Self-reflexive practice through the Human Scale Development approach — competencies needed for transformative science research

Author: Salina Spiering

Helmholtz Centre for Environmental Research GmbH – UFZ, Permoserstraße 15, 04318 Leipzig, Germany

Email: salina.spiering@ufz.de

Abstract: Solution-oriented transformative science (TSc) is increasingly being discussed as a means to produce participatory and actionable knowledge for sustainability transitions. This requires that researchers adopt different roles, competencies and a degree of reflexivity, which thus far, are often not fully applied. This article proposes the Human Scale Development approach (HSDA) of the Chilean economist, Max-Neef, as a valuable framework to engage in self-reflexive research practices. Inspired by autoethnography, I draw on my own sustainability research as a PhD-student, paying close attention to deprivations, potentials that I encountered, exploring how self-reflexive practices enhance the understanding of competencies and elucidating how to adopt and fulfil required research roles and procedures. I show how such a self-reflexive process can be a useful (training) tool not only for early PhD researchers and for supervision, but may add value for TSc scholars in general.

Keywords: autoethnography, transformative science, self-reflexive practice, Human Scale Development approach, roles of researcher, competencies, values, reflexivity, sustainability science

Biographical notes: Salina Spiering, née Centgraf, is a researcher at the Department of Environmental Politics at the Helmholtz Centre for Environmental Research – UFZ. She is a geographer by training (with a diploma from the University of Leipzig) and a PhD student in the Department of Geography at the University of Münster (WWU). Her research interests involve biodiversity policy, methods for transformative change, conflict transformation, narratives, and the support of sustainable agri-food-systems.

Prologue

I dare to take the opportunity to undertake this very personal experiment at the end of my PhD process. After I have motivated other people in my research and have accompanied them in reflecting on the basis of their personal needs to develop further within their environments and on what were the factors that made this development difficult, I will also go through this process myself, and retrospectively reflect on what the hindering and supporting factors were in my doctoral process. This endeavour excites me and scares me. What a great chance, to remember my experiences again, to classify them, to integrate them into my research and to complete the process and thus, hopefully, to enable others to learn, in case they need it. On the other hand, it scares me: I leave the safe haven of the "Introduction, Methods, Results, and Discussion" structure, I forego professional distance and dare to disclose my observations, feelings, needs, values and wishes and thus make myself vulnerable. Nevertheless, it comforts and encourages me that I am not the first to implement such an undertaking. For action researchers and autoethnographers, this way of embedding one's own experiences in the cultural context in first-person research is a habit; and yet it is an innovation in sustainability science. And precisely because transformative science is in its infancy and is attacked because of its normativity and solution orientation, various resistances are evident, my ambition is high not to damage the reputation of this form of science. On the contrary, I would like to show that a paradigm shift, the introduction of values, experimentation and new development paths for science on the basis of needs on a human scale provide added value.

1 How and why is a self-reflexive practice valuable for transformative science scholars?

With climate change and biodiversity loss, humanity faces a sustainability crisis on an unprecedented scale. In response to these pressing challenges, transformative approaches are increasingly seen as promising options to facilitate the necessary sustainability transformations. Transformation-oriented transdisciplinary research and transformative science (TSc) aim at producing actionable knowledge, thereby catalysing transformative changes towards sustainability following the Agenda 2030 as its normative compass (Schneider et al. 2019). This also implies changes in the roles that researchers adopt. These roles, but also the competencies and skills that

TSc scholars need, differ heavily from that of "conventional" researchers and are increasingly under scrutiny (Wittmayer and Schäpke 2014, Adelle et al. 2019, Bulten et al. 2021). Within an ongoing endeavour to evaluate the quality of TSc methods, one aspect that is repeatedly emphasised is the need for reflexivity (Popa et al. 2015, Fazey et al. 2018). Reflexivity entails two dimensions: First, approaches for transformation-oriented transdisciplinarity/TSc need to be reflexive. In a previous publication together with a colleague, I presented the Human Scale Development approach (HSDA) of the Chilean economist, Manfred Max-Neef, and his colleagues, as a reflexive approach based on its unique reflection of human needs (Spiering and Barrera 2021). Secondly, the personalities of the researchers with their normative assumptions, values, backgrounds, intentions and the roles they adopt need to be considered using (self-) reflexive practices. It is assumed that given all of these dimensions, TSc scholars influence the research they undertake. So far, within sustainability science, few reflexive approaches have been presented that may be suitable for undertaking self-reflexive practices (Lipp 2007, Van Mierlo et al. 2010, Horlings et al. 2020). Although there is this manifold claim for reflexivity, little is known on how to undertake a valuable self-reflexive practice (Popa et al. 2015). A meaningful self-reflexive practice has to enable TSc scholars to explicate their responsibilities and accountabilities and to shed light on their needs for support while fulfiling their very demanding tasks.

Within this paper, I will focus on the self-reflexive practice of TSc researchers. I aimed to understand the competencies that promote TSc scholars in adopting different roles. Thus, this work is inspired by autoethnographical sensibility and deals with my personal experience in undertaking empirical research using insights from ten HSDA workshops that I undertook in Chile and Germany. As a TSc scholar, I became a significant part of the research in the way I interacted, represented science and related to the research participants. As such, I acknowledge subjectivity, emotionality and my [direct] influence on the research results. I use my personal experience to illustrate challenges and potentials that other TSc scholars may also face and, in so doing, make characteristics of TSc research better known to insiders and outsiders. Thereby, I aim at contributing to the discussion on competences and training needed especially for transdisciplinary TSc research (also in higher education).

My main research question is: How can TSc scholars - whose research is situated between science and fields of action - undertake a self-reflexive practice within their research? This entails the

following sub-questions: Which frameworks support TSc scholars in undertaking a self-reflexive practice? Which competencies do TSc scholars acquire and improve themselves during their research? What is the added value of the self-reflexive process for the researchers, their respective research and research in general?

I propose the HSDA as a valuable tool to undertake self-reflexive practice, in general. Further, I argue that it is a valuable approach for reflexive TSc research (Spiering and Barrera 2021) and for the self-reflexive practice of TSc scholars.

First, I show on a theoretical level, why (self-)reflexivity is perceived as being important for TSc research and how an autoethnographic sensibility can inform TSc self-reflexive practice. I present different roles of TSc researchers and respective skills and competencies. Secondly, I present a brief overview of the HSDA, arguing that it serves as a valuable tool for self-reflexive practice. Thirdly, I undertake the self-reflexive practice concerning deprivations and potentials that I faced within my research. In the discussion, I point out the implications of applying the HSDA as a tool for self-reflexive practice for TSc scholars and conclude by showing the value added by applying it.

2 Self-reflexive practice on competencies through the lens of Human Scale Development approach

2.1 Self-reflexive practice within transformative science

2.1.1 Transformative science and the need for reflexivity

TSc aims at contributing to sustainability transformations, is committed to the 2030 Agenda as its normative compass and applies transdisciplinary methods (Scholz 2017). It follows three main goals: creating scientific/conceptual knowledge, catalysing change/creating actionable knowledge and following educational goals (Beecroft et al. 2018, Spiering and Barrera 2021). TSc is driven by human values, thereby challenging the predominant understanding and foundation of modern science as being objective and value-abstinent (Ziegler and Ott 2011, Martin 2015, Schneidewind 2015, Messerli et al. 2019, Fazey et al. 2020). The research processes within TSc are characterised by practical relevance/solution-orientation, democratic co-production of knowledge and values,

deliberation, normativity and learning – all mutually with societal actors (Jaeger-Erben et al. 2018, Schneider et al. 2019).

To guarantee the quality of transformative transdisciplinary research, reflexivity is one of the crucial criteria widely proposed (Wittmayer et al. 2018, Fazey et al. 2018, Sharpe et al. 2016, Defila and DiGiulio 2019). It is in contrast to the concept of reflection, which is traditionally defined as "a mirror image - an objectivist ontology based on the idea that there is an original reality we can think about and separate ourselves from" (Cunliffe and Jun 2005: 226) and that encompasses a collective process where learning from experiences is linked to understanding of past action and to improvement in future action (Päsillä et al. 2015: 69, Vince and Reynolds 2009). Instead, reflexivity goes further, based on the idea that the meanings of our worlds and ourselves are continuously constructed (Päsillä et al. 2015). Reflexivity is "grounded in constructionist and deconstructionist views of the world" (ibid.: 70), is characterised as dialogic and relational activity and means unsettling conventional practices (Cunliffe and Easterby-Smith 2017) by questioning one's taken-for-granted assumptions (Päsillä et al. 2015). It is, therefore, a "deeper learning process to the relatively superficial act of reflection" (Fazey et al. 2018: 66).

One main challenge of TSc is to integrate certain forms of reflexivity regarding intentional and unintentional results of the research processes (Wittmayer 2018: 93). On the one hand, research processes need to be critically reflected due to the need for transparency and legitimacy. On the other hand, the influence of TSc researchers on "their" research processes and outcomes is increasingly under observation (Avelino 2011, van der Hel 2018, Bulten et al. 2021). Even though the claim for self-reflexive practice is not new (Schön 1983), the prevalent transdisciplinary sustainability discourse lacks a clarification of the concept of reflexivity: "in the absence of such a clarification, transdisciplinarity risks being reduced to formal consultation (to validate a pre-existing technocratic or ideological agenda) or becoming politicised at the expense of scientific soundness and reliability" (Popa et al. 2015:14). Thus, careful reflexive practice in regard to epistemological assumptions and normative positioning held by TSc scholars is needed to contribute to transparency and accountability of TSc research (Wittmayer et al. 2018). Disclosing the values underlying one´s research assures an appropriate relation between research and values and avoids "the risk of being instrumentalised by dominant actors or to blindly execute power without realising it" (Schneider et al. 2019: 1601). Herweg and colleagues (2017) propose to

integrate reflexive practice as part of scholarly activities, including university teaching and project work. Other scholars propose to include ethicists for thorough theoretical articulation of these questions into large sustainability projects, as they might stimulate deep questions (Ziegler and Ott 2011).

