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SPECIAL FEATURE: ORIGINAL ARTICLE

The Reality of Transdisciplinary Processes

Case-based Mutual Learning Sessions: knowledge integration and transfer in transdisciplinary processes

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Abstract Mutual learning is a fundamental element in transdisciplinary (Td) sustainability research. It allows for integrating knowledge and experiences gained in different contexts, including the building of consensus about necessary transformations to reach sustainability solutions. To successfully achieve mutual learning, appropriate conditions are required. These range from providing boundary objects that serve knowledge integration, the development of a common language and knowledge, and shared experiences to transparency concerning the objectives and motives of all those involved. Mutual learning is particularly challenging from an intercultural perspective in both local and global processes. Interaction among the participants is based on experiential, educational, and cultural dimensions that induce different types of knowledge and cognition, thought styles, socializations, constraints and preferences in socio-political structures and day-to-day practices. In this article, formats of *case-based* Mutual Learning Sessions (*cb*MLS) that organize mutual learning based on a single case or a set of cases are presented. The different formats have been developed and studied in the context of a global Td process on phosphorus management (i.e., the Global TraPs project). After presenting the formats of *cb*MLS, the paper presents the first results from an empirical, integrated qualitative study based on interviews and observations, and discusses potentials and limitations of *cb*MLS, in particular their application in an international context. We further highlight challenges and learning experiences that have to be met in Td mutual learning processes.

Keywords Mutual learning · Transdisciplinary sustainability research · Transdisciplinary methods · Interculturality · Culturally robust knowledge · Global TraPs

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Introduction

The urgent need to address critical sustainability issues—among others, climate change, food and water security, global justice, and resource management—is acknowledged by a large community of scholars and international policy institutions (Osborn et al. 2015; United Nations Development Group 2014; Reid et al. 2010; Kates et al. 2001). These challenges have in common that they are

complex phenomena that are often intertwined and interconnected across space, time, and organizational levels (Liu et al. 2015). Furthermore, they are related to the separation of scientific knowledge production, to the sectorial division of responsibilities in contemporary societies, and to the diverse nature of the societal contexts in which people are living (Lawrence and Després 2004). To address these challenges, there is increasing consensus that institutionalized cooperation between scientists from different disciplines and actors from outside academia is needed (Zscheischler and Rogga 2014; Scholz 2011; Hirsch-Hadorn et al. 2008; Bammer 2005; Klein et al. 2001; Gibbons et al. 1994). Transdisciplinary (Td) research has been widely discussed and experienced in a series of projects as a promising way to meet these objectives (Jahn et al. 2012; Lang et al. 2012; Hirsch-Hadorn et al. 2008; Scholz 2000, 2006). A joint identification of problem fields and definitions of research questions, a joint process of problem representation and knowledge generation as well as the re-integration of results, including joint initiation of problem solving, are considered crucial to generate knowledge that is socially robust, i.e., knowledge that can be understood, discussed, and processed by all parties involved and that serves societal transformation (Lang et al. 2012; Scholz et al. 2006; Gibbons 1999).

"Mutual learning" was introduced by Scholz and colleagues at the Zurich 2000 conference as a basic principle of Td (Klein et al. 2001; Scholz 2000). It is defined as "the basic process of exchange, generation, and integration of existing or newly developing knowledge in different parts of science and society" (Scholz 2001). In Td mutual learning processes, the production of knowledge is a joint process among stakeholders and scientists (Walter et al. 2007). Through mutual learning, "the knowledge of all participants is enhanced, including local knowledge, scientific knowledge, and the knowledge of concerned industries, businesses, and non-governmental organizations (NGOs)" (Häberli et al. 2001). It should allow for combining scientific insights with knowledge gained in non-scientific contexts to ensure a high degree of validity and reliability of the results, on the one hand, and applicability and relevance, on the other.

Mutual learning is considered a core aspect when it comes to linking knowledge and experiences gained in different contexts with decision making and the transformation of unsustainable situations in professional and day-to-day practices. A series of authors highlight the importance of mutual learning (e.g., Jahn et al. 2012; Bergmann et al. 2012; Bunders et al. 2010; Wiesmann et al. 2008; Rist et al. 2004), especially for investigating issues of uncertainty (Polk and Knutsson 2008). It is considered to be highly relevant for sustainability research, as it supports the understanding of sustainability challenges and the creation of new knowledge that contributes to the amelioration of an unsustainable situation. However, mutual learning clearly goes beyond the exchange, generation, and integration of knowledge. To gain a better understanding of a given situation and to achieve appropriate capabilities and a decisiveness to transform unsustainable situations, it is necessary to engage with the situation. This requires a series of personal, social, and organizational prerequisites. On the personal level, an attitude of openness and willingness to learn and to expose oneself to the otherness of the other is of the utmost importance. It implies the acknowledgment of the boundaries of one's epistemic and experiential capacities, the situatedness of any form of knowledge production (Haraway 1988), and the context dependency of any viewpoint, as a matter of principle. This also accounts for institutional/societal entities, such as "different disciplines and different conceptions of sciences and cultures [that] are based on different world views (cosmologies), basic assumptions, epistemics, and reference systems" (Scholz 2011). It is the complexity of the given situation that requires multiple perspectives to understand and successfully induce sustainable solutions. These perspectives emerge from positionings of the involved persons in their relation to the situation (Rose 1997). They are based on personal, professional, sociocultural, or ethnic backgrounds, among others. Thus, mutual learning requires that these dimensions be addressed explicitly, along with a strong reflexivity, to create mutual understanding.

Mutual learning can be characterized as an intercultural endeavor, whether it is realized in an international, national, or local context. It is based on cultural differences that emerge from different understandings of symbols, meanings, knowledge, actions, or materiality (Smith and Riley 2009; Moore and Sanders 2006). Hence, culturality and, consequently, interculturality cannot be reduced to cultures of origin but are apparent in different practices of knowledge production and emerge as knowledge cultures and cultures of cognition. In this perspective, mutual learning can reveal previously neglected or ignored differences, such as ways of knowing and sense making, world views, working styles, practices, and power relations that lie beneath the surface of disciplines, professions, working fields, or sociocultural contexts. It is a process of differentiation and "othering" that can make research topographies and inherent hegemonies visible (Hall 1996; Bhabha 1994) and that helps to bring different qualities of knowing and acting into fruition.

Mutuality is more than a simple reciprocity. In the process of differentiation and othering, differences can be disclosed as complementarities that serve integrity when it comes to addressing complex phenomena. However, we

propose that ambiguity, complexity, and contradictions should be taken into account as fundamental features of knowledge and situated knowledge production that provide not only socially robust but also culturally robust knowledge. This holds particularly true for mutual learning in international research settings where dimensions of culturality are expanded. We consider mutual learning in Td processes as a means to promote the finding of socially (or socio-technologically) and culturally robust knowledge by creating spaces for people who are situated in different cultures of knowledge or cognition, sociocultural or political contexts, symbolic systems, or everyday practices.

To organize mutual learning, "Mutual Learning Sessions" (MLS) were introduced for the first time in the course of the Zurich 2000 Conference (Klein et al. 2001; Scholz 2000, 2001) as "a tool to establish an efficient transfer of knowledge both from science to society and from problem owners (i.e., from science, industry, politics etc.) to science" (Scholz 2000). They were considered all-day "laboratories and design factories" (Scholz 2001). Subsequently, MLS have been applied in a series of case studies [see Scholz and Steiner (2015)], but they have not been described or formalized in detail. To strengthen Td sustainability research, it is important to provide methods or formalized procedures to foster traceability in highly unpredictable situations such as Td processes. At the same time, MLS need to provide openness, flexibility, and recursivity to enable cooperation that is heterarchical and allows for all persons involved to contribute, regardless of their educational, professional, and sociocultural backgrounds (Bergmann et al. 2012; Pohl et al. 2008). Thus, the challenge is to develop formats that provide both openness and formalization to create space for knowledge integration and transfer.

