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RESEARCH

Codes of Conduct for Collaboration as Social Rule Systems for Transdisciplinary Processes

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Abstract
This paper addresses the need for effective and fair codes of conduct for public-good-oriented transdisciplinary processes. These processes are characterized by the production of socially robust orientations (SoROs) through mutual learning and developing better action strategies by merging knowledge from practice and science. We argue that transdisciplinary processes should be governed by an appropriate social rule system that comprises codes of conduct for collaboration (CCC) in transdisciplinary discourses. In our view, participants in a transdisciplinary process must (1) follow rules of mutuality between science and practice (accepting the otherness of the other) and (2) enable the use and integration of knowledge from science and practice (e.g., through responsibility and/or co-leadership at all levels of a project). This requires (3) a protected discourse arena similar to an expanded Chatham House Rule that facilitates the generation of groundbreaking, novel ideas for sustainable transition. In transdisciplinary processes, CCC are based on these three perspectives and can be explicitly introduced yet require cultural and situational adaptations. Many aspects of transdisciplinary processes, such as legal status (e.g., who owns the data generated, whether it is a group or formal organization), are often unclear and need further investigation.

Keywords Social Rule Systems · Transdisciplinarity · Action Research · Codes of Conduct for Collaboration · Equal Footing · Knowledge Integration

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Introduction: Transdisciplinary Codes of Conduct for Collaboration

What is Understood by Transdisciplinarity?

There are many concepts and definitions of transdisciplinarity in the literature (see review in Lawrence et al. 2022). They all agree that dealing with wicked problems require multiple types of knowledge, in particular academic, experiential and practical knowledge, inclusion of stakeholders and integration of academic and practical viewpoints (Scholz et al. 2006); Renn 2021). Transdisciplinarity is understood in this paper as the integration of knowledge from science and practice to better cope with problems of a certain complexity, particularly in the field of sustainability transformations (Häberli and Grossenbacher-Mansuy 1998; Jantsch 1972; Klein et al. 2001; Lawrence et al. 2022; Polk 2015; Renn 2021; Scholz 2020; Scholz et al. 2000, p. 6; Scholz et al. 2006). Different notions of transdisciplinarity exist. The term is sometimes used to refer to the integration of different (scientific) knowledge systems that cannot be easily integrated (Mahan Jr., 1970; Nicolescu 2000, 2011; Piaget 1970; Scholz and Steiner 2015a). This may even involve an inner-disciplinary level; for instance, in physics, theories related to quantum dynamics and particle physics cannot be well-integrated (Hossenfelder 2018; Nicolescu 2007, 2011). This inner-science search for an overarching consistency or unity of knowledge has been called Mode I transdisciplinarity (referring the the destinction Mode I and Mode II science by Gibbons et al. 1994). This paper focuses on transdisciplinary processes (Td processes) that relate and/or integrate knowledge from science and practice. Transdisciplinarity and interdisciplinarity are thus understood as complementary terms focusing on different types of knowledge integration. Transdisciplinarity relates the epistemics of scientists and practitioners. Interdisciplinarity is based on the merging of concepts and methods from different scientific disciplines. However, transdisciplinary approaches rely on (targeted) interdisciplinary cooperation, while interdisciplinarity can be accomplished without transdisciplinary methods or procedures.

Transdisciplinarity goes beyond participatory research, meaning an "orientation toward inquiry." In participatory research, the scientists maintain control of the process. The inputs from practice often merely serve the interests of the science side. Thus, the better understanding and reflection of an (abstracted) scientific topic is the subject of participative or participatory research (Cornwall and Jewkes 1995). Yet participatory approaches are not fundamentally distinct from other empirical social research procedures (Bergold and Thomas 2012). On the contrary, the structuring and formation of jointly developed orientations for a concrete, complex, societally relevant, ambiguous, and usually contested real-world problem (i.e., a real-world case) are elements of a transdisciplinary process. Since Td processes involve research and questions at certain periods, participatory research is a component of these processes.