2.1.2 Autoethnography inspires self-reflexive practice within transformative science

I argue that self-reflexive practice processes within TSc may be enriched by autoethnographical approaches. These have a long-standing reflexive tradition within social sciences (Ellis and Bochner 2000, Butz 2010) even though they – very similar to TSc research – reject the deep-rooted binary concept of objectivity and of being value-free (Ellingson and Ellis 2008). Thus, autoethnography is a critical response "to the alienating effects on both researchers and audiences of impersonal, passionless, abstract claims of truth generated by such research practices and clothed in exclusionary scientific discourse" (ibid.: 450). Analogously, Van der Hel and colleagues (2018) demand for solution-oriented sustainability researchers to "'step out of their academic comfort zone' of objectivity and independence" (ibid.: 249).

Butz (2010: 139) pleads for an "autoethnographic sensibility" that he understands not as methodology or set of methods, but as epistemological orientation to the relationships among experience, knowledge and representation with a variety of methodological implications. Autoethnography as the "study of one´s own humanity" (Scott 2019) is the intent to undertake a self-reflexive practice by having a closer look at personal (familiar) experiences from a distance by changing perspectives. Understanding occurs when the autoethnographer locates the "self" in the social context and links the personal experience with culture (Alsop 2002). In this case, it is the "culture" of doing TSc research. Thereby, the autoethnographer embraces and foregrounds her subjectivity and emotionality rather than subduing or deactivating it. She acknowledges her (direct) influence on research and provides descriptions and critique of cultural beliefs, practices, values, politics and positions (Alvesson and Sköldberg 2009). Being reflexive on the researcher´s positionality includes exploring her relationship with the object of research (Harding 1989). This makes the research understandable (ibid.) and her engagement in a self-referential analysis gives context on how her biography, place and the positioning of self and the other shape the research process (Day 2012, Gergen and Gergen 2000).

Gram-Hanssen and colleagues (2021) argue for a self-reflexive practice to "uncover blind spots, question assumptions and allow oneself to be affected, even transformed, in the process of engaging with the world". Alsop (2002) argues for the importance of self-reflexive practice with the analogy of a psychotherapist: psychotherapists need to understand the relations between their own (childhood) experiences and their behaviour to have integrated their own fears, motives, resistances and relationship patterns, to be able to support and accompany their clients in their self-reflexive practice. Adapting and applying this to TSc scholars, it is crucial to understand and make the motives and underlying needs of TSc scholars explicit when engaging in transformative change. Doing this includes self-reflexive practice on the states of mind, positions of power or ways of producing knowledge, as an interplay between the stakeholders within the scope of her research and herself. Thus, self-reflexive practice is essential in the research process to understand the social practices of all those involved.

When practically applied, reflexivity is a skill and capacity that requires practice, training and being inclined to apply it on a regular basis (Fazey et al. 2018: 57). Reflexivity involves scrutinising aspects usually taken for granted and that seem to be self-evident. The self-reflexive practice allows the researcher to understand herself as part of the dynamics that she is aiming to change and supports her in a number of aspects (Wittmayer et al. 2018: 9):

- Situating and positioning him/herself in the research
- Exploring the researcher-researched relationship and the co-constitution of research
- Offering social critique and deconstructions of established meanings
- Introspection:
    - a positioning of oneself as a researcher in time and space
    - regarding one's background
    - normative orientation
    - questioning the ways in which the researcher shapes the research and vice versa
- Critical reflection on the situatedness of the research, the social context and political dimensions
- Possible unintended effects

Several risks, challenges and concerns go along with self-reflexive practice both on a systemic/professional and personal level such as missing or confusing the dialectics of the personal and the cultural (Alsop 2002), career risks (Milkoreit et al. 2015) and the concern "that the credibility and authority of science could be undermined by its direct engagement with value-laden discussions and political debates" (Van der Hel et al. 2018: 249).

2.2 Different roles and competencies of transformative science researchers

> "Scientists are used to multiple, often conflicting roles, but often lack the time and training to reflect on what they are doing. This may result in contradictions they have difficult[ies] coping with or end in sheer frustration. Again, it's important within research institutions to create spaces where such tensions can be made visible and guidance towards self-reflection can be offered." (Nowotny 2018:7)

Within participatory action research (Heen 2005, Burgess 2006), feminist research (Oakley 1981, Fonow and Cook 1991, England 1994) and autoethnography (Lac 2018), it is common practice to discuss the roles of the researchers in particular. Within TSc, it is increasingly recognised that the range of tasks for TSc scholars expands and they need to adopt different roles throughout the research process (Wittmayer and Schäpke 2014, Hilger et al. 2018, Horlings et al. 2020). Still there is a pressing need to emphasise the potentials and value of the different roles, how academics choose to adopt certain roles, which skills and competences they need to "become effective 'change agents', transition managers, problem solvers, and effective performers" (Salgado Perez et al. 2018:164) and what problems they face in doing so (Horlings et al. 2020, Bulten et al. 2021). Wittmayer and Schäpke (2014) presented a highly regarded framework to assess these different roles of researchers within transformation research: 1) reflective scientist, 2) facilitator, 3) change agent, and 4) (self-)reflexive scientist.

Brundiers and colleagues (2021) presented a consolidated framework of key competencies "to enable and empower students to become effective in positively contributing to sustainability problem-solving in their lives, professions, and communities." The framework consists of clusters of related "key competencies in sustainability" that are interdependent, such that each competency contributes its part to the sustainability problem-solving processes. This framework is perceived as being helpful for understanding the different competencies needed for adopting the different roles

within sustainability research (Brundiers et al. 2021). I had this in mind, like a memo box, when undertaking my self-reflexive practice. I did not analyse every competency in detail but rather used the competency framework to later classify my experiences (cf. 5.1.1).

Figure 1: Framework of key competencies in sustainability [adapted from Brundiers et al. (2021)]
Table 1: Extended description of competencies in the framework of key competencies in sustainability

3 Human Scale Development approach as tool for self-reflexive practice

3.1 Human Scale Development approach in a nutshell - analytical framework for systematic self-reflexive practice

In this sub-chapter, I present the Human Scale Development approach of the Chilean Economist, Max-Neef and his colleagues (1990), as a valuable framework to undertake a self-reflexive practice, as it provides a unique evaluation framework based on human needs. The main endeavour of my research was to suggest and test the HSDA as a reflexive approach for conducting transdisciplinary TSc research (Centgraf 2018, Spiering and Barrera 2020, Spiering and Barrera 2021). The HSDA proved to be a very suitable tool. Within this paper, I will go a step further and undertake the experiment to apply HSDA as a self-reflexive tool for assessing my own research journey.

Max-Neef and colleagues (1991) introduced the HSDA as a human-centred-approach, and thus an alternative to neo-classical approaches, to increase human well-being through the potential of meeting individual and societal needs with appropriate strategies. They provided a taxonomy of human needs as a theoretical concept and introduced a matrix of needs and satisfiers as a participatory tool to empower Latin American communities (Table 2). In a deliberative reflection and evaluation process, communities can identify their potentials and deprivations according to the level of satisfaction of their needs. Therefore, Max-Neef and colleagues (1991:16) presented a list of human needs that they describe as few, finite and classifiable: subsistence, protection, affection, understanding, participation, idleness, creation, identity and freedom. Whereas the needs are assumed to be constant through all human cultures and across historical time periods, the means

by which the needs are satisfied change over time and across cultures (ibid.). These so-called satisfiers are either the idea or realisation of how needs are to be implemented, depending on internal abilities (endogenous) and external circumstances (exogenous). The distinction between needs and satisfiers is a central notion of the HSDA: needs can be satisfied along the existential categories of being ("how am I/are we/not?"), having ("what do we/I have/not?"), doing ("what are we/am I doing/not?") and interacting (listing locations and milieus). Each need can be satisfied at different levels and with different intensities. Satisfiers can be classified as singular, synergic, destructive, inhibiting or as pseudo-satisfiers, according to the way in which they fulfil one or several needs. Jackson and colleagues (2004:12) go further and link needs fulfilment with emotions and feelings: they provide a categorisation of feelings according to the typology of needs and argue that the satisfaction of a need yields pleasant feelings, whereas the dissatisfaction of needs yields unpleasant feelings. Focusing on needs and linking satisfiers to needs "allow[s] for the discovery of unexpected facets of a problem, thus increasing awareness about what [is] relevant" (Max-Neef et al., 1991: 43). For further details regarding the HSDA methodology, see Spiering and Barrera (2020, 2021).

Within this paper, I follow suggested workshop-formats and retroactively and selectively fill in a so-called negative matrix [with all of the factors that impeded my needs realisation (deprivations)] and a positive matrix [with all the factors that supported my needs fulfilment (potentials)]. Then, I juxtapose all satisfiers and identify common topics to distil endogenous and exogenous strategies that may optimally contribute to my synergic needs' actualisation (Max-Neef et al. 1991, Guillen-Royo 2016, Spiering and Barrera 2020). Inspired by autoethnographic-sensibility, I assemble my experiences using hindsight and aim at emphasising the roles, competencies, challenges and supportive factors within my research journey.

Table 2: Introduction to HSDA - from matrix filling to distilling synergic endogenous and exogenous strategies [adapted from Spiering and Barrera 2020]

3.2 The cases - insights from applying the Human Scale Development Approach in 9 case studies

This self-reflexive piece is informed by a participatory TSc research process that I conducted between 2014 and 2020 as a graduate student in geography. To ground my current inquiry in the context of doing TSc research, I will exemplify the self-reflexive practice with vignettes from my experiences of engaging in ten HSDA workshops, four of which I conducted within the German research project EnGeno on German Energy Cooperatives (Lautermann et al. 2017) (Table 3).

Within a first EnGeno case study (2014-2016), HSDA workshops in three German energy cooperatives were conducted as a means of supporting the civic engagement of their members (Centgraf 2018). A fourth workshop within the EnGeno project brought together three other German energy cooperatives from within one region and additionally a transition town initiative from the same area. The workshop aimed at supporting them in identifying deprivations, potentials and common strategies for citizen-driven renewable energy projects in their region.