The article consists of a conceptual and an empirical part. We first present different formats of "*case-based* Mutual Learning Sessions" (*cb*MLS) that organize mutual learning in Td sustainability research as learning spaces that deal with one specific case or set of cases in Td processes. They have been developed in the context of a global Td process on phosphorus management (Global TraPs). Further, we present the first results of an empirical, integrated qualitative study, based on interviews and observations, on eight *cb*MLS that have been realized in the course of a Global TraPs conference in China (Scholz et al. 2014). The study provides a critical view on the differences between the models presented conceptually and their implementation in an international Td process. In particular, we investigate characteristics of mutual learning in an intercultural and international research setting as well as factors that both hinder and strengthen *cb*MLS.

Formats of *case-based* Mutual Learning Sessions (*cb*MLS)

MLS can be considered a group-based method for Td sustainability research that aims at both knowledge production and societal transformation. Due to their explicit transformative character, MLS are different from other group-based methods that have been developed in qualitative empirical research, such as focus groups or group discussions (Bohnsack 2004; Flick 2009; Morgan and Spanish 1984). They serve integration between different knowledge fields and the transfer from science to practice (industry, politics, and other areas) and vice versa (Scholz and Vilsmaier 2013). In contrast to MLS that organize mutual learning within a case, *cb*MLS are focused on cases. In *cb*MLS, a case serves as a boundary object (Star and Griesemer 1989) through which different perceptions and conceptualizations of the phenomenon the case stands for are analyzed and negotiated. These differences are based on the participants' individual perceptions, scientific backgrounds, sociocultural origins, world views, or prior experiences. In addition, *cb*MLS differ from other transformative, group-based methods that are topic centered, such as Neo-Socratic Dialogues that focus on joint thinking about philosophical issues (Grießler and Littig 2003) or Dialogue Sessions, in which a specific topic, theme, phenomenon, or concern instead of a case is the focal point (Scholz 2000).

Characteristics of *case-based* Mutual Learning Sessions

The overall objective of *cb*MLS is to learn from a case or a small set of cases. A case is a specific phenomenon within a historical context and, as such, it is conceptually, socially, and culturally framed. Cases are unique and, at the same time, related to something general; in addition, they are functional, as they are viewed from a certain interest (Scholz and Tietje 2002). Learning from cases is linked to a holistic mode of understanding and analog reasoning. It serves "in-depth understanding [of] the complexity and contextualization and thus the multi-layered natures which have to be understood for successful, sustainable transitions" (Global TraPs 2012: 6). Generalizability may have an empirical, frequency of observation-based foundation (Gigerenzer et al. 1999) or may be based on holistically identified commonalities (Green et al. 2012; Scholz and Tietje 2002; Sternberg 1977). In *cb*MLS, both systematic (evidence-based) analytic and intuitive analogy building take place. The outstanding characteristics of a case are analyzed systematically in a preparation phase and captured intuitively through in-depth discussions with case

representatives or site visits. While the first foster cognitive learning, the latter strengthen the experiential level of learning, in particular.

The way in which mutual learning is organized in *cb*MLS allows for (1) transfer of knowledge to other cases, (2) for extrapolation to higher-level contexts and (3) for producing generalizable results in terms of abstract, conceptual knowledge on the issue a case stands for. To extract the generic from a specific related to a case, it is necessary to identify populations of cases that are similar to learn about mechanisms, barriers, and options for sustainability. Naturally, because of the uniqueness of each case, no direct or bi-directive relationships between cases are possible. Rather, the understanding of each case is required before generic conclusions about sustainable transformations can be made (Global TraPs 2014; Krohn 2010).

In the following, we distinguish (A) a concrete, material–biophysical, observable phenomenon-based level and (B) an abstract, conceptual, cognitive level related to salient features or causal relationships. From a cognitive perspective, the distinction between these levels resembles the difference between the concrete operational stage and the formal operational stage introduced by Piaget (1977). The subject of cognitive operation on the former level is concepts that are close to perception. By contrast, the latter deals with abstract formal and theoretical constructs or (mathematical) variables. Compared to topic-based learning, which often starts and remains on the level of (B), *cb*MLS have an important additional up- and downscaling potential and allow for multidirectional transfer of knowledge and recommendations on how to improve sustainability (see Fig. 1). Through extrapolation, case-specific insights allow the deduction of conclusions for strategies on higher-level contexts. Scales can refer to geographical (e.g., regional, global), administrative (e.g., departmental, national, international), or organizational (e.g., regional office, national, or multinational company), entities.

When we focus on the real and factual actions (the concrete operational level) of an organization, the concrete, observable behavioral and physical operations are in the foreground rather than the abstracted implicit rules which are supposed to generate the behavior. In *cb*MLS, the two scales are differentiated on level (A).

1. The first scale represents the case level. Here, the objective is to learn within one case as well as from and for similar cases. It addresses the dual question: How is sustainability achieved in the case(s) and what can be learned from and for similar cases?
2. The second scale represents the extrapolation (upscaling) of the prior findings to higher levels in geographical, administrative, or organizational terms (see Fig. 1). Through downscaling, back-to-the-case recommendations can be generated. It addresses the dual

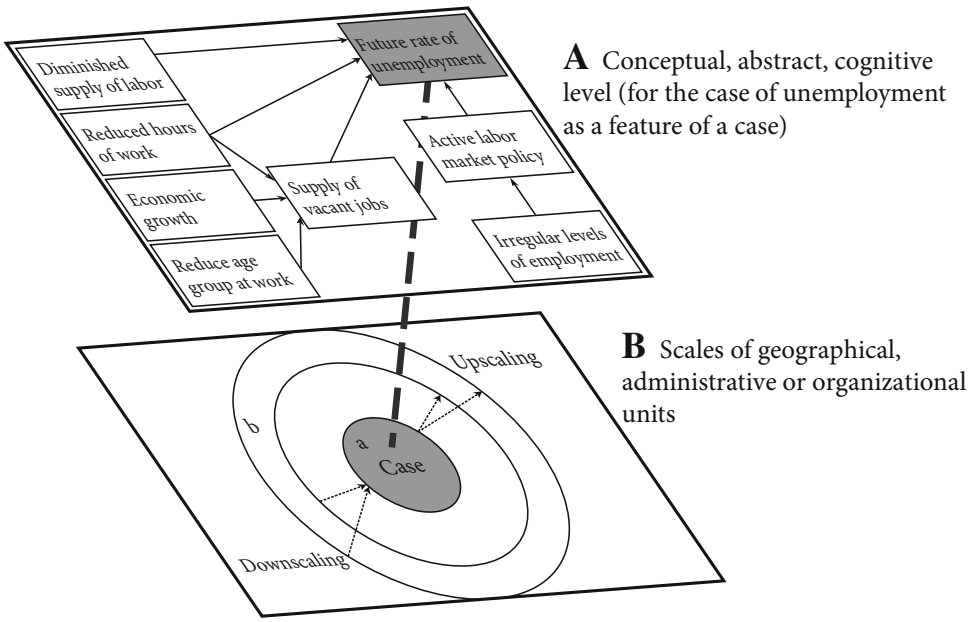

Fig. 1 Levels of transfer and abstraction in *cb*MLS: Directions of up- and downscaling of a single *case-based* Mutual Learning Session on a geographical, administrative, and organizational level (**A**), and the process of abstraction (*dashed line*) for operating on the conceptual, abstract, cognitive level (**B**). Level B is the cognitive map that is based on concepts and relationships among the concepts. The *grey oval* represents a case (*a*); the surrounding *ellipses* represent the different scales to which the case is related (*b*); the *arrows* between the *ellipses* represent the directions of knowledge transfer. Scales can address geographical (e.g., regional, global), administrative (e.g., departmental, national, international), or organizational (e.g., regional office, national, or multinational companies) entities

question: Which insights on sustainable transition can be extrapolated to higher-level contexts and how can coherent multi-scale actions be achieved?