The second variant to address is action research. Compared to many variants of action research, Td focuses on the capacity-building of participants for sustainable action rather than on direct, concrete, practical problem-solving actions (Bradbury 2015). Both approaches are oriented toward addressing real-world problems Yet, typically, action research targets solving problems directly (i.e., takes a solutionist perspective; Bisaro et al. 2016), while Td research includes the search for a common understanding and often reframing of the problem and the exploration of a resolution space rather than a concrete solution. A major difference is that, in action research, the normative values and goals of scientists rule the interaction with practitioners. By contrast, scientists participating in a Td process are fundamentally oriented toward the common good, while practitioners add the necessary

experiential and interest-driven knowledge and perspectives required to define the problem and the solution space. To put it in other terms, specific normative aspects of scientists do not guide the Td process. The focus is on the facilitation of conflicts emerging from different values, interests, and worldviews among stakeholders (Baskerville 1997; Scholz 2017b; Wittmayer and Schäpke 2014). The three approaches, participatory research, action research, and transdisciplinarity describe different kinds of science–practice collaboration (Scholz and Steiner 2023a). In a transdisciplinary process, there is, ideally, equal-process ownership and co-leadership by practitioners and scientists. For this reason, we do not use the term "transdisciplinary research," which indicates that researchers take the lead, but rather Td approach or process. We should note that community-based participatory action research (CBPAR, McTaggart 1991; Whyte 1989, 1991; Wilson 2018) is closely related to our understanding of transdisciplinarity as used in this paper. Often, CBPAR also relies on co-governance, but it is not based on the assumption that science is affected by and benefits from science–practice collaboration, which is the case when applying transdisciplinarity.

A transdisciplinary process is conceived as a time-limited process that is jointly initiated, managed, and governed by a social community and newly formed to deal with particularly complex challenges. Participation is voluntary and unpaid, except for a few people responsible for the management of the process. The collaboration is goal-oriented and usually focused on strategic management or finding strategies for action. In practice, membership on a transdisciplinary team is sometimes formalized by a participation or cooperation agreement. Frequently, however, this is informal (as a basis we take here the 40 transdisciplinary processes analyzed by Scholz and Steiner 2015a, 2015c). From an organizational science perspective, a transdisciplinary team may be something between a group and an organization. (the latter requires formal admission and membership). This paper discusses codes of conduct for collaboration (CCC) in Td process as a social rule system (Burns and Dietz 1992) that supports a transdisciplinary team to take agency in sustainable transitioning. The term "sustainable transitioning" is used synonymously with sustainable development (Scholz and Stauffacher 2007). We should note that transition management also denotes a specific collaboration approach between science and practice that may follow an activist "radical" approach (Loorbach 2022; Rotmans et al. 2007).

What Does a Code of Conduct Include?

There are different understandings of codes of conduct for collaboration, or CCC. Any CCC is a set of values, standards, rules, and principles describing expectations for what members of an organization or participants of a process should do. Yet we find applications of the term that include a code of ethics or even a whole set of objectives that are linked to an organization or process. As indicated by the phrasing in the title "codes of conduct of collaboration," this paper is largely limited to (1) the rules of interaction and mutuality of collaboration, (2) acceptance of the diversity of roles, and (3) several constraints to allow all participants equal access to the process and to the shaping of the outcomes. Td process, for instance, may take place only in settings that follow an open, democratic, pluralist discourse culture. Thus, interaction among the participants, particularly the social rules agreed upon and followed by scientists and practitioners, are in the foreground.

It is important to note that the current practice of transdisciplinarity has been developed over the last three decades in small-, medium-, and large-scale Td projects that aimed to produce socially robust orientations (SoROs; the singular is SoRO) as products of Td processes. SoRos represent results of a co-creation process between academics and practioners

on the causes of a problem or potential solutions to a problem. They are based on a process that generates processes of knowledge integration of different types of epistemics (e.g., scientific, and experiential knowledge, utilizing and relating disciplinary knowledge from the social, natural, and engineering sciences; Scholz and Steiner 2015a).

The transdisciplinary process primarily serves strategic objectives (how to reach a specific goal, for example in sustainability management) and aims to ensure that, in some way, all stakeholder groups are participating in a balanced manner. This means that "a merger of scientific and practical knowledge" – when following an "orientation toward the common good" (Renn 2021) – is a major general constraint. Thus, transdisciplinarity has also been called a major method of sustainable transition management. We want to note that advocacy-based, solution-oriented transdisciplinarity may call for a different approach as usually certain solutions (such as using nuclear power to address fuel shortages) are principally excluded from the outset.

SoROs are the primary outcomes or products of Td processes and are based on multiple triangulations of perspectives (science vs. practice, multidisciplinary and multistakeholder, etc.). As outcomes, they meet the characteristics of (i) knowledge integration, (ii) scientific compatibility (e.g., with state-of-the-art science knowledge, (iii) understandability (of the salient rationale by all participants), and (iv) two characteristics of integrity, i.e., a revelation of the limits of knowledge (related to both its uncertainty and incompleteness) and the full disclosure of interests, financial resources, and other constraints (Scholz 2011).