In collaboration with the German BMBF-project "Klima-Citoyen," (Schweizer-Ries et al. 2016) I conducted three workshops in a southern German community to facilitate the decision-making process on forming a communal energy cooperative in their municipality.

A third case study took place in 2016 in Paillaco, Chile. It was conducted in collaboration with partners from the University Austral de Chile (UACh) and the Community Innovators Lab at the Massachusetts Institute of Technology, Boston (MIT CoLab). Together with master students of the UACh who co-facilitated the process, teachers and students of a Chilean technical school could be supported, in the bottom-up foundation of a programme for renewable energies at their school.

In a last case study, I conducted a workshop in two online sessions with HSD-master students of the UACh (2020). Between ten to thirty people participated in each of the ten workshops.

The self-reflexive practice is based on many sources: workshop discussions, observation protocols, research diaries and on semi-structured interviews that I conducted within the case studies. As the research process was constantly reflected, the methodological steps of my application of the HSDA were "polished" iteratively throughout my research journey and are outlined in Spiering and Barrera (2020, 2021).

Table 3: Cases in which I acted as reflective scientist, facilitator, change agent and (self-)reflexive scientist

4 Learnings from the cases: stocktaking of deprivations and potentials within my transformative science research project

4.1 My normative positioning and important values guiding action

As a first step of my autoethnographic-sensible endeavour, I reflect myself as to where I stand regarding values and how I got there.

After a first semester in ethnography, I decided to study geography and political sciences as I perceived these fields to be more application-oriented. I was fascinated by the special perspective of geography to link natural sciences and social sciences and I was convinced that only this holistic understanding could contribute to addressing 'wicked' or 'super-wicked' sustainability problems. In an internship on an Argentinian ecovillage, I joined an Ecovillage Design education course in which for the first time, I came into contact with non-violent communication as a needs-based approach to increase personal well-being. I perceived this as a highly valuable tool that revolutionised my communication. After graduating, I started to work as fundraiser for the German non-governmental organisation "Friends of the Earth International" and understood myself as political activist. Convincing other citizens in the pedestrian areas or even at their front doors to become member of an environmental organisation was a meaningful, although sometimes a frustrating endeavour. Out of personal motives, I took the training to be a mediator and later trained mediators myself with a focus on diversity- and needs-based-communication. Driven by the longing to develop myself further, I headed back into the science domain, with the opportunity to do a PhD on the transformative potential of German energy cooperatives, within the Department of Environmental Politics at an international centre for environmental research.

I would like to add another dimension of my personal background to this chapter concerning my positionality (see chapter 2.1.2). With regard to research roles, not all of them can be put on and taken off in the cloakroom, but are in part closely interwoven with one's own background and identity - the social self (Coffey 1999). Accordingly, this dimension is an elementary component of self-reflexive research practice. Therefore, I draw on my very personal background in relation

to my identity as scientist: *Growing up in a working-class family, I struggled with the fears and devaluations of my parents - my mother, who usually felt too stupid for everything, and my father, who wanted to keep me from not being good enough. As the first child at high school, contrary to my father's wishes, who wanted to see me at secondary school to save me from disappointment, from then on, I had the task of proving "that I could."*

Within the research project on energy cooperatives, I was never very much interested in the technical aspects of the energy transition but more in the questions on how to promote transformative change of the energy system from the ground. With the background of an activist, I struggled to find my position within academia and basically clinged to qualitative research. Still, I felt I would have liked to engage even more in a normative solution-oriented approach, although difficult when surrounded by mostly descriptive-analytical colleagues who were sceptical of or even reluctant to consider, let alone accept, approaches like participatory action research. Still feeling somewhat like an alien but at last having found a community within literature, I now define my research as research within transformative science at the interface between science and practice. Still, this reminded me of the struggles I faced during infancy – being a working-class child and the first one in the family at university; there it was again - the necessity of, and at the same time the horror and helplessness when entering unknown territory, being a pioneer without someone to guide me. The inner doubts took control - am I good enough for science? Am I intelligent and smart enough? Do I have sufficient skills? Is that real science? Do I harm the reputation of science by adopting normative standpoints and actively promoting change?

Undertaking a self-reflexive practice, I was able to uncover, make explicit and integrate the connections between my personal origins and my roles as a TSc scholar.

4.2 Deprivations and Potentials

In Table 4, I collected all obstacles to meeting my needs which were linked to negative (destructive or pseudo) satisfiers. In Table 5, I collected all factors which were linked to positive (singular or synergic) satisfiers.

Table 4: Collection of all negative satisfiers that impeded my needs fulfilment [building on the categories suggested by Max-Neef et al. (1990)]

Table 5: Collection of all positive satisfiers that supported my needs fulfilment [building on the categories suggested by Max-Neef et al. (1990)]

After juxtaposing these factors, I identified the four main sub-categories to describe potentials and deprivations during my research journey.

4.2.1 Academic Environment

The main obstacles to meeting my needs, with respect to the academic environment I was involved in, are linked to negative satisfiers such as a lack of a working group within which I could have reflected on my research on a regular basis, colleagues in working groups that rejected value-laden, normative and solution-oriented approaches and a graduate school that focussed on the formation of natural scientists conducting quantitative research, where the needs of TSc researchers have not yet been acknowledged. Further, a strong hierarchical system within the research institute, in which I experienced the behaviour of one of my supervisors as devaluation that affected my needs for freedom, identity and creativity negatively. This resonated gravely with internal criticism that already doubted my right to belong to the "sphere of real scientists."

On the other hand, the academic environment enabled me to meet my need for subsistence, as I could contribute to sustainable development by supporting energy cooperatives' members in their endeavours. As part of the workshop with master's students in Chile and in a workshop with colleagues from the University of Vienna, I was able to train others to implement the HSDA themselves, which contributed to the realisation of my needs for creation and participation.

4.2.2 Tools and resources

With respect to obstacles concerning tools and resources, I linked negative satisfiers such as a lack of resources and time to meeting my needs for protection and understanding. Due to these shortcomings, I conducted one-off workshops and thus, was not convinced to understand the power relations among the workshop participants sufficiently. In one case, this resulted in uncertainties as I had the impression that not all negative factors were mentioned due to a difficulty of participants to criticise and question hierarchies.

On the other hand, I could profit from setting clear boundaries and communicated the limits of the workshops/interventions to address different expectations in advance. This clarification very much contributed to meet my needs for freedom and idleness.

4.2.3 Abilities and competencies

I identified factors that impeded my needs realisation with respect to abilities and competencies, such as the high effort to take responsibility for the workshop processes which impeded my needs for protection and idleness. The internal doubt which made me question my competencies to undertake "real" scientific research highly affected my needs for identity and protection.

When reflecting on abilities and competencies, I perceived several factors as supportive in meeting my needs, such as a high flexibility in the organisation of the workshops, the coordination with workshop participants and the facilitation of the workshops (to meet my need for participation). One very important factor that was linked to other supporting factors was my training as a professional mediator and facilitator. This supported my need for identity and I could profit from various connected abilities such as the ability to create safe spaces and create trust (therefore also supporting me in meeting my need for protection), the ability and capacity for active and deep listening (therefore also supporting me in my need for affection) and the ability to let go, trust and follow the flow of the workshop processes (therefore also supporting my need for idleness). Valuing tacit knowledge (of myself and of other research partners), being open for experimentation and enabling embodied experiences instead of mere intellectual exchanges, all contributed to my needs for creation, participation and affection. Another important aspect was the iterative process of learning – after each workshop, I reflected on the process and adapted future workshop procedures respectively. Progressively learning from experience and feedback of the participants contributed to my needs for creation and understanding.

4.2.4 Human Scale

When trying to allocate into groups the most important factors (from Tables 4 and 5) which influenced my research, I framed another category: "human scale". I realised that several factors affected me on a very personal level, and thus were maybe less "professional." However, understanding my research as embodied experience, I argue that these factors are worth being

explicitly described, especially because most of them were supporting my needs fulfilment and contributed to my motivation of conducting research using the approach that I have chosen.

One aspect negatively affecting my needs for identity and protection was related to gender. In the workshops with the energy cooperatives, I found myself, as young female scholar within a large majority of retired male academics engaged in the energy cooperatives, intimidated me as I faced the self-devaluation of presumably not being as intelligent as them. Very similar to this, in the working group on energy at my research institution, disproportionately many (young) men were involved and I had an outsider-role that negatively affected my needs for belonging and creativity. On the other hand, I had a university supervisor who was very supportive, had an open ear when I needed it and inspired me with new aspects and ideas that I could incorporate. Additionally, I was in contact and exchanged with a small community of other scholars and practitioners who dealt with the HSDA. Within this group, I perceived a lot of sensitive and warm-hearted, supportive interaction amongst each other. This interaction contributed much to my needs for participation, creation, idleness and affection. Also, that I met Manfred Max-Neef in person, in Jena, Germany at a conference and in a side-event workshop that I had organised together with my supervisor, and again later in Chile, and that he interacted with me like a mentor, highly interested and supportive of my work, contributed tremendously to my need for participation and creation.

With respect to the workshops, the cooperation, openness and willingness of the energy cooperative board members and the other responsible actors to promote the workshops, touched me and contributed to the fulfilment of my need for idleness. Additionally, the openness of participants to interact, experiment and get involved in the challenge of reflecting on the basis of their personal needs, and thus their trust in the process, contributed to my need for (deep) understanding. Human encounters made this process special, for example - a deaf-mute woman who otherwise could not participate in workshops because she could not read the lips of others, benefited enormously from a specialised accommodating seating arrangement in the discussion circle and was infinitely grateful for the opportunity to participate and that I had understood her need. Other examples include eating homemade, incredibly delicious currant cake together with participants before a workshop at an energy cooperative and in which I sang a German birthday song for a participant in the Chilean on-site workshop, met my need for affection. Although I often felt the expectations

of my role as a scientist, these moments meant that the research participants and I met on a personal level on an equal footing.