Beyond the case selection, the composition of participants in a *cb*MLS is crucial. To unfold this up- and downscaling potential, the *cb*MLS needs to include representatives of, e.g., different regions and sociocultural contexts, representatives of national or international policy-making institutions, and case experts representing the exemplary case. The selection of scientists who participate in a *cb*MLS mostly refers to level (B). Here, the team that prepares a *cb*MLS may determine key aspects of the case and think about which discipline and which representatives of this discipline should be involved. The format brings together people with different knowledge, responsibilities, and interests related to the case: "For each real-world case, there are case experts, (who have lived with a case and who embody 'experiential knowledge'), people from practice who have knowledge of similar cases, scientists from different disciplines who may explain certain phenomena or dynamics, policy makers who are framing the case, and other stakeholders interested in the case" (Scholz and Vilsmaier 2013). The goal of participation in a *cb*MLS differs according to the perspectives of the involved parties. They range from improving specific practices in cases and policy options for higher-level contexts to gaining a better understanding of a certain phenomenon on a generalizable level. Furthermore, *cb*MLS support capacity building among all participants, facilitate consensus building, serve as mediation, and legitimize solutions that are developed in the course of a project (Scholz 2011).

Guiding principles of *case-based* Mutual Learning Sessions

We suggest seven general principles that should be agreed upon in a *cb*MLS (Box 1). They ensure mutual learning in a jointly framed, protected space that is characterized by respect for the otherness of the other, even in the case of competition or opposing interests, and by the development of a common language that is understandable and compatible for all participants.

Box 1: Guiding principles of a case-based Mutual Learning Session

Protected discourse: Making mistakes, preliminary remarks, and working with tentative assumptions are inherent to *cb*MLS. To support open and protected discourses, all participants agree that nothing said by anyone in a *cb*MLS may be cited without explicit permission.

Pre-competitive collaboration: *cb*MLS may ask for collaboration between competitors, given that there is a joint interest in contributing to sustainability. Issues, which are subject to the direct economic interests of the participating stakeholders, for instance, have to be framed in a way that interests all participants.

Authentic collaboration: Mutual learning requires that the otherness of the other is acknowledged. This includes the respective societal position, culture, and personality of every participant.

Common language: The participants have to develop a common language in order to secure a mutual understanding. Particular efforts have to be made to translate abstract, scientific, and technical language into understandable terminology for all.

Agreement on roles, agenda, and methods: To ensure efficiency and to achieve acceptance for the process, the roles of all participants have to be agreed upon, and consensus on the agenda and applied methods is required.

Agreement on content: Problem definition, representation, and recommendations for transformation have to be jointly elaborated. Contradictions and contested aspects should not be excluded but have to be made visible.

No day-to-day policy topics: Although the *cb*MLS deals with critical real-world problems, the participants shall avoid dealing with day-to-day political topics, as this causes people to get stuck in common reasoning and defense/attack that interferes with mutual learning.

Source: Scholz et al. 2014, adapted

Types of *case-based* Mutual Learning Sessions

We distinguish between single *cb*MLS, multiple *cb*MLS, and on-site *cb*MLS (see Fig. 2). Single *cb*MLS relate to one single case. The objective of this format is to learn from one specific case. Multiple *cb*MLS include a small number of cases with comparable aspects and deal with similar issues in different contexts. The objective of this format is to learn from diverse but similar cases. While both formats are based on analogy building between similar cases, in multiple *cb*MLS, this process is fostered by relating a small set of cases on the same level of cognitive and experiential attention to each other. However, multiple *cb*MLS are more complex by nature in organizational, cognitive, and experiential dimensions. At the same time, generic conclusions are more likely to be provided during a multiple *cb*MLS. On-site *cb*MLS are a variant of single or multiple *cb*MLS with a strong experiential component, including a visit to the case site. The aim is to gain experiential knowledge by interacting with

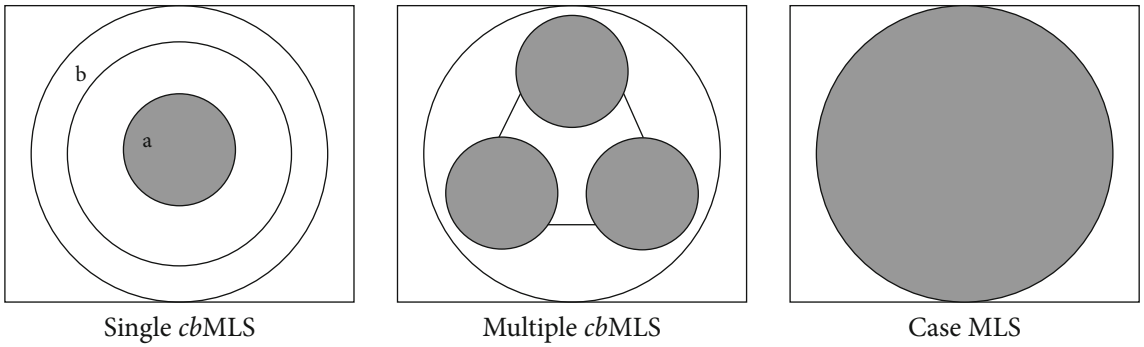

Fig. 2 Types of mutual learning sessions: the *grey bowl* represents a case (*a*); the *circles* represent the scales a case is related to (*b*). Scales can address geographical (e.g., regional, global), administrative (e.g., departmental, national, international), or organizational (e.g., regional office, national or multinational companies) entities

case agents in their fields of expertise and to share experiences gained during the session among all participants involved.

The number of participants varies according to the number of cases a *cb*MLS deals with and the number of scales that are addressed. A single *cb*MLS may serve mutual learning for representatives of similar cases and scientists to improve their understanding of the phenomenon the case stands for, but it might also serve as a boundary object for policy development on different geographical scales, e.g., departmental, national, and international policies (see Fig. 1). In this case, more participants need to join the *cb*MLS. However, there should be at least 8 but not more than 20 participants in a *cb*MLS who continuously work together during all phases. The format can be applied as a single event or a series of events, depending on the dimension of the Td process.

Phases of *case-based* Mutual Learning Sessions

The organization of *cb*MLS comprises three phases: a preparation phase, a case encounter, and a post-processing phase (an overview of the major steps is provided in Table 1).

Preparation phase

The initiation of a *cb*MLS is an iterative and recursive process that addresses the identification of critical issues, goals, representative cases, and team building. Based on the definition of an issue, topic, or problem (e.g., eutrophication due to phosphorus overuse in rural low-income regions) and the formulation of an overall guiding question (1), a case or cases that are suitable for investigating the phenomenon of concern in a Td way are identified and selected (2). Appropriate cases have to meet the following criteria: (i) there are similar cases, and (ii) previous investigations provide sufficient information for a mutual learning process. The selection of (a) case(s) and team building are already learning processes in themselves. Contacts with representatives of cases (i.e., scientists or decision makers working in the field of concern) are established, and additional potential participants from science and higher-level contexts become involved in the *cb*MLS (3). A *cb*MLS team consists of at least one facilitator, case expert(s) from science, and (a) case agent(s) representing the selected case(s). It is their joint responsibility to develop a balanced *cb*MLS team in terms of representatives of the relevant knowledge fields, cases or policy institutions, gender aspects and—according to the issue of concern—sociocultural backgrounds. Subsequently, the goals of the *cb*MLS are identified (e.g., mutual learning between different regions), and roles and responsibilities as well as principles of cooperation (principles, see Box 1) are agreed upon (4). Before beginning work on the case(s), the starting process is reflected and revised where necessary (5).

To build up case knowledge, basic case information is acquired from case agents and case experts from science (6). Likewise, each participant formulates his/her perspective on the case (7) and develops critical questions related to the case(s) from his/her perspective and, if available, provides best practices and ideas about case transformation for sustainable solutions (8). Thereby, the initial step in boundary work is activated among the participants by linking different types of knowledge and perspectives from different societal fields and levels of concern. Critical questions can thus be elaborated prior to the case encounter. These contributions are structured and provided in a written format (e.g., in the form of a *cb*MLS booklet) (9) that serves the preparation of all participants. In order to successfully run a case encounter, the organizational framework, such as location, setting, and schedule, is prepared (10).