Td processes are costly with respect to time and money; they make sense only for a certain type of problem. Transdisciplinary problems are complex, ill-defined, socially contested, real-world problems with a high degree of ambiguity. They call for multiple trade-offs and cannot be appropriately addressed with disciplinary or interdisciplinary approaches. Transdisciplinary problems exhibit a multiple complexity that can be properly understood only by experts in both science and practice. Therefore, a Td process must be organized in such a way that the collaboration allows for an orientation on how to successfully cope with these types of problem. How this can be achieved from a social interaction perspective has not been thoroughly discussed. Only a few papers have focused on conflicts among participating representatives of stakeholders (Löhr et al. 2017; Siebenhuner 2018). In fact, mitigating between various stakeholders' legitimate interests may be viewed as a key challenge, and "being contested" is one characteristic of a transdisciplinary problem.

Td process require first the willingness of all participants to engage in such a process and, second, a specialized competence in process leadership. Such a process-oriented leadership is provided by facilitators. A facilitator is a kind of process-rule manager who organizes the Td processes, mitigates conflicts (particularly of goals among stakeholders), and assists in integrating different types of knowledge. The concept of the facilitator has been described as a person who can reliably communicate the goals, rules, and constraints of the process (Rasmussen et al. 2010).

Facilitators' roles go far beyond moderating; they must have the capability to structure the content and the process and, thereby, must be literate in the subject matter. The facilitator sets the rules for the discourse in consultation with the organizers and the participants. Facilitators must be able to communicate clearly in the language chosen for the Td process, understand the various interests of participants, and be aware of hidden and personal agendas of participants. Their core mandate is the facilitation of knowledge integration among and between the participating scientists and practitioners. Moreover, facilitators should be able to work together with organizers and process manages for coordinating all subgroups and serving as interface to the public at large in a way that does not disturb or jeopardize the internal process. Given these challenging demands, finding an effective facilitator represents a significant challenge in itself.

Yet, likewise, there are conflicts among scientists about which disciplinary processes are needed and which are not. Various scientific approaches may well differ in their mode of justification and/or validation. Here, the art of the facilitator is to support the selection and justification of the theoretical approach that is meaningful. This is linked to the most significant challenge, i.e., to understand the degree to which – depending on the task to be accomplished – science knowledge or practice knowledge is useful in order to reach SoROs.

In What Domains do Transdisciplinary Processes Take Place?

As previously mentioned, the focused mode of transdisciplinarity is quite similar to CBPAR (Israel et al. 2017; Wallerstein and Duran 2010; Wilson 2018). The main difference here is that CBPAR does not strive to affect or to change/innovate sciences in the same way. Transition management (Schneidewind et al. 2016; Wittmayer 2016) also utilizes Td processes. A comprehensive overview on 15 types of science-practice collaboration is provided by Scholz and Steiner (Scholz et al. 2023a).

There are many variations for how to conduct transdisciplinary studies and activities. They can be grouped into transition-oriented (aiming for SoROs; here, action-oriented approaches are subsumed) or reflective transdisciplinary approaches (preparing the groundwork for SoROs). But we may also find approaches including both sides. We have mentioned CBPAR and the Dutch transition management approach (Loorbach 2010) above, but real-world labs (Huning et al. 2021) or variants of participatory research are often subsumed under transdisciplinary approaches.

Although the practice of Td processes emerged from small, mostly environmental science case studies (Bergmann et al. 2012; close to 40 small studied are described in Scholz and Steiner 2015b), large-scale studies or Td processes not directly related to the natural environment have been run following the conception of transdisciplinarity presented in this paper. The Digital Data as the Subject of a Transdisciplinary Process (DiDaT) project dealt with unintended side effects of the critical/irresponsible use of digital data (Scholz et al. 2021b). About 150 participants, half from science and half from practice, developed SoROs in a two-year process, which were published in a white book (Scholz et al. 2021a). The Global Transdisciplinary Processes for Sustainable Phosphorus management (Global TraPs) was organized on a global level with workshops around the world, with more than 250 people from science and practice following most of the rules below presented (Scholz et al. 2014).

Codes of Conduct for Collaboration as Tools to Stabilize a Td Process: Historical Background and Objectives of This Paper

Although we are looking at an increasing number of Td processes involving practitioners, the conception of transdisciplinarity is generally unknown in practice (Scholz and Steiner 2015a, b, c; Stauffacher and Scholz 2013). Potential affiliating practitioners should be interested in the subject and the process of mutual learning. However, some may fear that economically competitive information may fall into the wrong hands, that they might participate in groups where they represent a minority opinion, or that preliminary thoughts developed to explore unconventional solutions could be used publicly to harm them. These are particularly more likely to happen in an increasingly polarized world. A CCC, thus, should include rules to protect those practitioners who, for example, want to think outside the box when searching for groundbreaking social innovations or who are interested in discussing topics that may be taboo in a transdisciplinary problem. Against this background, the Chatham House Rule is of interest. It was developed by

an international think tank (Martin 1995) that brings together people who are interested in open dialogue on issues of a sensitive nature. The Chatham House Rule simply expresses that everything that has been discussed may be conveyed to the public but without revealing the identity of who said it, thereby, protecting open discourse and building trust.