Another important supporting factor that I experienced in all of the ten workshops was a moment of special attention, tense euphoria, and above all, closeness when participants engaged in painting pictures of their desired futures. The joy, happiness and a shared sense of hope in the vision phase of the workshop exercise contributed very much to my need for affection.

With respect to power relations, I found it quite difficult for myself to criticize and question supervisors without discrediting someone. It was also remarkable that in undertaking the self-reflexive exercise, I realised, gratefully, that although the weight of the negative factors was heavy, the positive aspects predominated. I undertook this self-reflexive exercise after the entire process was finalised and I argue that it would have supported me tremendously if it would have been a regular event. In the next chapter, I will describe factors that I think would have been helpful and supportive to me in earlier stages of my research and would also have made the research process easier altogether. Therefore, I turn the discussion to synergic bridging satisfiers, which can be endogenous and exogenous interventions that would have supported me (and most likely the research team) in the project.

5 Implications of self-reflexive practice for transformative science scholars

Is it not too late to undertake this self-reflexive practice after the entire process is finalised? During my research project, I often had the idea of using the HSDA within our team. But I wasn't brave enough to meet possible rejection, and the issue did not seem important enough to allocate the necessary amount of time to it. Today, I wish we had reflected more systematically, and asked ourselves more often what it was that made things difficult and what we needed.

5.1 Singular and synergic satisfiers for conducting transformative science research

As one of the three objectives of TSc is to achieve educational goals, I derived the following satisfiers from my personal self-reflexive practice, not only as strategies that would have supported me in my research, but also as a proposal for other TSc scholars – students of higher education or more experienced TSc scholars. I would like to make them aware that it is important to have these

satisfiers in mind from the beginning, already when designing the research project. I clustered the synergic satisfiers in respect to three dimensions where I perceived most need for action and also the best leverages for change: competencies and inner transformation (as an endogenous dimension, in regarding this, I could have better contributed to my needs fulfilment myself), support and resources (with respect to supervision, as the first exogenous dimension) and structural changes (as the second exogenous dimension).

5.1.1 Competencies and inner transformation

5.1.1.1 Competencies

In hindsight, I realized that I adopted all of the four roles described by Wittmayer and Schäpke (2014) when using the HSDA and that I did not do so consciously. I claim that it would have been helpful to consider in advance of my research project a) whether certain roles were needed for the process and if so, who in the team could take on which role (i.e., reflective scientist, facilitator, change agent and (self-)reflexive scientist), and b) to question which specific competencies were necessary for fulfiling these roles well. This is not a new finding, but confirms what Bulten and colleagues (2021) previously described. Thus, my experiences go in line with colleagues emphasising the challenges that TSc scholars may face when adopting these different roles, as the competency requirements are very high (Hilger et al. 2018, Bulten et al. 2021). They may be challenged in their identity and self-perception as a researcher due to different internal and external expectations concerning "new roles" that sometimes conflict with "traditional" skills (Bulten et al. 2021): "more engaged roles in transdisciplinary sustainability research require new skills and competences that researchers are often not trained in."

I claim that the very valuable framework of sustainability competencies, presented in Chapter 3, should be an integral part of every methods training for students of higher education in the field of sustainability research, as is the case at Leuphana University of Lüneburg, Germany (Barth 2019), and in trainings for more established researchers. Concerning interpersonal and implementation competencies and change-oriented skills, such as conflict resolution or negotiation abilities (Salgado Perez et al. 2018: 172), I very much benefitted from my training as a professional mediator.

5.1.1.2 Mind-sets and inner-transformation

> "Self-transformation happens by engaging with critical theories related to sustainability and transformations (head), by reflecting upon one's own normative position as a researcher (heart), by experimenting with methods grounded on one's own values (hands) and by engaging in places as a human being open to developing response-ability (feet)" (Horlings et al. 2020: 480).

According to Horlings and colleagues (2020: 480), self-transformation "can be a legitimate outcome of [sustainability] research". I uncovered some of my struggles during my research journey and I have observed how my very personal challenges, experiences and attitudes have influenced my research process and how this process, on the other hand, has triggered the awareness for these topics. For example, my deep self-devaluation and the great pressure to prove, due to the internal classism I experienced, that I am able to carry out high-quality research, was submitted to an internal process of transformation. But the synergic satisfiers for intervention on how to deal with this classism-experience affected two dimensions: A professional coach accompanied me in integrating these issues, as they became visible through my awareness and self-reflexive practice. At the same time, I plea for increased recognition within academia, very similar to upcoming diversity debates (Hunt et al. 2015, Powell 2018), to also recognise internal and external classism and the deprivations and challenges for people affected by it (Russel 1996, Agyeman 2008). But even further, intersectionality with respect to race, class, disabilities, ethnicity, culture, religion or/and gender, needs increased recognition (Rawls and Duck 2020).

An increasing body of literature highlights the importance and potential of linking individual and collective change and is concerned with this "inner transformation" (Parodi and Tamm 2018) or "personal sustainability" (Horlings 2015) and may support TSc scholars in acknowledging the complex interrelatedness of the "inner" and the "outer" world or even the interbeing (Wamsler et al. 2020, Woiwode et al. 2021).

So-called "transformative skills," like openness, self-awareness, compassion and empathy, perspective-seeking, empowerment, values-based courage and engagement, all call for greater consideration (Wamsler et al. 2020). I follow the argument that a "change in mindsets can be supported by changing the way we relate to ourselves, others, the environment, and/or the future" (ibid.: 231); and these dimensions (micro or individual level "Eigenwelt," meso or social group

level “Mitwelt,” environment or macro level “Umwelt” and future level or future generations “Nachwelt”) are exactly the same dimensions within which HSDA invites us to reflect our needs actualisation (Spiering and Barrera 2021). TSc processes, by providing safe spaces for open dialogue, an atmosphere of trust and co-creation without fear, further such introspections and reflections for mindset changes and thus “link negotiations, interaction and integrated learning” (Wamsler et al. 2020: 232).

5.1.2 Support and resources

> “Research is usually perceived as an intellectual activity and being trained as a researcher includes reading theory and learning refinements of analyses, but there is little or no formal training in the practical art of actually doing research. Even action research is very much a craft that is learned by doing, and often without any organized supervision.” (Heen 2007: 272)

Here, I argue for the need of competent and organised supervision for early TSc scholars as a synergic strategy for meeting the needs for understanding and participation within the academic environment. The competencies presented in the previous section hold true for supervisors as researchers as well; but I further argue that PhD students and their supervisors could equally benefit from a more organized supervision of TSc projects. Gordon and colleagues (2021: 647) spelled out several leadership qualities of sustainability leaders such as - “harmonize values and empirical rigour,” “foster equity, shared leadership and consensus,” “cultivate nimbleness and flexibility” or “persevere and be resilient in the face of substantial pressures”- which provide an environment within which transdisciplinary science may thrive. Developing the necessary leadership skills and attributes requires new, targeted training programmes, mentoring programmes and networks of colleagues. I particularly follow Kläy and colleagues (2014: 8) when they argue that there is a need for a “common will to address meta-level issues of science for sustainable development”; this is where I assume mutual learning is possible.

I consider these competencies to be prerequisites for further efforts to jointly consider which resources are helpful in the research process and how they can be procured.

5.1.3 Structural changes

> "How can critical reflexivity be maintained when performing research that aims to contribute to normative goals such as sustainability? Often too much weight is given to individual responsibility. It's important, but institutions bear a much greater share of responsibility. They are to be held accountable. Sometimes, one gets the impression that academic institutions have become trapped in a fierce competition to obtain funding and high rankings. This leads to a distorted idea of what a university is, and puts their mission of being the voice of reason in society and of transmitting values like societal responsibility to the next generation at risk of being forgotten." (Nowotny 2018: 6)

Greater recognition of TSc in science and research funding is needed

Milkoreit and colleagues (2015: 87) speak of "conducting science in a hybrid space" and TSc scholars can be seen as "agents at the boundary between the sphere of science and policy." They highlight career risks that the practice-orientation may evoke and that they may be "negatively framed as 'environmentalists', 'hippies', fervent defenders of social justice, or people who hide ulterior motives behind the protective language of research and objectivity. […] Even without advocating for a specific policy or institutional change, scientists can be attacked by political actors for having non-scientific motives, can be exposed to criticism and misrepresented in the media, and as a result lose some of their science-based authority in the process" (ibid.: 87). Greater recognition of TSc within academia, adapting the procedures related to financing and project duration to the specifics of TSc research, but also different kinds of policy support, could support TSc approaches to get out of the niche (Muhonen et al. 2020, Caniglia et al. 2020, Defila and DiGiulio 2020).

Addressing institutional barriers

Hernandez-Aguilera and colleagues (2021) as well as Lang and Wiek (2021) stress on the urgency to address institutional barriers, as "despite strong personal interest, students and early career researchers are often reluctant to engage in this research trajectory" and "scholars choose 'safer' and better-established career trajectories" (Hernandez-Aguilera and colleagues 2021: 374). Both formulate several very similar actions on how to overcome these barriers, which I would have appreciated to be implemented within my research environment in general (and also within my

graduate school, in particular): capacity building in solution-oriented research on all academic levels, changes in the academic reward system to incentivize solution-oriented research, outline of career paths for early career researchers interested in solution-oriented sustainability research including supporting tenure and promotion policies that acknowledge achievements beyond conventional outcomes and publication outlets.

For my internal struggle to find synergic satisfiers on how to meet my need for identity, it was of utmost importance to acknowledge and explicitly spell out the differences and the specific value of the normative positioning as a TSc researcher. Bulten and colleagues (2021) formulate that, on a "more fundamental level, researchers struggle with their normative position. Researchers may feel that committing themselves explicitly to the normative goals of a programme reduces their credibility as neutral and objective providers of knowledge in this particular domain. From a constructivist perspective, however, researchers will never be fully objective, because all scientific practices include normative considerations (Scholz 2017)." This acknowledgement and the awareness of belonging to a research community is comforting and conveys a sense of security and belonging.