Table 1 Phases and tasks of a *case-based* Mutual Learning Session

Preparation Phase 3-6 months	**Case Encounter 1-2 days**	**Post-Processing Phase 2-4 months**
Getting started 1. Define and select issue, topic, problem and formulate overall guiding question 2. Identify case(s): from problems to cases 3. Identify relevant actors and build the *cb*MLS team 4. Agree on goals, roles, responsibilities and principles of cooperation 5. Reflect on starting process and adopt where necessary **Building up the case knowledge** 6. Acquire, structure and document basic case information from case agents and case specialists 7. Formulate individual perspectives on the case from participants 8. Acquire critical questions and ideas about case transformation from participants 9. Booklet production: document basic information, perspectives and critical questions from all participants **Preparing the case encounter** 10. Prepare location, setting, schedule and other arrangements of the case encounter	**Setting the stage for mutual learning** 1. Seek agreement on principles, agenda, and discussion rules 2. Clarify roles and objectives of participants **Promoting mutual learning** 3. Physical case encounter or case agent story/picture-based envisioning of the case 4. Agree on, adapt, or modify guiding question 5. Present individual perspectives on the case 6. Identify and characterize different/diverging perspectives, positions, and interests 7. Construct a shared view on what component/aspects of the case are crucial for sustainable transition and document alternate/contrasting views **Up-and down-scaling & projecting** 8. Formulate orientations on sustainable transitioning for different scales (level A, see Fig. 1) 9. Find a generic conceptual description (level B, see Fig 1) 10. Identify knowledge-gaps 11. Provide written agreement on results	**Consolidating results & consensus building** 1. Update the booklet based on the case encounter, in particular the synthesizing 2. Circulate updated booklet among all participants and ask for inputs/corrections and agreement 3. Update the booklet based on inputs, iterative circulation and final consenting 4. Consolidate results and communicate in diverse forms (e.g., scientific articles, hand-outs, press releases, policy recommendations) 5. Distribute and use outcomes in various fields

Case encounter

The case encounter is conducted in a 1–2 day session where participants meet with case agents (either at the physical case site or elsewhere) and work on the questions identified during the preparation phase, guided by (a) facilitator(s). To set the stage for mutual learning, the agenda, principles, and discussion rules are agreed upon at the beginning of the session (1). Furthermore, the roles and objectives of all participants are clarified before working on the case to support the group-building process (2). Here, possible hegemonic structures (e.g., scientists might be considered as contributors of "higher-valued" knowledge), presumptions of "hidden agendas," and imbalances in the proportion of contributions (e.g., due to a lack of team members' experience in formulating and presenting their own contributions or because of language differences) can be addressed explicitly as challenges of a *cb*MLS. The examination of the case starts with an introduction to the case(s), either by a physical visit to the case site or by a case agent story/picture-based envisioning of the case in a workshop session (3). Based on the experience-based introduction, the previously identified guiding question is agreed upon, adapted, or modified (4) and the individual perspectives on the case(s) are presented by all participants (5). In the next step, different/diverging perspectives, positions, and interests with respect to the case(s) are identified and characterized (6) by considering (i) the relationship to the case, i.e., being an insider or outsider to the case, and (ii) the type of knowledge and experience each person brings to the case, i.e., as a scientist concerned with the case or the general issue the case stands for, a case expert from within or outside the case under investigation, or a policy maker with particular interests. There are no ideal typical structures and methods to realize the knowledge integration and transfer in this step, as it depends largely on the type, size, and duration of the *cb*MLS. In the following, the objective of the case encounter is to construct a shared view on what components/aspects of the case are crucial for sustainable transition and to document alternate/contrasting views (7). In the following step, the mutual learning outcomes are translated into orientations

on sustainable transformations of the case(s) and different levels of concern through upscaling and back-to-case recommendations (8). The abstraction and production of generalizable knowledge (9) complement this upscaling, and knowledge gaps—if these have been identified in the course of the session—are formulated for further research (10). At the end of the case encounter, a written agreement on the results is provided, taking into consideration contested aspects and contradictions as well (11).

Post-processing phase

During the post-processing phase, the facilitator, together with the responsible scientist(s) and case expert(s) of the *cb*MLS, consolidates the results and guides consensus building on publishable outcomes. Based on the case encounter, the *cb*MLS booklet is updated (1) and circulated among all participants in order to provide the opportunity to adopt or agree upon the written results (2). The finalization of the written output is an iterative and recursive process as well (3). Before publishing, results are approved by all participants of the team. Different outputs for the different target groups are prepared (e.g., scientific articles, handouts, press releases, or policy orientations). Finally, all participants distribute and use the outcomes of the session in their communities and fields of action (5).

Practical example

In the following, we report on the implementation of eight *cb*MLS that have been realized in a large-scale international Td process (Global TraPs). We first provide information about the project and describe how we implemented the *cb*MLS that we presented in the section "Formats of *case-based* Mutual Learning Sessions" during a conference in China, followed by the objectives and expected outcomes. Subsequently, we present the methods and results of an integrated qualitative study on the perspectives of participants that was realized in the course of the project.

Case-based Mutual Learning Sessions in Global TraPs

"Global TraPs" (Global Transdisciplinary Processes for Sustainable Phosphorus Management) was realized between 2011 and 2014. Its aim was to tackle the challenge of global sustainable phosphorus management (Scholz et al. 2014; Eilittä 2012; http://www.globaltraps.ch). The Global TraPs project was structured along nodes of the supply–demand chain (see Scholz et al. 2014) and followed the Zurich 2000 conception of Td (see Scholz 2000, 2011; Klein et al. 2001; Scholz et al. 2006; Scholz and Steiner [2015]). Prior to the *cb*MLS, a series of workshops had been organized in Switzerland (2011, 2012) and Morocco (2012). Thereby, first steps were taken in defining problems, formulating overall critical questions, and identifying cases that represent major challenges. The guiding question of the project was: "What new knowledge, technologies, and policy options are needed to ensure that future phosphorus use is sustainable, improves food security and environmental quality, and provides benefits for the poor?" (Eilittä 2012: 5). This was negotiated and agreed upon by all participants of the Global TraPs project during the first two workshops. During the third and fourth workshops, critical questions to be considered in depth by the means of case studies and, subsequently, in *cb*MLS were identified.

When preparing for the First Global TraPs World Conference in Beijing, China, in June 2013, the project leaders and the leaders of the subprojects consented to which critical questions should become subjects of consideration and inquiry by means of a one full-day case encounter. The objectives of the conference were formulated in the title of the Beijing conference, "Learning from cases and exploring policy options". The overall objective was the development of policy orientations for challenges of global sustainable phosphorus management. The conference was co-led and co-organized by science (Fraunhofer IWKS, Germany, Roland W. Scholz; Chinese Agricultural University, CAU, China, Fusuo Zhang), practice (International Fertilizer Development Center, Muscle Shoals, AL, USA, Amit Roy), and UNEP-GPNM (Nairobi, Kenya, Anjan Datta). Co-leadership was practiced at all levels of the Global TraPs project and was also aspired in the *cb*MLS. Each subproject was supported also by a Td coordinator/facilitator; i.e., a scientist knowledgeable in Td who facilitated the interaction between scientists and practitioners. In the *cb*MLS, representatives of research institutions (universities, national and private research institutions, academies of science), international organizations (e.g., FAO, UNEP), NGOs (e.g., Greenpeace International, IFDC, Alliance for a Green Revolution in Africa), international associations (e.g., Cereal Growers Association of Kenya, International Fertilizer Industry Association), industry (e.g., Outotec, OCP, Foskor), and policy institutions (e.g., European Union, representatives of national governments) were involved.