Historically, with respect to Td processes, a first significant development was made during a study on transforming a highly contaminated industrial urban area in Zurich. The site owners, producers of large machinery, were very concerned that a Td process would endanger the "permitting process and design plan" negotiated with the city council (Andres 1996, p. 6). However, as expressed by the owners, they and the scientific team succeeded "without any problems" … "to find rules of the game for conducting the study," e.g., when regulating how and when critical data could be communicated to the public. This allowed "what is sure to be a mutually beneficial dialogue to be established" (1996, p. 7).

Sustainability learning between science and practice needs a properly designed learning space and rule systems designed to build trust. The personal dimension is most important in this context. Ideally, the practice and science co-leaders together provide a first draft of the rules. Yet, in the sometimes multi-year collaboration, new problems may continually emerge when linking science and practice needs. This is why the Global TraPs project, a global Td process on sustainable phosphorus use, introduced a facilitator for each group (Scholz et al. 2014, p. 87). A facilitator may be viewed as a pivotal actor at the interface between science and practice (see Fig. 1). This position aims to extract basic rules that support knowledge integration, the mitigation and reframing of conflicts, the formation of trust, and other issues needed for open discourse. Under the heading of "Principles of mutual learning sessions," a first comprehensive CCC can be found in Scholz et al. (Scholz et al. 2014, p. 94).

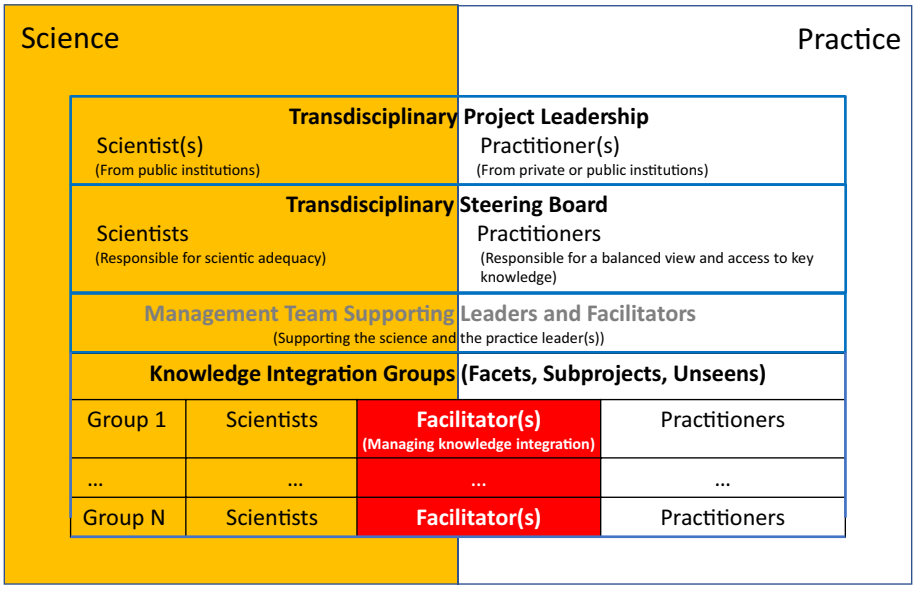

Fig. 1 A standard organizational chart of a transdisciplinary study (adapted from Scholz et al. 2021c, p. 10) for a Td process (Binder et al. 2015) including facilitator(s) as key agent(s) and manager(s) who run a Td process and facilitate knowledge integration

Origins of The Concept and Functions of Codes of Conduct for Collaboration

Social Rules are Real and can be Measured

When studying codes of conduct for transdisciplinary research, it is essential to base such a study on generic concepts that have been developed for justifying rules and orientations in a larger societal context. For example, Émile Durkheim (1858–1917), one of the founders of sociology, stressed the importance of social and moral norms and rules for understanding social development. Durkheim considered the sociocultural system to be widely independent from natural resources (Humphrey and Buttel 1982; Rosa and Richter 2008), yet he took a realist, positivist view of the social rules that govern social systems, in the small and large scale (Durkheim 1895/1982; Scholz and Steiner 2023b). He stated that social rules are social facts (that have to be explained by other facts) and considered them real phenomena similar to physical facts since they can be observed by the appropriate methods, scientifically validated, and in most cases, objectively measured (by their impacts on social systems). Similarly, for the new institutional economics approach (North 2005; Williamson 2000), the rules of interaction – or rules of the game – are seen as the basic pillar for governing socioeconomic systems.