Brundiers and colleagues (2021: 22) argue that it would be helpful to spell out "learning objectives in direct response to widely held prejudices that sustainability science aims to overcome." They formulate the following as learning objectives for students and I argue they may be used even further as arguments for all TSc scholars to characterise TSc: "1. Sustainability is `not first and foremost about the environment` and not just about technical solutions and engineering; but is instead a layered concept with justice and equity as foundational elements. This would involve broadening the perspective on justice and equity beyond environmental justice to also include more general and explicit forms of social and racial justice. 2. Integrate values into scientific inquiry, countering the positivistic perception that `values are outside of the realm of science` as science´ is considered to be objective` and the positivistic instruction that `scientists should not deal in values´. 3. Articulate sustainability science as a solution-oriented field, which employs the same rigor, using systems-, values-, futures-, and strategic-thinking competencies, to researching solutions to sustainability challenges as to researching sustainability problems. 4. Articulate the necessity of stakeholder engagement (a 'must' have) in sustainability science research (transdisciplinary approaches)".

I think it is not just my own personal experience to have been under high pressure. Of course, my previous experiences aggravated the pressure I felt to master this process well incredibly. Within literature you can find various tips on how to deal psychologically and physically with this pressure (Stock et al. 2014, Auerbach et al. 2018). Is it then not perhaps high time to change this system that makes many PhD students and others so sick? Is it not time to change the underlying values? We as humankind have a huge problem with climate change and dwindling biodiversity - is there not a need for cooperative science instead of competitive science? Is there not a huge need for space to experiment, for failure that is free of judgement, of support structures that allow creative potential to develop?

5.2 Added-value of self-reflexive practice within transformative science applying the Human Scale Development approach

I would like to close this section with a last reflection, and maybe from my perspective, the most powerful result and insight of my research process: an important lever of intervention is the researcher's self-reflexive practice using the HSDA. Following Fazey and colleagues (2018: 66), self-reflexive practice may involve the researchers' critical reflecting on how they may need to undergo transformations within themselves to be in a better position to understand or shape transformative change in the systems in which they are embedded. Having applied the HSDA not only during my research in ten workshops, but also using it as tool for self-reflexive practice, I could not only reflect on what factors impeded my needs fulfilment, but I could also see what potentials I already had. This practice helped me to consider not only expected influences, but it additionally made hidden influences visible and I could integrate them. In doing so, I could point out strategies that not only affected me in my different roles as a researcher, but also on a personal and a systemic level (by questioning the academic environment, its cultures and practices). Retrospectively, I would have liked to pass through such a process more regularly and also within a research team. Cruz and colleagues (2009: 100) propose such evaluations at different time periods throughout a project, to identify improvements and/or worsening of given dimensions and/or trends. Thus, I do very much promote the HSDA as a valuable tool for self-reflexive practice for students of higher education, PhD students, researchers and research teams on a regular basis.

Table 6: Compilation of supporting factors for transformative science scholars

6 Some concluding remarks

This article has turned out to be an experiment in content and form. I penned this autoethnographic-sensible self-reflexive practice to point out the value of HSDA as a self-reflexive tool for TSc scholars, but also as very personal piece to integrate my experiences during my research journey. Undertaking this self-reflexive practice has been a challenge and an opportunity at the same time – I was able to better understand and integrate my motives for engaging in the normative value-laden transformative science research. I understood now that I was triggered by the fact that this kind of research is in its infancy and must assert itself permanently and stand up for its quality, justification and procedures; this was very similar to my personal struggle – and helped me to appreciate my personal journey. I have learned through my research to recognize my own strengths and this has shown me how, through those strengths, if I let them grow within me, other people will trust my abilities and I can take them along, motivate and inspire them. I would be delighted if more HSDA practitioners and TSc scholars could fill in and (jointly) undertake a (self-)reflexive practice of their experiences, applying the HSDA process based on a human scale.

References

ADELLE, C., PEREIRA, L., GÖRGENS, T. & LOSCH, B. 2020. Making sense together: The role of scientists in the coproduction of knowledge for policy making. Science and Public Policy, 47, 56-66. https://doi.org/110.1093/scipol/scz046

AGYEMAN, J. 2008. Toward a 'just' sustainability? Continuum, 22, 751-756.

ALSOP, C. K. 2002: Home and away: Self-reflexive auto-/ethnography. Forum Qualitative Sozialforschung/Forum: Qualitative Social Research.

Alsop, C. K. (2002). Home and Away: Self-Reflexive Auto-/Ethnography. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, Vol. 3 No. 3. https://doi.org/10.17169/fqs-3.3.823

ALVESSON, M. & SKÖLDBERG, K. 2009. Reflexive methodology: New vistas for qualitative research, London: Sage.

AUERBACH, R. P., MORTIER, P., BRUFFAERTS, R., ALONSO, J., BENJET, C., CUIJPERS, P., DEMYTTENAERE, K., EBERT, D. D., GREEN, J. G. & HASKING, P. 2018. WHO world mental health surveys international college student project: prevalence and distribution of mental disorders. Journal of abnormal psychology, 127 (7), 623.

AVELINO, F. 2011. Power in transition: empowering discourses on sustainability transitions (PhD-thesis). Erasmus University, Rotterdam

BARTH M (2019) Change Agents für das 21. Jahrhundertausbilden—Nachhaltigkeitswissenschaften als Studiengang. In: Michelsen G, Barth M, Fischer D (eds) Bildung für nachhaltige Entwicklung in der Hochschule: Wege und Wirkungen am Beispiel der Leuphana Universität Lüneburg. Budrich, Opladen

BEECROFT, R., TRENKS, H., RHODIUS, R., BENIGHAUS, C. & PARODI, O. 2018. Reallabore als Rahmen transformativer und transdisziplinärer Forschung: Ziele und Designprinzipien. Transdisziplinär und transformativ forschen. Springer VS, Wiesbaden.

BRUNDIERS, K., BARTH, M., CEBRIÁN, G., COHEN, M., DIAZ, L., DOUCETTE-REMINGTON, S., DRIPPS, W., HABRON, G., HARRÉ, N. & JARCHOW, M. 2021. Key competencies in sustainability in higher education—Toward an agreed-upon reference framework. Sustainability Science, 16, 13-29. https://doi.org/10.1007/s11625-020-00838-2

BULTEN, E., HESSELS, L. K., HORDIJK, M. & SEGRAVE, A. J. 2021. Conflicting roles of researchers in sustainability transitions: balancing action and reflection. Sustainability Science, 1-15. https://doi.org/10.1007/s11625-021-00938-7

BURGESS, J. 2006. Participatory action research: First-person perspectives of a graduate student. Action Research, Vol. 4 Issue. 4, 419-437. https://doi.org/10.1177/1476750306070104

BUTZ, D. (2010). Autoethnography as sensibility. In: DeLyser, D., Aitken, S., Herbert, S., Crang, M., and McDo-well, L. (eds.) Handbook of qualitative geography. London: Sage, pp. 138–155

CANIGLIA, G., LUEDERITZ, C., VON WIRTH, T., FAZEY, I., MARTÍN-LÓPEZ, B., HONDRILA, K., KÖNIG, A., VON WEHRDEN, H., SCHÄPKE, N. & LAUBICHLER, M. 2020. A pluralistic and integrated approach to action-oriented knowledge for sustainability. Nature Sustainability, Vol. 4 Issue. 2, 1-8. https://doi.org/10.1038/s41893-020-00616-z

CENTGRAF, S. 2018. Supporting civic engagement in German energy cooperatives–Transdisciplinary research based on the reflection of individual needs. Energy research & social science, 44, 112-121. https://doi.org/10.1016/j.erss.2018.05.003

Coffey, A. (1999). The Ethnographic Self. 1999 p. 1-192 London: SAGE Publications Ltd https://dx.doi.org/10.4135/9780857020048

CRUZ, I., STAHEL, A. & MAX-NEEF, M. 2009. Towards a systemic development approach: Building on the Human-Scale Development paradigm. Ecological economics, 68 (7), 2021-2030. https://doi.org/10.1016/j.ecolecon.2009.02.004

CUNLIFFE, A. L. & EASTERBY-SMITH, M. 2017. From reflection to practical reflexivity: Experiential learning as lived experience. Organizing reflection. London: Routledge.

CUNLIFFE, A. L. & JUN, J. S. 2005. The need for reflexivity in public administration. Administration & society, 37, 225-242.

DAY, S. 2012. A reflexive lens: Exploring dilemmas of qualitative methodology through the concept of reflexivity. Qualitative sociology review, 8(1): 60-85.

DEFILA, R. & DI GIULIO, A. 2019. Wie Reallabore für Herausforderungen und Expertise in der Gestaltung transdisziplinären und transformativen Forschens sensibilisieren–eine Einführung. Transdisziplinär und transformativ forschen, Vol 2. Wiesbaden: Springer VS

DEFILA, R. & DI GIULIO, A. 2020. Science policy recommendations for funding real-world laboratories and comparable formats. GAIA-Ecological Perspectives for Science and Society, 29 (1), 63-65. https://doi.org/10.14512/gaia.29.1.14

ELLINGSON, L. & ELLIS, C. 2008. Autoethnography as constructionist project. In J. A. Holstein, & J. F. Gubrium (Eds.), Handbook of constructionist research (pp. 445-465). New York: Guilford.

ELLIS, C. & BOCHNER, A. 2000. Autoethnography, personal narrative, reflexivity: Researcher as subject. In N. K. Denzin & Y. S. Lincoln (Eds.), Handbook of Qualitative Research (2nd Ed.), London: Sage, p. 733-768

ENGLAND, K. V. 1994. Getting personal: Reflexivity, positionality, and feminist research. The professional geographer, 46 (1), 80-89. https://doi.org/10.1111/j.0033-0124.1994.00080.x

FAZEY, I., SCHÄPKE, N., CANIGLIA, G., HODGSON, A., KENDRICK, I., LYON, C., PAGE, G., PATTERSON, J., RIEDY, C. & STRASSER, T. 2020. Transforming knowledge systems for life on Earth: Visions of future systems and how to get there. Energy Research & Social Science, 70, December 2020, 101724.

