M. (1981). The Dialogic Imagination. Austin: University of Texas Press.

Barab, S. A., & Duffy, T. (2000). From practice fields to communities of practice. Theoretical Foundations of Learning Environments, 1(1), 25–55.

Barth, M., Adomßent, M., Fischer, D., Richter, S., & Rieckmann, M. (2014). Learning to change universities

from within: a service-learning perspective on promoting sustainable consumption in higher education. Journal of Cleaner Production, 62, 72–81. https://doi.org/10.1016/j.jclepro.2013.04.006

Bodorkós, B., & Pataki, G. (2009). Linking academic and local knowledge: community-based research and service learning for sustainable rural development in Hungary. Journal of Cleaner Production, 17(12), 1123–1131. https://doi.org/10.1016/j.jclepro.2009.02.023

Bowen, G. A. (2006). Grounded theory and sensitizing concepts. International Journal of Qualitative Methods, 5(3).

Brundiers, K., & Wiek, A. (2013). Do We Teach What We Preach? An International Comparison of Problem- and Project-Based Learning Courses in Sustainability. Sustainability, 5(4), 1725–1746. https://doi.org/10.3390/su5041725

Brunetti, A. J., Petrell, R. J., & Sawada, B. (2003). SEEDing sustainability: Team project-based learning enhances awareness of sustainability at the University of British Columbia, Canada. International Journal of Sustainability in Higher Education, 4(3), 210–217. https://doi.org/10.1108/14676370310485401

Budwig, N. (2015). Concepts and tools from the learning sciences for linking research, teaching and practice around sustainability issues. Current Opinion in Environmental Sustainability, 16, 99–104. https://doi.org/10.1016/j.cosust.2015.08.003

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. Planning for Higher Education, 31(3), 15–22.

Dale, A., & Newman, L. (2005). Sustainable development, education and literacy. International Journal of Sustainability in Higher Education, 6(4), 351–362. https://doi.org/10.1108/14676370510623847

Engeström, Y. (1987). Learning by expanding: an activity-theoretical approach to developmental research. Helsinki: Orienta-Konsultit.

Engeström, Y. (2016). Studies in Expansive Learning: Learning what is not yet there. Cambridge: Cambridge University Press.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy, 31(8), 1257–1274.

Hagvall-Svensson, O. (2016). Sustainability Competences: A study based in Chalmers Challenge Lab (Master of Science Thesis). Chalmers University of Technology.

Holmberg, J. (1995). Socio-Ecological Principles and Indicators for Sustainability (Thesis for the Degree of Doctor of Engineering). Chalmers University of Technology, Gothenburg, Sweden.

Holmberg, J. (1998). Backcasting: A Natural Step in Operationalising Sustainable Development. Greener Management International, 23, 30–51.

Holmberg, J. (2014). Transformative learning and leadership for a sustainable future: Challenge Lab at Chalmers University of Technology. In P. B. Corcoran, B. P. Hollingshead, H. Lotz-Sisitka, A. E. J. Wals, & J. P. Weakland (Eds.), Intergenerational learning and transformative leadership for sustainable futures (pp. 91–102). The Netherlands: Wageningen Academic Publishers. Retrieved from http://www.wageningenacademic.com/doi/pdf/10.3920/978-90-8686-802-5_4

Holmberg, J., Lundqvist, U., Svanström, M., & Arehag, M. (2012). The university and transformation towards sustainability: The strategy used at Chalmers University of Technology. International Journal of Sustainability in Higher Education, 13(3), 219–231. https://doi.org/10.1108/14676371211242544

Isaacs, W. N. (1993). Taking flight: Dialogue, Collective Thinking and Organizational Learning. Organizational Dynamics, 22(2), 24–39.

Jiusto, S., McCauley, S., & Stephens, J. (2013). Integrating shared action learning into higher education for sustainability. Journal of Sustainability Education, 5. Retrieved from http://www.jsedimensions.org/wordpress/content/integrating-shared-action-learning-into-higher-education-for-sustainability_2013_06/

Jordan, T. (2011). Skillful Engagement with Wicked Issues - A Framework for Analysing the Meaning-making Structures of Societal Change Agents. Integral Review: A Transdisciplinary and Transcultural Journal for New Thought, Research, and Praxis, 7(2), 47–91.