The above-mentioned Chatham House Rule was developed 100 years ago after WWI in Great Britain. The founders of Chatham House were striving toward a new world order to improve international affairs; the objective was the consolidation of a peaceful world. This was believed to be best achieved by promoting "partnership" between "politicians, businessmen … in order to launch a frequently confidential discussion and collaborative study" (Martin 1995, p. 698). The idea was to "develop a completely new working method" to reflect on the causes of war and to support diplomats. The Chatham House founders were targeting capacity-building and avoiding interest-driven politics. Edward Grey, British foreign secretary from 1905 to 1916, stated in 1920 that it is possible to develop rules of practice "that will not interfere with policy, but provide materials from which politicians, statesmen and journalists can form sound opinions in regard to policy" (see Morgan 1979, p. 242). Science was not the main recipient at that time, but the advancement of political science and the development of a sound knowledge base (focusing on building a sound library) were early Chatham House objectives.

A CCC is a set of clearly articulated rules of communication between members of a social system. It includes norms, behavioral rules, and responsibilities that all members are expected to follow. CCC are often, but by no means always, related to ethics (moral norms). Cooperation became a common tool of company and industry branches (White and Montgomery 1980). Some CCC also refer to the relationship between the subjects and objects of research, particularly if transdisciplinarity is conceived as practicing science in cooperation with actors from society. Research with Indigenous peoples or disaster-zone research where ethical norms may avoid the presence of hundreds of "onlooker" researchers investigating unequal people (Gaillard and Peek 2019) is another example.

Social Rules of a Td Process

Transdisciplinary approaches, at least those that include multistakeholder discourses and the mitigation of conflicts, can be seen in the context of utilizing deliberation and expertise in participatory processes (Renn 2004). Moreover, a common-good-oriented transdisciplinary collaboration is usually based on democratic ideas. The basic principle of collaboration between science and practice on an equal footing or the inclusion of all relevant stakeholder groups

when acknowledging the otherness of the other may be seen as key objectives of a Td process. Adequate rules of communication within the Td project team and beyond are required. Here, for instance, when questions of liability emerge, the question arises: Are teams engaged in Td processes considered a group or an organization? Groups have no formal membership and are not legal entities; they are characterized by fluid boundaries of informal membership.

Against the general theoretical background above, a transdisciplinary process is related to a (temporary) actor system (or social system) that has to develop a rule system of interaction, appropriate behaviors, and "go / no-go" actions functional for the goal (i.e., major outcomes), e.g., for producing a SoRO. For this to be effective, all actors must accept or negotiate on the rules of collaboration; please note that this depends on the roles assigned to the participants (e.g., you are representing stakeholder group X). Furthermore, the rules of a CCC strongly depend on the sociocultural context. For instance, the rule of equal footing, which in Western culture signals that all members of a transdisciplinary team have the same rights and power, is not applied the same way in the Japanese culture for Td processes (Scholz et al. 2018; Sugiyama et al. 2017), where social hierarchies (Curhan et al. 2014) and elder respect (Scholz et al. 2014) play a larger role.

Thus, generally, a transdisciplinary team viewed as a temporary social system develops a kind of collective reasoning, rationality, or mindset (Franck 2002; Pingle 2016; Scholz 2011). The rules for both decision-making and interactions are somewhat negotiated, and values, norms, and ethics are framed in such a way that a functional collaboration becomes possible. We argue that this should not be done implicitly but should become the subject of a Td process, particularly in the preparation and planning phase.

We consider Habermas's speech-act theory and the construction of a protected discourse arena as important elements of a rule system for the CCC in Td processes (Renn 2021). Habermas emphasized the importance of discourse in conflicting arguments and claims of validity (German: Geltungsanspruch, Habermas 1984, p. 131). This requires an undisturbed arena of communication based on equal rights of all participants to make and criticize speech acts if pragmatically rational conclusions are an aspiration (Renn 1999, 2004).