In every *cb*MLS, a maximum of three policy orientations should be derived from exploring and (physically) encountering (a) case(s). The idea was that dealing with specific cases in *cb*MLS could support the development of policy strategies on an international level by extrapolation to higher-level contexts (see Fig. 1). The policy orientations should be roughly formulated during the case encounter and elaborated in the post-processing phase. Furthermore, the sessions aimed at identifying knowledge

gaps, research demands, and possible follow-up activities, such as additional case studies. These goals were conveyed in a special tutorial offered to all participants of the conference the day before the *cb*MLS.

The preparation phase for the *cb*MLS started in January 2013. The post-processing phase was planned to be completed in October 2013. The Knowledge Integration Unit (KIU) of Global TraPs, including five experienced Td scientists, was responsible for the development and implementation of the *cb*MLS. Twelve master and PhD students from four European universities built the KIU Support Team. This team coordinated the *cb*MLS during the three phases, supported by 10 Chinese students from CAU during the case encounter, and realized the integrated qualitative study. In total, 10 *cb*MLS were prepared: five on-site *cb*MLS dealing with Chinese cases on manure, sewage, biotech processing, vegetable and crop production; four single *cb*MLS on cereal production (Kenya), urban agriculture (Vietnam), oil palm plantations (Malaysia), and detergents (Manila); and one multiple *cb*MLS on sustainable mining (case descriptions are provided online: http://www.globaltraps.ch).

Methods of the integrated qualitative study: participants' perspectives

The overall objective of the integrated qualitative study was to analyze the implementation of the *cb*MLS formats, in particular the case encounter, to better understand factors that hindered or strengthened mutual learning in Td processes and to learn about dimensions and characteristics of mutual learning in an international Td process.

The empirical research is qualitative. As such, its aim is not a representative sample size and quantification but is rather to gain a more-detailed understanding of experiences that participants gained during the *cb*MLS (Hennink et al. 2011). The study has an exploratory and evaluative character (von Kardorff 2004). In addition, it has an integrated character, as the KIU Support Team that ran the study was also involved in preparing and implementing the *cb*MLS and the production of the booklet. While some members of the team prepared the *cb*MLS and served as Td coordinators/facilitators, others made observations. The whole team conducted interviews, but none with participants of *cb*MLS where he/she was involved.

Empirical data were collected during the course of the Beijing Conference from June 18 to 20, 2013. Participatory observations were made during the *cb*MLS case encounter. Semi-structured interviews (Flick 2009) were conducted with participants of the *cb*MLS on the following two days by 12 specially trained master and PhD students of the KIU Support Team. The observers received a brief set of guidelines that supported a critical reflection on their role as part of a social process. Observation guidelines (see Appendix S1: Guidelines for observation) and guiding questions for the interviews (Appendix S2: Guiding questions for interviews) aimed at the insights and experiences of the participants and their interactions.

During the *cb*MLS, no audio or video recordings were made in order to support a "protected discourse" (see Box 1). The interviewees were guaranteed that statements would be published only in such a way that they could not be attributed to them. To gain multi-perspective insights, at least three to five interviews with a diverse mix of participants in regard to cultural, professional, and gender backgrounds were conducted for all *cb*MLS. In total, 26 semi-structured interviews lasting between eight and 36 min and six observations were made. Two interviews could not be used for analysis because of their recording quality, and another two observations could not be used due to language problems. In sum, 24 interviews and four observations were taken into consideration for the analysis. The transcribed interviews and observations were analyzed by qualitative content analysis (Kuckartz 2012; Mayring 2004) using the software MAXQDA. A coding scheme was established in a recursive process within a team of three persons (authors of this paper). To ensure an intersubjective analysis, categories were jointly developed inductively and deductively by the authors in order to achieve intercoder reliability (Flick 2009). First, an inductive category formation (Mayring 2004) was exercised by developing codes from the material. Subsequently, key categories were derived from the theoretical assumptions and integrated into the coding scheme. The results presented in this paper were derived from eight categories: communication, group characteristics, structure, outcome, knowledge, culture, learning, and language. These categories contain several subcategories (see Appendix S3: Categories and subcategories).

Results

In this section, we first present a report on the implementation of eight *cb*MLS in Global TraPs that provides a critical view on the applicability of the model of *cb*MLS presented in this paper under the conditions of a large-scale international Td process. Second, we summarize the results of the interviews and observations of the integrated qualitative study. Third, we give examples of outcomes and outputs that have been produced in the course of *cb*MLS in the Global TraPs project to make the potentials and limitations of this format conceivable.

Implementation of *case-based* Mutual Learning Sessions in Global TraPs

While ten *cb*MLS were initiated in the preparation phase, only eight were realized in Beijing. Five were on-site *cb*MLS, two were *single cb*MLS, and one was a *multiple cb*MLS. Six sessions lasted for one full day and two sessions for about four hours. Two *single cb*MLS were united ad hoc in Beijing, as several participants could not join the conference due to visa and other issues. The planned multiple *cb*MLS on mining was turned into a Dialog Session (a non-case-based setting of learning), as the representatives of Chinese mining companies and no representatives of other cases with outsider perspectives could attend for various reasons. For the case experts from Morocco, this was a disappointing development since their principal objective in joining the session was to meet with representatives of Chinese and other cases. In total, 75 persons participated in the *cb*MLS during the conference. All groups of representatives/sectors that had been involved in the preparation process participated. However, there were several imbalances in *cb*MLS concerning the number of participants from science and non-scientific fields. The largest session had 23 participants; the smallest had only five. Of the 24 practitioners and 46 scientists who participated, five appointed themselves to both science and practice. Most of the participants came from China (30 people). The second-largest group (16 people) came from Germany due to the high number of German students and early-stage researchers of the KIU Support Team. The tutorial for the case encounter, provided the day before the *cb*MLS, was attended by only about two-thirds of the participants.

The *cb*MLS were implemented according to the steps presented (see "Phases of *case-based* Mutual Learning Sessions"). During the case encounter, each session followed its own structure developed by the facilitator(s) and the case representatives. Thus, the elements as well as the degree of structure varied among the sessions. Nevertheless, concluding from the observations, sessions of the same type had a similar structure. In the on-site *cb*MLS, the site visit was combined with a discussion with employees or other case experts. After the visit, a discussion of two phases was realized: first, it addressed the case, the site visit, and the critical questions identified in the preparation phase. Second, the discussion moved onto the formulation of policy orientations. The other *cb*MLS started with a general introduction of the case(s) by the case agent(s) and case expert(s) from science, followed by brief inputs of case representatives and the participants presenting their perspectives on the case(s) and its possible transformation(s) toward greater sustainability. Subsequently, critical questions that were formulated in advance were discussed and new questions identified. The sessions were finalized with a formulation of the policy orientations. These were presented at a plenary meeting of the Global TraPs 2013 conference, which was attended by most participants of the *cb*MLS (Vilsmaier and Scholz 2013).

Results of the integrated qualitative study: participants' perspectives

The data collected in the integrated qualitative study show that the *cb*MLS were generally positively experienced by the participants and appraised as supportive formats for mutual learning in Td processes. The main learning experience was based on the interaction with people in which a broad spectrum of differences is highlighted. A representative from industry stated: "What is interesting is to share ideas and information with people with very different backgrounds and from different sectors from different countries and positions and topics". The sessions were evaluated as fruitful for the exchange and generation of new knowledge and ideas about sustainable phosphorus management. The fact that diversified stakeholder groups consisting of industrial representatives and scientists from various countries and disciplines could achieve the target of the sessions to come to common agreements about certain policy orientations was also mentioned as an outstanding learning experience. Some participants highlighted the potential of comparing cases with similar problems in different regions. Even if the settings of the cases seemed to be the same, challenges and contextual constraints turned out to be different, which supported the learning process.