Kahu, E. R. (2013). Framing student engagement in higher education. Studies in Higher Education, 38(5), 758–773. https://doi.org/10.1080/03075079.2011.598505

Larsson, J., & Holmberg, J. (2017). Learning while creating value for sustainability transitions: the case of Challenge Lab at Chalmers University of Technology. Journal of Cleaner Production, to appear. https://doi.org/10.1016/j.jclepro.2017.03.072

Lave, J., & Wenger, E. (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge: Cambridge University Press.

Lewis, M. (2008). Inside the no: Five Steps to Decisions that Last. Pretoria: M. Lewis.

Lönngren, J. (2017). Wicked Problems in Engineering Education. Preparing Future Engineers to Work for Sustainability (Thesis for the Degree of Doctor of Philosophy). Chalmers University of Technology, Gothenburg, Sweden.

Lotz-Sisitka, H., Wals, A. E., Kronlid, D., & McGarry, D. (2015). Transformative, transgressive social learning: rethinking higher education pedagogy in times of systemic global dysfunction. Current Opinion in Environmental Sustainability, 16, 73–80. https://doi.org/10.1016/j.cosust.2015.07.018

Lozano, R. (2006). Incorporation and institutionalization of SD into universities: breaking through barriers to change. Journal of Cleaner Production, 14(9–11), 787–796. https://doi.org/10.1016/j.jclepro.2005.12.010

Mcmillin, J., & Dyball, R. (2009). Developing a Whole-of-University Approach to Educating for Sustainability: Linking Curriculum, Research and Sustainable Campus Operations. Journal of Education for Sustainable Development, 3(1), 55–64. https://doi.org/10.1177/097340820900300113

Mezirow, J. (1991). Transformative Dimensions of Adult Learning. San Francisco: Jossey-Bass.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68.

Sandow, D., & Allen, A. M. (2005). The nature of social collaboration: how work really gets done. Reflections: The SoL Journal, 6(2–3), 2–3.

Scholz, R. W., Lang, D. J., Wiek, A., Walter, A. I., & Stauffacher, M. (2006). Transdisciplinary case studies as a

means of sustainability learning: Historical framework and theory. International Journal of Sustainability in Higher Education, 7(3), 226–251. https://doi.org/10.1108/14676370610677829

Schön, D. A. (1983). The reflective practitioner: how professionals think in action. New York: Basic Books.

Senge, P., Hamilton, H., & Kania, J. (2015). The dawn of system leadership. Stanford Social Innovation Review Winter, 2015, 27–33.

Sterling, S. (2011). Transformative learning and sustainability: Sketching the conceptual ground. Learning and Teaching in Higher Education, 5(11), 17–33.

Tilbury, D. (2011). Education for sustainable development - An Expert Review of Processes and Learning. Paris, France: UNESCO.

Tilbury, D. (2016). Student Engagement and Leadership in Higher Education for Sustainability. In M. Barth, G. Michelsen, M. Rieckmann, & I. Thomas (Eds.), Routledge Handbook of Higher Education for Sustainable Development (pp. 273–286). New York: Routledge.

UNESCO. (2014a). Roadmap for Implementing the Global Action Programme on Education for Sustainable Development. France: UNESCO.

UNESCO. (2014b). Shaping the Future We Want: UN Decade of Education for Sustainable Development (2005-2014) : Final Report. Paris, France.

United Nations. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. New York: United Nations.

van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in Teacher–Student Interaction: A Decade of Research. Educational Psychology Review, 22(3), 271–296. https://doi.org/10.1007/s10648-010-9127-6

Vare, P., & Scott, W. (2007). Learning for a Change: Exploring the Relationship Between Education and Sustainable Development. Journal of Education for Sustainable Development, 1(2), 191–198. https://doi.org/10.1177/097340820700100209

Wals, A. E. J. (Ed.). (2009). Social learning towards a sustainable world: Principles, perspectives, and praxis. The Netherlands: Wageningen Academic Publishers. Retrieved from http://www.wageningenacademic.com/doi/book/10.3920/978-90-8686-594-9

Wals, A. E. J., & Jickling, B. (2002). "Sustainability" in higher education: From doublethink and newspeak to critical thinking and meaningful learning. International Journal of Sustainability in Higher Education, 3(3), 221–232. https://doi.org/10.1108/14676370210434688

Wendelheim, A. (1997). Effectiveness and Process in Experiential Group Learning (Dissertation). Stockholm University, Department of Psychology.

Wenger, E. (1998). Communities of Practice: Learning, Meaning, and Identity. United Kingdom: Cambridge University Press.

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. Sustainability Science, 6(2), 203–218. https://doi.org/10.1007/s11625-011-0132-6