Unambiguously clarifying whether a transdisciplinary team is a group or an organization is difficult both formally and legally. Describing the distinction between a Td project and a Td process may help clarify this. We refer to a standard organizational scheme that has been applied in numerous Td studies listed in Scholz and Steiner (2015c) (Binder et al. 2015). Mostly, a Td project needs funding by an external organization (e.g., public agencies, science, or business organizations). The recipients of the project employ scientific and administrative staff who become formal members of an organization (see 1, Fig. 1). The staff is usually employed by the universities, companies, or organizations to which the co-leaders belong. In addition, there is often a formal or verbal contract between the science project leaders and the practice partners, for example, a property owner, governmental agent, leader of an association, or head of an indigenous group, etc., at the start of a Td process. Typically, a first draft of the contract of collaboration is negotiated with all stakeholders involved at a very early stage of any Td process.

A Td process has six stages: (1) a triggering phase in which the idea for the project emerges; (2) an initiation phase (including creating the idea by a scientist or practitioner and network-building among key actors and stewards); (3) a preparation phase to acquire resources and funding for running a process of mutual learning between and among scientists and practitioners; (4) a planning phase for the process of (5) a core phase for conducting the process; and (6) a post-processing phase (Scholz and Steiner 2015b). It starts with an idea about the need for a Td project, normally initiated by representatives of science or practice. The ideas about the objectives of a Td process and how it might be conducted

unfold and develop during the course of direct interaction between the project's future leaders or stewards. At or following a kickoff event, a steering board is often established comprising practitioners and scientists (see 2, Fig. 1); this is agreed upon in a verbal or written statement. Many of these agreements become part of the CCC. The practice of formal agreements between science and practice in Td projects have yet to be explored. As it is extremely difficult, if not impossible, to include a co-leader from practice (or the legal equivalent) in contracts with a public research institution such as a national science foundation or third-party funding recipients, supplementary contracting is likely to be necessary.

If participating scientists approach colleagues from other departments to participate in a Td project and build a partnership, these colleagues will want to know how the process works, how their roles relate to the roles of others, and what they might expect to result from their participation. Communication becomes much smoother and easier if these questions and concerns can be addressed and answered by a draft of the CCC. A CCC should also include rules in regard to when, in the course of the project, the intermediate or final results of a Td project should be communicated to others, particularly to the public.

We refer again to the above example of the management of a contaminated site. The question of how to handle data (regarding confidentiality) on soil contamination or data generated in a Td process may become a major issue when drafting the CCC. Who has access to the data and who may utilize which data are normally subjects of the contract between the co-leaders, and these can be complicated and ambiguous legal issues. A Td process for contaminated urban land management may be taken as an example. In such cases, individual agreements (supplementing the CCC) may be required, including rules for compliance in the event that damage emerges from a breach of the data-use rules by someone who releases data in confidentiality.

In many Td processes, there are individuals who step in and out during the project. Thus, the organizational model of a Td process must clarify who has what kinds of obligations and to whom. Usually, the core team (see Fig. 1, Levels 1 and 2) is well aware of the CCC and knows how to operate in compliance with these rules. Yet those who are only marginally involved in a Td process (for example, those who participate in interviews or in several meetings or workshops) may not share or even know about the CCC. In addition, transdisciplinary studies with Indigenous peoples may raise particular questions about ethics and property ownership. This implies that Indigenous participants should have leadership or even co-leadership (Moewaka Barnes et al. 2021; Scholz 2012; Shiroyama et al. 2012).

A CCC Blueprint for Transdisciplinary Processes and The Importance of Communication

In particular practioners are reluctant to join a transdisciplinary project when they have the impression that the rules for how their input is being used and integrated is not specified (Scholz and Steiner 2023a). This is especially true for controversial Td problems in which SoRO formulated in a certain way may affect the stakes of some members. No actor is willing to participate voluntarily if he/she is at risk of significant harm by participating. Thus, the CCC must provide transparency and security for participants (and recipients) and describe how the study is designed and how outcomes, i.e., SoROs are constructed.

A complete draft of the CCC should be available at the start of a project. In the previously mentioned large-scale Td project, DiDaT – Digital Data as the Subject of a Transdisciplinary Process as the focus of a new Td project, immediately after receiving the first seed money for

preparing the Td project, a brochure including (potential) goals, a (preliminary) time frame, and a draft CCC were published (see Renn and Scholz 2018, p. 5). These rules were repeatedly presented, discussed, and extended (e.g., by role descriptions among all 150 participants). This transparent procedure was essential for dealing with conflicts and creating fair representations of different viewpoints in the resulting documents.

The four groups of CCC developed in the last three decades based on the practice of the authors (see Box 1). The first group refers to basic rules and norms of mutuality, the second on the roles of the participants, and the third on rules regarding how the participants of a Td process can be protected by excluding topics and modes of external communication. The fourth group of CCC rules relates to the outcomes as, finally, the CCC have to be functional for the goals of the study.