Receiving firsthand knowledge by engaging with affected people and visiting sites was related to new insights, especially on an interpersonal level. For a scientist, it was particularly interesting to collaborate with farmers during the case encounter: "Interacting with the farmers was very helpful to see their motivations and their level of technology and their interest in the topic. So, certainly it puts a human face on something that you don't experience when you read a technical paper in a scientific journal". For international participants, the Chinese perspective provided by the numerous Chinese participants was experienced as an "eye-opener". Furthermore, participants confirmed that the insights gained from the *cb*MLS may contribute to their work in the future. The formation of new relationships was also mentioned as a positive outcome and helpful for future projects. However, also a series of critical aspects was identified concerning both the preparation phase, case encounter, group composition, distribution of roles, and communication and language, as well as attitudes and behaviors of individuals that were attributed to cultural differences and hegemonies.

Organizational structure of cbMLS

The overall organizational structure of the *cb*MLS was evaluated very positively. In particular, the joint elaboration of a written basis during the preparation phase (i.e., the booklets) was considered to be a very efficient way to become deeply oriented in the case and a good basis for the discussions that followed. A participant noted that the preparation was as important as the session itself. However, several suggestions to improve the preparation phase were offered. First, more people should be engaged (if possible, all participants of a *cb*MLS) in order to relieve individuals concerning the workload and to form a team that is equally prepared. Second, the booklet should be made available to the participants in a timely manner. Third, the aim of writing the booklet and the principles of the *cb*MLS should be communicated to all participants at the beginning of the preparation phase. Most of the interviewees acknowledged that the case encounter was very flexible, which gave participants time to discuss and express their opinions and special concerns. In particular, informal phases and discussions, such as on the bus or during lunch, were classified as very valuable for engaging more intensively with the case and establishing personal contacts. However, some experienced their *cb*MLS more like a question-and-answer session. Inadequate time was often mentioned as a limiting factor for reflection in order to create an appropriate understanding of the diverse perspectives and, finally, to produce solid outcomes.

Group composition and group dynamics

Many participants considered the group composition to be beneficial, especially with regard to diversity in terms of professional background, discipline, degree of experience, and origin. However, several missing links and shortcomings in the composition of the sessions were noted considering policy makers (e.g., governmental representatives) and smallholder farmers. A scientist stated: "More of the official world, the official voice from the government extension service, would have been useful". A suggestion was made to appoint participants more systematically to the sessions. As the aim was to formulate policy orientations, it would have been necessary to engage with policy makers more intensively. Smallholder farmers were considered important stakeholders in several sessions, but only one representative of an African farmers' association participated, which was the closest link to the farmers' interests. In one single *cb*MLS, the case representative was not present, which constrained the participants from deeply engaging with the case. As a consequence, the discussion shifted and lost content. Sometimes, perspectives that were not represented by participants appeared to be important only during the course of the case encounter.

The collaboration within the groups was generally described as good, as there was high participation and involvement, willingness to think respectfully, and space for contributions. A "genuine spirit of inquiry" was considered by a practitioner to be the key for a successful collaboration in heterogeneous groups. Nevertheless, one participant noted that in his session the perceived safety seemed insufficient to express everything. Another interviewee observed a change in the group dynamics when a Chinese person with high status entered the room. Others seemed to feel that they were not knowledgeable enough to contribute compared to the dominant participants.

Dominance of participants occurred in several *cb*MLS and was related mainly to their roles or expertise. Participants with significant roles in the *cb*MLS (case agents, or case experts from science), as well as individuals with profound knowledge about the respective issue, were dominant in the discussions. For instance, a case agent perceived herself as dominant but, at the same time, felt responsible for providing a large amount of information. Conversely, case agents and case experts from science were considered to have a high level of responsibility and influence on the session and its outcomes, as they were a direct source of case information. This was critically commented upon, in particular when they pursued a certain interest. Others were perceived as very passive and not contributing at all. Several interviewees mentioned that, particularly at the beginning of a case encounter, there was little engagement on the part of Asian participants, even in the case of highly prominent scientists. They contributed more actively when they were invited to join the discussion.

Participants of on-site *cb*MLS noticed that farmers and managers were not plainspoken to all the questions. In contrast, several interviewees and observers identified the Europeans as the main active participants. A representative of an international farmers' organization noticed a "great majority of men and great majority of white men" being very active in the session. European participants particularly identified differences between their own and Chinese participants' behavior in the groups. While in some *cb*MLS these differences presented a problem during the whole session, others experienced a positive development over the course of the session. However, activeness and passiveness were also attributed to the personal characteristics of others by several interviewees.

Communication and language

Overall, the communication was perceived as open and fruitful, which was also seen as a result of the facilitation. However, in several cases, language problems occurred between different national languages and people

with different professional or cultural backgrounds. Language, behavior, and understanding can be related, as a practitioner states: "I was thinking some people may not have been understanding everything. I suspect it. Especially from Asian countries. But I was not sure. I only thought the way they were quiet, I thought maybe they may not have understood". To overcome difficulties and to gain more depth in the discussion, some participants proposed to involve people in the preparation phase more intensively. Concerning the technical language and communication problems between scientists and practitioners, many participants were aware of possible language barriers and did make significant efforts to use simple terminology. Here, some of the participants and observers emphasized the importance of the facilitator. He or she summarized statements in order to overcome language barriers. In particular, in several *cb*MLS in which the local Chinese stakeholders did not speak English, simultaneous translation would have been necessary. Regarding the use of words, terms, and phrases, participants observed differences between their cultural backgrounds. However, these differences were not perceived as problems or hindrances; rather, they were experienced as learning insights. Some participants felt that focusing on the subject supported the development of a common language.

Objectives, output, and outcome

With regard to the general objectives of the *cb*MLS, the perceptions of the participants varied. For some participants, the goal of the session was vague, and the focus on the case was not strong enough, which made it difficult to meet the overall objectives of a *cb*MLS. Generally, the written output was considered to represent useful conclusions. Many of the participants saw their positions reflected in the formulated results. However, participants of several *cb*MLS perceived the presented results as either the lowest common denominator, remaining on a very general level, or as only a glimpse of what had been discussed.

Documentation during the session was seen as important, especially in order to capture aspects and opinions, which have not been followed up in the summaries and policy orientations. As an important outcome, the formation of new relationships was mentioned by many participants. Several planned new cooperations and considered redesigning their own case study research.

Outputs and outcomes of the *case-based* Mutual Learning Sessions in Global TraPs

In this section, we follow the distinction between outputs and outcomes, as suggested by Walter et al. (2007). The outputs of a *cb*MLS are measurable units, such as written products, the amount of time participants spent on elaborating the booklets, or the number of emails that referred to the *cb*MLS among the participants. The outcomes represent what was learned with respect to the goals of the conference.

We identify three types of output that were generated in the course of the *cb*MLS. The first is the texts of policy orientations (three at maximum) that were identified, discussed, and recorded immediately at the end of the case encounter. Not all *cb*MLS provided policy orientations as planned. Three *cb*MLS provided a list of critical issues. These lists did not provide a sufficient description of what actions could be taken to transform the case or how to deal with critical questions related to the case in a way that would allow them to be classified as policy orientation. The second output is the revised booklets that have been produced in the post-processing phase. The third output is a strategic paper that was produced by the project leaders after the conference and was related to the *cb*MLS (Roy and Scholz 2014).

If we want to assess the outcome, we have to identify the change of perspectives or problem framing (e.g., altered system boundaries), perceived system dynamics (i.e., what are seen as impact factors for system change; what rebound effects or tipping points are identified), priority setting of actions (including technology development and coping with trade-offs), and new ideas about case and system transformation (e.g., when operationalizing resilience) that may serve for a comprehensive policy orientation. We can also denote this as the development of "sustain-abilities" (Scholz 2011). Two policy orientations that are considered innovative and good examples are presented in the following:

Example 1 refers to an on-site *cb*MLS on manure management. A pig farm on the outskirts of Beijing served as the case. The policy orientation provided by this *cb*MLS reads:

> "There is an increasing need for manure management and also new potential because of increasing numbers of CAFOs (Concentrated Animal Feeding Operations) in China. This calls for a re-coupling of animal and plant production on an altered scale, for technology development, for spatial planning, and even nutrient balances including utilizing the organic matter" (quoted in Vilsmaier and Scholz 2013).