FAZEY, I., SCHÄPKE, N., CANIGLIA, G., PATTERSON, J., HULTMAN, J., VAN MIERLO, B., SÄWE, F., WIEK, A., WITTMAYER, J., ALDUNCE, P., AL WAER, H., BATTACHARYA, N., BRADBURY, H., CARMEN, E., COLVIN, J., CVITANOVIC, C., D'SOUZA, M., GOPEL, M., GOLDSTEIN, B., HÄMÄLÄINEN, T., HARPER, G., HENFRY, T., HODGSON, A., HOWDEN,

M. S., KERR, A., KLAES, M., LYON, C., MIDGLEY, G., MOSER, S., MUKHERJEE, N., MÜLLER, K., O'BRIEN, K., O'CONNELL, D. A., OLSSON, P., PAGE, G., REED, M. S., SEARLE, B., SILVESTRI, G., SPAISER, V., STRASSER, T., TSCHAKERT, P., URIBE-CALVO, N., WADDELL, S., RAO-WILLIAMS, J., WISE, R., WOLSTENHOLME, R., WOODS, M. & WYBORN, C. 2018. Ten essentials for action-oriented and second order energy transitions, transformations and climate change research. Energy Research & Social Science, 40, June 2018, 54-70. https://doi.org/10.1016/j.erss.2017.11.026

FONOW, M. M. & COOK, J. A. 1991. Beyond methodology: Feminist scholarship as lived research, Indiana: Indiana University Press.

GERGEN, M. M. & GERGEN, K. J. 2000. Qualitative inquiry: Tensions and transformations. Handbook of qualitative research, 2, 1025-1046.

GORDON, I., BAWA, K., BAMMER, G., BOONE, C., DUNNE, J., HART, D., HELLMANN, J., MILLER, A., NEW, M. & OMETTO, J. 2019. Forging future organizational leaders for sustainability science. Nature Sustainability, 2, AUGUST 201, 647-649. https://doi.org/10.1038/s41893-019-0357-4

GRAM-HANSSEN, I., SCHAFENACKER, N. & BENTZ, J. 2022. Decolonizing transformations through 'right relations'. Sustain Sci 17, 673–685 (2022). https://doi.org/10.1007/s11625-021-00960-9

GUILLEN-ROYO, M. 2016. Sustainability and wellbeing: Human-scale development in practice, New York: Routledge.

HARDING, S. 1989. 'Introduction: Is there a feminist method?', in S. Harding (ed) Feminism and Methodology: Social Science Issues. Bloomington: Indiana University Press. pp. 1-14.

HEEN, H. 2005. About feelings in action research: An experiment in first-person inquiry. Action Research, 3(3), 263-278. https://doi.org/10.1177/1476750305056002

HERNANDEZ-AGUILERA, J. N., ANDERSON, W., BRIDGES, A. L., FERNANDEZ, M. P., HANSEN, W. D., MAURER, M. L., NÉBIÉ, E. K. I. & STOCK, A. 2021. Supporting interdisciplinary careers for sustainability. Nature Sustainability, 4 (5), 1-2. https://doi.org/10.1038/s41893-020-00679-y

HERWEG, K. G., ZIMMERMANN, A., LUNDSGAARD, L. M., TRIBELHORN, T., HAMMER, T., TANNER, R. P., TRECHSEL, L. J., BIERI, S. & KLÄY, A. 2017. Integrating Sustainable Development into higher education—Guidelines with in-depth modules for the University of Bern. Foundations. University of Bern, Vice-Rectorate Quality, Vice-Rectorate Teaching, Centre

HORLINGS, L. G. 2015. The inner dimension of sustainability: personal and cultural values. Current Opinion in Environmental Sustainability, 14, June 2015, 163-169. https://doi.org/10.1016/j.cosust.2015.06.006

HORLINGS, L. G., NIETO-ROMERO, M., PISTERS, S. & SOINI, K. 2020. Operationalising transformative sustainability science through place-based research: the role of researchers. Sustainability Science 15, November 2019, 467–484 (2020). https://doi.org/10.1007/s11625-019-00757-x

HUNT, V., LAYTON, D. & PRINCE, S. 2015. Diversity matters. McKinsey & Company, 1 (1), 15-29. https://www.insurance.ca.gov/diversity/41-ISDGBD/GBDExternal/upload/McKinseyDivmatters-201501.pdf (Accessed 03.08.2022)

JACKSON, T., JAGER, W. & STAGL, S. 2004. Beyond insatiability: needs theory, consumption and sustainability. ESRC Sustainable Technologies Programme Working Paper Series, 2/2004, 1-34.

JAEGER-ERBEN, M., NAGY, E., SCHÄFER, M., SÜßBAUER, E. & ZSCHEISCHLER, J. 2018. Von der Programmatik zur Praxis: Plädoyer für eine Grounded Theory transformationsorientierter Forschung. GAIA-Ecological Perspectives for Science and Society, 27(1), 117-121. https://doi.org/10.14512/gaia.27.1.5

KLÄY, A., ZIMMERMANN, A. B. & SCHNEIDER, F. 2015. Rethinking science for sustainable development: Reflexive interaction for a paradigm transformation. Futures, 65, January 2015, 72-85. https://doi.org/10.1016/j.futures.2014.10.012

LAC, V. T. & FINE, M. 2018. The good, the bad, and the ugly: An autoethnographic journey on doing participatory action research as a graduate student. Urban Education, 53(4), 562-583. https://doi.org/10.1177/0042085918762491

LANG, D. J. & WIEK, A. 2022. Structuring and advancing solution-oriented research for sustainability. Ambio 51, January 2022, 31-35. https://doi.org/10.1007/s13280-021-01537-7

LAUTERMANN, C., DORNIOK, D., RAUSCHMAYER, F., MASSON, T., CENTGRAF, S. & MOSER, P. 2017. Transformationspotenziale von Energiegenossenschaften: Mit postfossilen Dezentralisierungsstrategien zur Energiewende (EnGeno): Schlussbericht: gemeinsamer Bericht zum BMBF-Forschungsprojekt, Carl von Ossietzky Universität Oldenburg.

LIPP, A. 2007. Developing the reflexive dimension of reflection: A framework for debate. International Journal of Multiple Research Approaches, 1(1), 18-26. https://doi.org/10.5172/mra.455.1.1.18

MARTIN, L. 2015. Incorporating values into sustainability decision-making. Journal of Cleaner Production, 105, October 2015, 146-156. https://doi.org/10.1016/j.jclepro.2015.04.014

MAX-NEEF, M., ELIZALDE, A. & HOPENHAYN, M. 1990. Human scale development: an option for the future, Development Alternatives Centre [Centro de Alternativas de Desarrollo] (CEPAUR): Santiago, 1990.

MAX-NEEF, M., ELIZALDE, A. & HOPENHAYN, M. (1991) Human scale development: Conception, application and further reflections New York: The Apex Press (Accessed 04.06.2021) http://www.wtf.tw/ref/max-neef.pdf.

Independent Group of Scientists appointed by the Secretary-General (2019) Global Sustainable Development Report 2019: The future is now—science for achieving sustainable development. United Nations, New York

VAN MIERLO, B., REGEER, B., VAN AMSTEL, M., ARKESTEIJN, M., BEEKMAN, V., BUNDERS, J., DE COCK BUNING, T., ELZEN, B., HOES, A.-C. & LEEUWIS, C. 2010. Reflexive monitoring in action. A guide for monitoring system innovation projects. Communication and Innovation Studies, WUR; Athena Institute, VU.

MILKOREIT, M., MOORE, M.-L., SCHOON, M. & MEEK, C. L. 2015. Resilience scientists as change-makers—Growing the middle ground between science and advocacy? Environmental science & policy, 53 Part B, November 2015, 87-95. https://doi.org/10.1016/j.envsci.2014.08.003

MUHONEN, R., BENNEWORTH, P. & OLMOS-PEÑUELA, J. 2020. From productive interactions to impact pathways: Understanding the key dimensions in developing SSH research societal impact. Research Evaluation, 29(1), 34-47. https://doi.org/10.1093/reseval/rvz003

NOWOTNY, H. 2018. 12 Questions to…. GAIA-Ecological Perspectives for Science and Society, 27(S1), 6-7. https://doi.org/10.14512/gaia.27.S1.3

OAKLEY, A. 1981. Interviewing women: A contradiction in terms. In: Roberts, H. (Ed.) 1981 Doing Feminist Research, London: Routledge and Keagan Paul [online] http://www.brown.uk.com/teaching/HEST5001/oakley4.pdf (Accessed 03.08.2022)

PARODI, O. & TAMM, K. 2018. Personal sustainability: exploring the far side of sustainable development, London: Routledge.

PÄSSILÄ, A. H., OIKARINEN, T. & HARMAAKORPI, V. 2015. Collective voicing as a reflexive practice. Management Learning, 46 (1), 67-86. https://doi.org/10.1177/1350507613488310

POPA, F., GUILLERMIN, M. & DEDEURWAERDERE, T. 2015. A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. Futures, 65, January 2015, 45-56. https://doi.org/10.1016/j.futures.2014.02.002

POWELL, K. 2018. The power of diversity. Nature, 558 (7708), 19-22.

RAWLS, A. W. & DUCK, W. 2020. Tacit racism, Chicago: University of Chicago Press.