Box 1: Remarks on the methodology of constructing Codes of Conduct for Collaboration (Table 1)

Three major sources contributed to the development of the components in Table 1

1. The comprehensive experience from 26 transdisciplinary processes and more than 24 processes of mediation and other forms of science–practice collaboration

The presented rules CCC in contexts of transdisciplinarity were developed based on the practical experience gained in many, mostly large-scale transdisciplinary processes. The first author participated as (co-) leader in 16 transdisciplinary processes in Switzerland (see Nr. 1–6 and 8–16 in Scholz and Steiner 2015c), two in Germany (see No. 30 and Scholz et al. 2021a), and one each in Sweden (see No. 21), Guatemala (Berger-Gonzalez et al. 2016; Scholz 2012), Kenya (Chebet et al. 2019; Njoroge et al. 2015), and Vietnam (see No. 20). One transdisciplinary process on the phosphorus cycle involved experts in science and practice from many countries (Scholz et al. 2014). All of those processes took place in large-scale studies, each including an average of approximately 80 scientists and 120 practitioners (for detailed data of participants see Scholz and Steiner 2023a; Stauffacher and Scholz 2013) (Scholz et al. 2014, pp. 87–89) (Scholz et al. 2021a, p. 10), and each process took 1–4 years. The first author conducted two mediations. The second author initiated, participated, and led planning cells (Dienel and Renn 1995a, b), more than 22 mediation processes (Benighaus et al. 2010; Renn et al. 2011), and at least 4 transdisciplinary processes, including one with the first author. In organizing those projects, the authors gradually developed an understanding of the need for rules to organize the processes—for instance, to raise awareness among participants about the integration of knowledge from both science and practice (see Table 1, 1), explicit role differentiation (2.2) and co-leadership (2.2), and the exclusion of everyday political issues in transdisciplinary processes (3.2) and other components in Table 1. The development of transdisciplinary processes began approximately three decades ago with the mentioned planning cells and initial projects on urban and rural development (Scholz et al. 1996, 1994)

2. Post hoc identification of principles of mutual learning

A global transdisciplinary process of sustainably managing the global phosphorus cycle—that is, Global TraPs—included practitioners and scientists at all stages of the phosphorus supply chain (i.e., exploration, mining, processing, use, dissipation, and recycling) as well as considered the aspects of trade and finance (Scholz et al. 2014). Strict co-leadership between practice and science was practiced in that process (see Table 1, 2.2). The need to structure the processes, which included more than 250 people who participated in the mutual learning process, by specialized fertilizers synthesizing the science and practice called for creating facilitators (see Table 1, 2.3) as a special type of process moderators. A post hoc analysis identified an initial table of principles of mutual learning (Scholz et al. 2014, p. 94) that included the items of protected discourse arenas (3.1), pre-competitive issues (3.3), co-leadership (2.2), the joint definition of problem to be focused (1.5), the differentiation of roles (2.1), and orientations instead of recommendations (4.1)

3. Pre-transdisciplinary process delineation of Codes of Conduct for Collaboration

Based on the previously described experiences, the authors suggest that the rules of mutuality, the rules of communication, and the basic characteristics of a transdisciplinary process should be established at the very beginning of such a process. Those rules and characteristics were established in the context of a DiDaT project, as discussed in this paper. In preparing a large-scale project on the responsible use of digital data as the focus of a new transdisciplinary project, a list of CCC was included in a brochure (Renn and Scholz 2018, 2018) that guided the initiators of the transdisciplinary project in engaging practitioners and scholars in the transdisciplinary process

Rules of Mutuality

When someone is asked to participate in a Td process, he or she wants to know why this form of extensive and time-consuming collaboration is necessary and how it can be useful for a particular Td problem. Our standard answer is that the complexity and multilevel context of wicked problems cannot be understood by practitioners or scientists alone (1.1; all numbers below refer to Table 1); they demand integrated and related knowledge from both sides in a targeted project. We further explain the other aspects of a Td problem, particularly the contestation, multiple uncertainties, and benefits of having some degree of consensus on what the core problem is and is not. Thus, at the beginning of the process, the organizers must provide clear answers to the questions of "why" and "how" someone should participate in a Td project to generate added value that cannot be attained without a comprehensive Td process.

Much can be elucidated in some detail when explaining the CCC. Mutual learning for providing answers is possible only if the social, cultural, and democratic norms of (1.2) accepting the otherness of the other are accepted (Scholz 2017b) and if (1.3) scientist and practitioner knowledge are seen as complementary modes with no superiority of one over the other but with different functions in the various settings and phases of the Td process (Krütli et al. 2010; Stauffacher et al. 2008). Equal footing should be realized on all levels of the project. Based on this (1.4), the integration of knowledge, i.e., the co-creation of SoROs based on joint problem definition, co-representation of positions, co-analysis of data, and co-design for perspectives of sustainable transitions, may take place.