The innovative part here is the re-coupling of animal and plant productions, including nutrient balances that should be used in spatial planning. This idea was not around in the Global TraPs team before the *cb*MLS.

The second example shows the outcomes of a *cb*MLS on vegetable production. The overuse of (phosphorus) fertilizers by smallholder vegetable farming in Asian urban and

suburban regions has become an environmental challenge. The policy orientation included:

> "There is little individual incentive for farmers to improve their P [phosphorus] management beyond improving their finances. Policies for improvement need to capture the externalities associated with low P efficiency. These could include financial incentives for conservation practices or marketing assistance for 'eco-friendly' production. This asks for develop[ing] better partnerships between government agencies and the fertilizer industry for delivery of the best fertilizer products in addition to the proper information related to fertilization practices. Transparency is needed. Thus, fostering the exchange of existing data about soil conditions, optimal fertilizer composition, and fertilizer applications between governmental and industrial institutions could lead to a more efficient usage of organic and chemical fertilizers" (quoted in Vilsmaier and Scholz 2013).

This quote exemplifies how policy orientations may be seen as examples of how case specifics are linked to generic conclusions. The policy orientation outlines how this smallholder farmers' economic dilemma (there are no incentives for the individual farmer; see Njoroge et al. (2015)) can be dealt with by national institutions and how global transdisciplinary processes can contribute. We discuss the methodological problems of measuring sustainability learning below. Three further *cb*MLS provided policy orientations on a very general level, indicating that the teams did not remain close enough to the case(s) they were dealing with in the course of the case encounter.

Discussion

In the following, we discuss the potentials and challenges of the *cb*MLS formats and explore factors that strengthen and hinder mutual learning in an international context. We first present the results of the integrated qualitative analysis of the participants' perspectives, and then we elaborate on the applicability and limitations of the presented formats.

The integrated qualitative study showed that the framing of mutual learning processes by providing principles, formalized procedures, and criteria for group composition has a positive impact on the mutual learning process and on the outcomes produced. The mutual learning process was significantly stimulated by the heterogeneity of the groups concerning national and societal backgrounds, in terms of professions and societal positions. Being exposed to unfamiliar, foreign, or even "alien" (Waldenfels 2011) perspectives provokes irritation that supports the learning processes (Copei 1969). However, to benefit from heterogeneous group compositions, a joint problem representation, a common knowledge basis, and a common language are required (Witte 2001; Bergmann et al. 2012). A principle-based stepwise procedure as presented with the *cb*MLS formats can support the challenge of building heterogeneous groups by creating a balanced group composition in regard to professional background, societal position, and gender, among others, and by explicitly elaborating on diverse dimensions of differences represented by the participants (see Table 1). In the design of a *cb*MLS, it should be taken into consideration that certain participants might be privileged because of their material and cultural resources (Elzinga 2008). Thus, the "transdisciplinary paradox," as Hollaender et al. (2008) call the tension between effectiveness and heterogeneity, also holds true for *cb*MLS. Providing enough time for recursive learning and reflection is indispensable to create an appropriate understanding of the case(s) and the issue(s) of concern. In this context, particular attention has to be paid to power relations. Unbalanced contributions between very active and very passive participants because of differences in social positions or educational backgrounds, ethnocentrism, and cultural hegemonies can mislead *cb*MLS and generate biased results.

In *cb*MLS, the development of a common language is crucial, not only for learning the terms of another language but also for understanding the perceptions behind the same terms (Baccini and Oswald 2008). This holds particularly true for technical language and scientific concepts. Insufficiency in creating a common language was perceived as a problem in *cb*MLS that lacked an extensive, joint preparation of the case encounter and where a series of different national languages were represented in one *cb*MLS. This remains a core challenge when working in teams with different nationalities and educational backgrounds, as unequivocal translation is often difficult and sometimes impossible. Contrary to scientific conferences, in international Td processes fluent English cannot be taken for granted—in China this holds particularly true for people who are not involved in academic or business networks. In this respect, only extensive preparation and excellent facilitation can overcome language barriers. In both the preparation and the case encounter, systematic concept work can substantially improve the development of a common "vocabulary," which is essential to jointly explore a case and to work with cultural differences (Geertz 1983). Words can serve as boundary objects to elaborate on different aspects of and perspectives on a case. Methods of concept work can support this process and foster traceability of discussions and outcomes (Bergmann et al. 2012; Freire 1970). In addition, methods of visual case and problem representation (Scholz 2011) may help to better understand the multi-layeredness of complex

human–environment systems when referring to the case experience and thus develop what have been called shared mental models (Connon-Bowers et al. 1993).

Another factor that turned out to be important for successfully running a *cb*MLS is the cooperative elaboration of a solid written basis in the preparation phase (i.e., a booklet), including visual representations (e.g., of phosphorus flows), shared by all participants prior to the case encounter. Format and length can vary significantly, depending on the availability of resources, type of case(s), and overall organizational framework. The concept of "rich pictures" (Bell and Morse 2010), properly adapted, may also be applied in the preparation phase, exploring, for example, settings for sustainable phosphorus use. As particular challenges, we identified the engagement of all participants in the preparation process of a *cb*MLS to create similar starting points for the case encounter. To meet this requirement, the objectives of the preparation phase have to be clearly agreed upon by all participants. This holds true for all phases of the *cb*MLS. A lack of clarity of purpose is reflected in the quality of the outcomes. An extensive preparation in the form of a written format provides a maximum of time for engaging with the case. The joint knowledge basis that is elaborated in advance is complemented by a common experience that allows for creating mutual understanding based on holistic impressions of the case and emotions related to it. The case encounter links the cognitive and the experience-based level of learning (Kolb 1984). The site visits in China were particularly impressive to foreign participants and were commented upon mainly by Europeans in the interviews.

Compared to other group-based formats, the clear focus on and the experiential encounter of a particular case or a small set of cases in *cb*MLS can be considered an important advantage and an effective way of addressing sustainability challenges. Through selective group composition, outcomes can serve both the transformation of the particular case(s) and similar cases (even on different scales), and the improvement of the general understanding of a phenomenon or problem of concern. In some *cb*MLS, for instance, cases appeared technically similar (e.g., unsuitable fertilizer), but the barriers to reaching sustainable phosphorus management turned out to vary significantly (e.g., lack of financial resources, no market accessibility to alternatives). In addition to the confrontation with very different perspectives, experiences, thought styles, and even emotions, this type of learning impulse supported the reframing of problems, opened up new questions, and led to new outcomes. The participants evaluated the case encounter as a suitable instrument to gain new knowledge and to empower people where conditions were provided as planned and where a "genuine spirit of inquiry" and an attitude that acknowledges the otherness of the other are present. It is the experience and articulation of the difference and the otherness of situations, practices, and perceptions that enable the elaboration of the specific for which a case stands. Consequently, the similar and diverging components/aspects of other cases or higher-level contexts can be identified. Here, the recursive character of learning in Td processes becomes apparent (Krohn 2008).

Aiming at policy orientations in the course of a *cb*MLS is an example of the acquisition of transformation knowledge (Schneidewind 2013). Based on the in-depth insights and multiple perspectives on the cases, the understanding and transformation of a given, unsustainable situation can be improved. In Global TraPs, *cb*MLS lacked suitable outcomes when few participants were involved in the preparation phase and therefore did not have a joint knowledge basis. As further reasons for deficient outcomes (in the case of Global TraPs: policy orientations), a series of participants indicated time constraints, unbalanced group compositions, or a lack of focused discussions during the case encounter. While the latter can be addressed by a more concentrated effort of participants and facilitators, the achievement of a balanced group composition is challenging for several reasons. First, according to the type of case, *cb*MLS require a very differentiated group composition that may not be easy to achieve, as participation in a Td process is voluntary and time consuming. Second, the involvement of governmental officials—as called for by some participants—can lead to a narrowing of solution horizons because of their (tactical or strategic) commitments to positions and day-to-day policy topics instead of reflecting interests (Fisher and Brown 1988; Fisher and Ury 1981). In Global TraPs, for instance, we excluded official governmental representatives in the phase of "learning from cases". Despite all challenges, a general advantage of heterogeneous group composition is that results can be distributed immediately and can accelerate sustainability learning and transformation toward more sustainable practices in different societal fields. However, outcomes have to be concise rather than too general or simply summaries of discussions. Therefore, they should consist of both results that participants can agree upon (in the case of Global TraPs: policy orientations) and diverging perspectives to gain a clear understanding of contested issues in a particular field requiring further Td research.