RAUSCHMAYER, F. (2019). The transition to sustainability as interbeing... or: from oncology to ontology. What Next for Sustainable Development? Edward Elgar Publishing. Cheltenham, pp 181–199

RUSSELL, G. 1996. Internalized classism: The role of class in the development of self. Women & Therapy, 18(3-4), 59-71. https://doi.org/10.1300/J015v18n03_07

SALGADO, P., ABBOTT, D. & WILSON, G. 2018. Dimensions of professional competences for interventions towards sustainability. Sustainability Science, 13(2018), 163-177. https://doi.org/10.1007/s11625-017-0439-z

SCHNEIDER, F., KLÄY, A., ZIMMERMANN, A. B., BUSER, T., INGALLS, M. & MESSERLI, P. 2019. How can science support the 2030 Agenda for Sustainable Development? Four tasks to tackle the normative dimension of sustainability. Sustainability Science, 14, 1593-1604. https://doi.org/10.1007/s11625-019-00675-y

SCHNEIDEWIND, U. (2015) Transformative Science – Driving Force for Good Science and a Living Democracy. GAIA 24/2 (2015). https://doi.org/88 – 9 10.14512/gaia.24.2.5

SCHOLZ, R. W. 2017. The normative dimension in transdisciplinarity, transition management, and transformation sciences: New roles of science and universities in sustainable transitioning. Sustainability, 9(6), 991. https://doi.org/10.3390/su9060991

SCHON, D. A. 1984. The reflective practitioner: How professionals think in action, New York: Basic books.

SCHWEIZER-RIES, P. R., FRIEDER; REISCH, LUCIA 2016. Klima-Citoyen. Neue Rollen, Möglichkeiten und Verantwortlichkeiten der Bürger in der Transformation des Energiesystems. In: 01UN1210A-C, S. Z. P. K.-C. F. (ed.). Project report [online] http://www.transformation-des-energiesystems.de/sites/default/files/KlimaCitoyen_Abschlussbericht.pdf (Accessed 03.08.2022)

SCOTT, J.-A. 2019: Performance, Documentary and Embodied Qualitative Inquiry. https://www.ualberta.ca/international-institute-for-qualitative-methodology/webinars/master-class-webinar/archived-webinars.html (Accessed: 02.11.2021)

SHARPE, B., HODGSON, A., LEICESTER, G., LYON, A. & FAZEY, I. 2016. Three horizons: a pathways practice for transformation. Ecology and Society 21(2):47. http://dx.doi.org/10.5751/ES-08388-210247

SPIERING, S. & VALLE BARRERA, M. D. 2020. How to?! Practical knowledge for transformative science - facilitation guidelines for two applications of the Human Scale Development Approach. https://doi.org/10.57699/a3y9-gd49

SPIERING, S. & BARRERA, M. D. V. 2021. Testing the quality of transformative science methods: the example of the Human Scale Development approach. Sustainability Science. https://doi.org/10.1007/s11625-021-00966-3

STOCK, S., SCHNEIDER, P., PEPER, E., MOLITOR, E. 2014. Ein Ratgeber von Promovierten für Promovierende. 3. überarb. und erw. Aufl, Berlin/Heidelberg: Springer

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, UNESCO (2017) Education for sustainable development goals: learning objectives. UNESCO, Paris, France. https://unesdoc.unesc o.org/image s/0024/00247 4/24744 4e.pdf. (Accessed 02.11.2021)

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, UNESCO (2018) Issues and trends in education for sustainable development. UNESCO, Paris

VAN DER HEL, S. 2018. Science for change: A survey on the normative and political dimensions of global sustainability research. Global Environmental Change, 52, September 2018, 248-258. https://doi.org/10.1016/j.gloenvcha.2018.07.005

VINCE, R. & REYNOLDS, M. 2009. Reflection, reflective practice and organizing reflection. In: Armstrong S. J., Fukami C.V. (Ed.) The SAGE handbook of management learning, education and development, p. 89-103, London: Sage

WAMSLER, C., SCHÄPKE, N., FRAUDE, C., STASIAK, D., BRUHN, T., LAWRENCE, M., SCHROEDER, H. & MUNDACA, L. 2020. Enabling new mindsets and transformative skills for negotiating and activating climate action: Lessons from UNFCCC conferences of the parties. Environmental Science & Policy, 112, October 2020, p.227-235. https://doi.org/10.1016/j.envsci.2020.06.005

WITTMAYER, J., HÖLSCHER, K., WUNDER, S. & VEENHOFF, S. 2018. Transformation Research: Exploring methods for an emerging research field. Texte 01/2018 Dessau-Roßlau, Umweltbundesamt [online] https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-01-09_texte_01-2018_transformation_research.pdf (Accessed 03.08.2022)

WITTMAYER, J. M. & SCHÄPKE, N. 2014. Action, research and participation: roles of researchers in sustainability transitions. Sustainability science, 9 (2014), 483-496. https://doi.org/10.1007/s11625-014-0258-4

WOIWODE, C., SCHÄPKE, N., BINA, O., VECIANA, S., KUNZE, I., PARODI, O., SCHWEIZER-RIES, P., WAMSLER, C. (2021) Inner transformation to sustainability as a deep leverage point: fostering

new avenues for change through dialogue and reflection. Sustainability Science: 1-18. https://doi.org/10.1007/s11625-020-00882-y

ZIEGLER, R. & OTT, K. 2011. The quality of sustainability science: a philosophical perspective. Sustainability: Science, Practice and Policy, 7(1), 31-44. https://doi.org/10.1080/15487733.2011.11908063

Figures and Tables

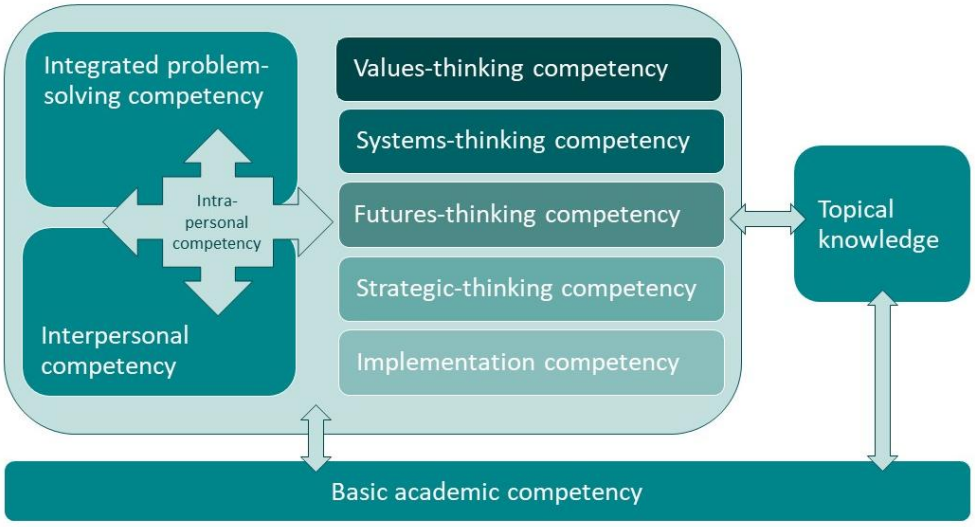


Figure 1: Framework of key competencies in sustainability [adapted from Brundiers et al. (2021)]

Integrated problem-solving competency	- *successfully integrate two or more of the key competencies in sustainability problem-solving endeavours* - *integrate all key competencies to create viable and equitable solutions for sustainability* - ***select and apply appropriate problem-solving frameworks***
Interpersonal competency	- *apply the concepts and methods of each competency not merely as "technical skills," but in ways that* ***truly engage and motivate diverse stakeholders and to empathically work with collaborators' and citizens' different ways of knowing and communicating*** - *include different types of collaboration, from small to large interdisciplinary teams, stakeholder engagements as well as transdisciplinary and action research methods; this reinforces the emphasis that each competency requires collective efforts and highlights the* ***wider set of professional skills, such as communication and deliberation, project-management, lifelong-learning, and leadership reflecting r****ecent literature*
Intrapersonal competency or self-awareness competency *Similar to interpersonal competency, intrapersonal competency underpins all other competencies.*	- *be* ***aware of one's own emotions, desires, thoughts, behaviours and personality*** - ***to regulate, motivate, and continually improve oneself drawing on competencies*** *related to emotional intelligence and social and emotional learning* - *UNESCO's (2017: 10) key competencies for sustainability, which define "self-awareness competency" in relation to context -* ***"reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires****"*
Values-thinking competency *Provides the normative orientation for all the other competencies (it thus stands on top of the hierarchy of competencies): values-thinking competency and sustainability values need to be the main reference point for the other competencies.*	- *d****ifferentiate between intrinsic and extrinsic values in the social and natural world; identify and clarify one's own values*** - *explain how values are contextually, culturally, and historically reinforced* - *recognise normalised oppressive structures; critically evaluate how particular stated values align with agreed-upon sustainability*
Systems-thinking competency	- *"collectively analyze complex systems across different domains (society, environment, economy, etc.) and across different scales (local to global), thereby considering cascading effects, inertia, feedback loops and other systemic features related to sustainability issues and sustainability problem-solving frameworks."*
Futures-thinking competency	- *"iterate and continuously refine one's own futures thinking (visions, scenarios, etc.), in productive and explicit tension vis-à-vis the status quo* - *recognise the "implicitly held (and largely unrecognized) assumptions about how society works" and how they influence the status quo* - *critically reflect how they might influence futures thinking*
Strategic-thinking competency	- *recognise the historical roots and embedded resilience of deliberate and unintended unsustainability and the barriers to change* - *creatively plan innovative experiments to test strategies* - *engage in and lead radical change, using concepts of transgression and disruption*

Implementation competency - *Its hands-on orientation distinguishes it from integrated problem-solving competency.* - *It catalyses the cognitively driven integrated problem-solving competency into manifest changes on the ground.* - *It is thus a primary motivation for conducting sustainability research.*	*Implementation competency is essentially action competency, using actionable knowledge that has been created through strategic-thinking competency. It is a competency explicitly about taking action: the ability to act, or to consciously implement interventions, was identified as a highly important competency for sustainability by student teachers […] and sustainability professionals. It is the collective ability to:* - *implement a planned solution toward a sustainability-informed vision, to monitor and evaluate the realisation process, and to address emerging challenges (adjustments), recognising that sustainability problem-solving is a long-term, iterative process between planning, realisation, and evaluation* - *disrupt and transgress to break habits and dominant and hegemonic structures and lead radical change*
Topical knowledge and basic academic competency *Competency underpinning key competencies in any degree programme*	- *recognise different approaches to theory building (e.g., social constructivism, critical theory)* - *acquire basic research competencies to enable evidence-based decision making, including conducting an interdisciplinary literature review* - *Critical thinking, being an important part of basic academic competency, is "the ability to question norms, practices and opinions; to reflect on one's own values, perceptions and actions; and to take a position in the sustainability discourse" (UNESCO 2018: 12)*

Table 1: Extended description of competencies in the framework of key competencies in sustainability [adapted from Brundiers et al. (2021: 19ff.)]