While practical and organizational weaknesses (e.g., missing participants due to financial or visa problems, lack of involvement in the preparation phase due to time constraints) can be addressed by improving project management and augmenting resources, the cognitive and cultural issues (e.g., unbalanced contributions due to cultural differences in discourse practices and cultural hegemonies) remain a major challenge. It is, therefore, important to

conceptualize Td research as an intercultural endeavor (Rist et al. 2004), whether it is realized on the local, regional, or international level, and to address the different dimensions of culture systematically, as proposed in the *cb*MLS formats, to provide socially (or socio-technically) and culturally robust knowledge for sustainability transformations. Mutual learning calls for a basic understanding of the otherness of others, which may refer to the concept of empathy. Empathy is based on the understanding of the other's thoughts, feelings, morality, and actions (Scholz and Tietje 2002). Therefore, empathy, which relies on an inner, emic perspective, may fail. Here, side changes (i.e., approaching the otherness by the other when delving into the etic life space) may be seen as a complement. The distinction of emic–etic perspectives, i.e., the rationale of an outside vs. the rationale of an inside perspective, may be applied here (Harris 1991; Headland et al. 1990). Compared to a widespread (narrowed) use of the concept of culture, we distinguish the following dimensions: culturality on the level of origin (nationality/ethnicity, societal and professional fields), language (technical/national), practices (communication/cooperation, engagement with the case), and an epistemic level in terms of cultures of knowledge [ways of creating and warranting knowledge (Knorr-Cetina 2007)], epistemic communities [questioning dominant narratives in disciplines (Rist et al. 2004)], and cultures of cognition (world views as fundamental for interpretation [Hamberger 2004]). Thus, *cb*MLS support the process of differentiation and disentanglement (Zierhofer and Burger 2007) of these dimensions of culturality. Conceptualized as intercultural situations, they allow for dealing explicitly with hierarchies and status; social, national, and professional backgrounds; and—on a broader level—hegemonies. Thereby, heterogeneity can be brought into fruition and mutual learning can be addressed in a more differentiated way.

However, we have to acknowledge that cultural differences can be fundamental and that short-term mutual learning sessions may not be successfully conducted. There may exist special constellations in which such a way of mutual learning is difficult. This, for instance, held true for a Td project in which Guatemalan elders and oncologists interacted on the emergence, genesis, and therapy of cancer (Berger 2015; Scholz 2012). Here, we find two fundamentally different world views and cosmologies among the participants, which did not allow for learning in the described format and time frame. The search for a feasible infrastructure in a new, informal settlement in South Africa (Boix-Mansilla et al. 2010) may be taken as another example. Such constellations may require what has been called "emergent design" (Bunders and Reeger 2009). The general principle that the method has to be adapted to the subject also holds true for *cb*MLS.

Not all of the aspects of *cb*MLS could be analyzed in detail in the course of the Global TraPs project. In particular, the extrapolation to a higher-level context (see Fig. 2) could not be systematically taken into consideration, neither could detailed facets of knowledge cultures and cultures of cognition (Knorr-Cetina 2007; Hamberger 2004; Shore 1996) and outcomes related to concepts of sustainability in phosphorus management. Here, we are facing a triple challenge: first, providing concepts and methods to measure and assess what constitutes these concepts; second, providing access to learning, including the building and changing of concepts and of causation; and third, understanding the intercultural dimension of knowledge cultures and cultures of cognitions.

Concluding remarks

Mutual learning has been identified as a fundamental principle of Td sustainability research by a series of authors (Scholz 2000; Klein et al. 2001; Hoffmann-Riem et al. 2008; Polk and Knutsson 2008; Wiesmann et al. 2008; Bergmann et al. 2012). Nevertheless, a gap exists between the great importance attached to mutual learning and methods or formalized procedures to realize mutual learning. Therefore, we developed the *cb*MLS formats and realized eight *cb*MLS in a large-scale international project (Global TraPs). We conceptualized *cb*MLS as a case-based and culturally sensitive way of structuring mutual learning in Td processes that allow for knowledge integration and transfer among people from different cultures of knowledge and fields of action, societal domains, and sociocultural contexts and different but similar cases as well as scales. In designing the *cb*MLS format, we conceptualized these differences as positionings of the people and institutions involved and the transfer as a means of de-contextualizing and re-contextualizing findings and experiences from cases.

We developed the *cb*MLS to contribute to a consolidation of Td research and to make this mode of knowledge production acknowledgeable to scientific communities and decision makers. Due to the formalization of procedures, group compositions, and principles, the outcomes of mutual learning gain robustness as traceability of the process is augmented and the need to develop strong research frames in terms of principles and process design is met (Lang et al. 2012). As presented in this paper, *cb*MLS can be applied in Td processes, tackling sustainability challenges on different scales. They are particularly suitable for knowledge transfer to other cases or higher-level contexts (geographical, administrative, and organizational). They call for a certain level of mutual understanding of problem representation, reasoning, feelings, morality, actions, etc.,

and this may not be feasible among certain stakeholder groups (e.g., between Mayan healers and traditional oncologists). Other formats may be useful here.

However, a contradiction is inherent in the challenge of consolidating Td research, as it calls for both formalization and traceability on one hand and openness and flexibility on the other. As a societally contextualized research practice, it takes place in complex and highly unpredictable "in vivo" (Nicolescu 2008) research situations and is realized in a context of application (Gibbons et al. 1994). It acknowledges the diversity of forms of knowledge and experiences gained in different ways (Rist et al. 2004) without prioritizing and is thus heterarchical (Gibbons et al. 1994). Td processes, therefore, require strong reflexivity of all persons involved, along with a transformation of attitudes and capacity building (Hirsch Hadorn et al. 2008) to deal with this contradiction and to develop a working mode that balances the opposing poles of openness and control. This circumstance requires the acknowledgement of the boundaries of anyone's epistemic capacities, the situatedness of any form of knowledge production, and the context dependency of any viewpoint, as a matter of principle.

Against this background, further research is necessary on the micro-scale of knowledge generation, integration, and transfer through mutual learning in Td processes. This is, in particular, the case when diverse dimensions of culturality are addressed. It requires identifying and addressing the positioning and the situatedness of the persons involved in a *cb*MLS in greater depth. However, measuring learning outcomes of *cb*MLS is a theoretical and methodological challenge. Theoretically, this calls for identifying what additional capabilities or increased knowledge that is generated in a *cb*MLS. Dealing with sustainability challenges, this would call for a clearly defined (1) subject of interest (i.e., what does a sustainable transformation deal with), (2) process (i.e., who and what organizations/institutions are involved), and (3) means of transformation (i.e., what knowledge and actions are necessary for a sustainable transition). Accordingly, research will also face methodological challenges. For measuring learning outcomes, the classical procedure of a statistical control group based on a pre–post comparison is theoretically thinkable but, practically, nearly impossible. Cases are unique, and it is difficult to control the conditions of the *cb*MLS in a way that the prerequisites of a sound statistical analysis are fulfilled. Nevertheless, a science for sustainability (Spangenberg 2011) requires a sustainable mode of research—one that enables both: (1) the augmentation of knowledge and understanding, on one hand, and (2) sustainability transformations on the other. Td research has already proven to be a very promising means—taking on the challenges of its consolidation is indispensable.

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