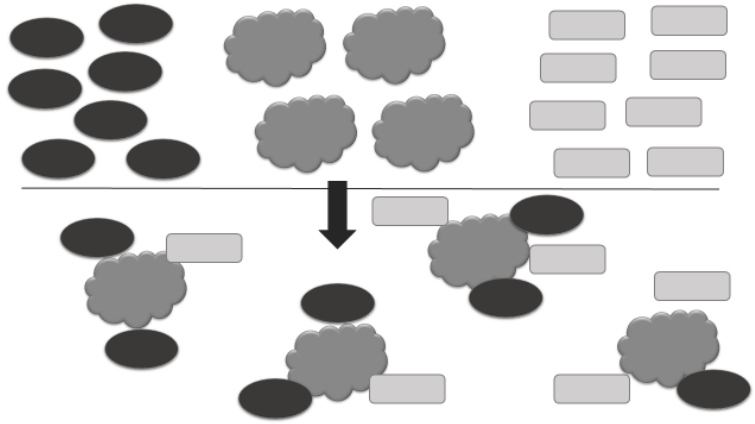
1. Filling in the negative matrix

	Being	Having	Doing	Interacting	Most important negative factors
Subsistence					
Protection					
Affection					
Understanding					
Participation					
Idleness					
Creation					
Identity					
Freedom					
	How are we/not?	What do we have / not?	What do we do / not?	Where do we interact / not?	

2. Filling in the positive matrix

	Being	Having	Doing	Interacting	Most important positive factors
Subsistence					
Protection					
Affection					
Understanding					
Participation					
Idleness					
Creation					
Identity					
Freedom					
	How are we?	What do we have?	What do we do?	Where do we interact?	

3. Finding head-topics of the most important negative and positive factors



4. Distilling synergic endogenous and exogenous strategies

	Being	**Having**	**Doing**	**Interacting**
	How do we want to be?	What do we want to have?	What do we want to do?	Where do we want to interact?

Table 2: Introduction to HSDA - from matrix filling to distilling synergic endogenous and exogenous strategies [adapted from Spiering and Barrera (2020)]

Case study	*Participants*	*Aims and Objectives*	*Process and role of HSDA*
Transformational potential of energy cooperatives EnGeno (2014-2016) (Centgraf 2018)	3 workshops with members of the management and supervisory boards and active and passive members of 3 German energy cooperatives	To support the members of German energy cooperatives, whose involvement is mostly voluntary, to support initiatives that are robust in the long-run	Facilitating the development of new strategies which help the individual members of energy cooperatives to meet the challenges arising from their civic engagement
	1 workshop with three regional energy cooperatives, a transition town initiative and political stakeholders	Networking of various actors to determine development strategies for renewable energy in the region	Identifying deprivations, potentials and common strategies for citizen-driven renewable energy projects
Transformation towards a program for renewables, Liceo Tecnico de Paillaco, Chile (2016)	1 workshop with teachers and students of the Technical School of Paillaco in Chile	To support the bottom-up foundation of a program for renewable energy in the technical school	Identifying common strategies to establish a programme for renewable energy within the school
Strategy process to form an energy cooperative in Nalbach, Germany in cooperation with the BMBF-project Klima-Citoyen (Schweizer-Ries et al. 2016)	3 workshops with major, council members and citizens of the municipality of Nalbach, Germany	To undertake a comprehensive consultation on challenges and opportunities of forming an energy cooperative in the municipality of Nalbach	Facilitating the decision-making process for forming an energy cooperative, reflecting on the negative and utopian factors and strategies for implementation
Digital Workshops with HSD-master students of the Universidad Austral de Chile (2020, 2021)	2 workshops with 7 HSD masters students	To reflect on being a master's student at UACh during the coronavirus pandemic	Two-fold aim: learn about how to facilitate an HSDA-workshop and increase the level of well-being of students within the master's programme

Table 3: Cases in which I acted as reflective scientist, facilitator, change agent and (self-)reflexive scientist

	BEING	HAVING	DOING	INTERACTING
SUBSISTENCE				
PROTECTION	+ Competency in different areas but never "real" expert (all-round dilettante)	+ Pressure of doing "excellent" research **+ Lack of resources to understand power relations within the "fields"** + Having not integrated participants in X right from the beginning	**+ Doubting thoughts - "Am I good enough? Is this research scientific enough?"** + Unsecure if I selected "the right" interview partners – not understanding power relations because of one-off-workshops	
AFFECTION				+ Competition culture
UNDERSTANDING		+ At the beginning of the thesis, difficulties to find literature on HSDA-applications	+ Challenge to conduct workshops in Spanish language	**+ Graduate school that focussed on the formation of quantitative natural scientists (neglecting the needs of qualitative social scientists or even TSc scholars)**
PARTICIPATION	+ When alone with my research, I become more passive and silent when I feel insecure	**+ Lack of good supervision** + Lack of "technical knowledge" + Lack of time/resources to deepen the collaboration with the workshop participants	+ Regular reflections within a research team + Lack of a daily working group within which I could reflect my research + Struggle with theoretical knowledge	**+ Colleagues that extensively criticise or do not value transformative research** **+ Internalised classism "you do not belong to this group"**
IDLENESS		**+ High effort to take responsibility for the workshop processes**		
CREATION		**+ Feelings of devaluation by supervisor's behaviour** + Lack of time for the PhD while working as part-time researcher	+ Although sufficient English proficiency, difficulties in expressing myself/writing in English	**+ Research culture where excellence is a main driver and failure or experiments are less valuable** + Doubts of supervisor if HSDA is the right tool
IDENTITY	**+ Intimidated as young female scholar within a field of retired male academics (in the workshops with the energy cooperatives)**	+ lacking theoretical knowledge	**+ Doubting my abilities as a "real scientist"**	
FREEDOM				
	How am I/not?	**What do I have/not?**	**What do I do/not?**	**Where do I interact/not?**

Table 4: Collection of all **negative satisfiers** that impeded my needs fulfilment [building on the categories suggested by Max-Neef et al. (1990)]

	BEING	HAVING	DOING	INTERACTING
SUBSISTENCE		+ Financial support of the FES grant	**+ Strong desire to contribute to Agenda 2030/ Sustainable Development**	
PROTECTION		+ Experimental character announced in advance	**+ Ability to create safe spaces and create trust**	
AFFECTION	+ Openness + Being fully present with the whole body (trained in yoga and meditation)	**+ Capacity for active/deep listening and reformulation** + Organisational skills + Surprise of the participants to be heard at eye-level	**+ Joy about having initiated a process of reflection** **+ Eating cake and singing birthday songs together** + Encounter others as humans with needs (interest in their driving motivations and values)	+ Joy, happiness and hope in the vision phase
UNDERSTANDING	+ Openness, interested, curiosity + Assertiveness (HSDA instead of Capability Approach because it is more practically applicable)	Courage to emphasise process-orientation (instead of output-orientation)	**+ Learning from experiences – adapting the methodology throughout the process**	**+ Participants who allow themselves to reflect on their needs** + Having a supervisor who supported me in publishing my work
PARTICIPATION	**+ Flexibility**	**+ Contact and exchange with other HSDA scholars**	**+ Embodied interventions instead of mere intellectual interventions**	
IDLENESS			**+ Letting go and being able to trust the process**	**+ Openness and willingness of cooperatives and responsible actors to promote workshops**
CREATION	+ Creativity **+ Openness for experimentation** + Motivation	**+ Value tacit knowledge** + Enabling embodied experiences and exercises in the room **+ Getting to know, "father" of HSDA, Manfred Max-Neef, in person**	+ Acknowledge failure as option **+ Support Master's students and colleagues on how to facilitate HSDA processes**	
IDENTITY		+ Ability to deal with resistances	**+ Trained as a mediator and facilitator** + Accompanied by a professional coach	
FREEDOM		+ Financial resources from research project and research institute (e.g., for language editing, conference fees, open access publication, etc.) + A university supervisor who extensively supported me	**+ Clear setting and communication of boundaries of interactions**	
	How am I?	**What do I have?**	**What do I do?**	**Where do I interact?**

Table 5: Collection of **all positive satisfiers** that supported my needs fulfilment [building on the categories suggested by Max-Neef et al. (1989)]

Competencies

- Foreseeing which different roles a research process will require and which competencies/abilities will be needed to fulfil these roles
- Distributing roles according to competencies/abilities
- Integrating the framework of sustainability competencies as an integral part of all methodological training for students of higher education and for sustainability science scholars

Inner transformations

- Acknowledging that personal challenges, experiences and attitudes influence the research process, and, at the same time, that the research process may lead to a self-transformation as a legitimate outcome of TSc processes
- Increasing the recognition of intersectionality within academia (be it with respect to race, class, disabilities, ethnicity, culture, religion and/or gender)
- Linking individual and collective change and acknowledging the complex interrelatedness of the "inner" and the "outer" world or even the interbeing (Rauschmayer 2019, Woiwode et al. 2021)
- Creating safe spaces for open dialogue

Support and resources

- Need for competent and organised supervision for early-career TSc scholars
- Enhancing the leadership qualities needed for sustainability leaders to provide an environment where transdisciplinary science may flourish. This requires new, targeted training programmes, mentoring programmes and networks of colleagues.

Structural changes

- Need for greater recognition of TSc in science and research funding, for the reduction or removal of the career risks facing practice-oriented TSc scholars, for adapted funding schemes and for policy support
- Addressing institutional barriers: need for capacity building in solution-oriented research, changes in reward systems for career paths and achievements beyond conventional outcomes

Table 6: Compilation of factors that support transformative science scholars