To better understand the types of knowledge that promote mutuality we can distinguish seven types as these as follows: (i) one related to the systemic ontological, (ii) one to the epistemological theory of science, (iii) a cognitive-psychology related one, (iv) another related to social-interest conflict and perspectives, and (v) one related to complexity theory. Further, (vi) they refer to the integration of sensory, enactive, iconic-conceptual, and formal-symbolic modes of knowledge integration (taking an evolutionary perspective) and to (vii) Brunswik's theory of probabilistic functionalism, which explains how complexity may be meaningfully integrated. Each type refers to different entities that are integrated (e.g., systems for (i), hypothesized modes of reasoning for (ii), or the relations between actors for (iii); see Scholz 2017a). Yet they are useful for improving the real process of co-creation (1.5) and mutual learning when describing and reflecting on it.

Processes of mutual learning can benefit from, among others, systematic procedures, techniques, organizational schemes, and designs for how knowledge may be integrated. Against this background, a set of practical and theoretical contributions (Bergmann et al. 2013; Nicolescu 2014; Scholz and Tietje 2002) describe specific methods such as participatory system description and scenario construction or multi-attribute evaluation. Applying these methods (1.6) or others is also obviously helpful and beneficial for attaining equal participation and reconstructing who takes process ownership at what stage of a Td project (Krütli et al. 2010). A critical issue here is that, by having control regarding the methods, "the researcher is the ultimate authority" (Berbés-Blázquez et al. 2016, p. 134). Thus, we need formal means (i.e., methods) for mitigating potential imbalances between science and practice and ensuring that all stakeholders may speak freely and will be heard (Vilsmaier et al. 2017).

Table 1 Potential elements of a code of conduct for collaboration (CCC) for Td processes

1. Rules of mutuality	**2. Rules of participants and funding**
1.1 Mutual learning as a basic principle	2.1 Differentiation of roles
Different epistemics, science vs. practice, from different fields of science are related; different fields of practice, etc.. knowledge integration and mutual learning as core principles	Participants are presented different perspectives, both in science and in practice)
1.2 Accepting the otherness of the other	2.2 Co-leadership
The various roles, values, and objectives of different interest groups are accepted	Joint responsibility and accountability of scientist and practitioners on all levels
1.3 Appraisal of scientific knowledge and practical knowledge	2.3 Facilitation
Experiential "wisdom" and academic rigor are appraised; both knowledge system show flaws because of incompleteness	The discourse between scientist and is and practitioners is organize, knowledge is integrated, conflicts mitigated, and common language for knowledge integration is identified
1.4 Equal footing of science and practice (co-leadership)	2.4 Science for serving the public good
Overall, an equal process ownership is provided on all levels of the project including co-leadership)	No science activism; developing social norms and practical solutions is seen as a matter of political actors and practitioners; no science activism and advocacy science
1.5 Co-creation: Joint problem definition, co-representation, co-analysis, co-design and co-accountability for the Td process	2.5 Sponsoring
The inclusion of both sides is a given at all activity stages, although abilities and competencies are functionally utilized	Financial support for doing targeted research (when keeping the independence of science) instead of service contract-based research
1.6 (Td) Methods-based integration of knowledge	2.6 Responsibility and accountability
By means of transparency, efficiency, and efficacy, methods of system representation, system evaluation and system transformation are used and co designed	Rules of responsibility, accountability, and liability, e.g., by defining levels of involvement in certain processes or clarifying what membership means; clarify data use rights
3. Rules of communication	**4. Outcomes and collaboration**
3.1 Learning in a protected discourse arena	4.1 Orientation instead of recommendations or solutions
Extended Chatham House rules, creating a protected discourse arena	Aspire capacity building by developing orientations which are valuable for all instead of providing recommendations such as consultants do
3.2 No day-to-day politics	4.2 Socially robust orientations (SoROs) not recommendations), as outcomes, including
Specific topics which are not the daily political agenda (e.g., for elections) have to be reframed/generalized for an open discussion to take place	4.2.1 Processes of different types of knowledge integration, particularly that of science and practice knowledge
3.3 Stay in the pre-competitive domain	4.2.2 State of the art knowledge (i.e., deliberative, evidence-based, resilience assessment for poorly understood problems) when relating knowledge from different disciplines
Data and topics should be dealt in a generalized way so that no economic advantages or disadvantages may result	4.2.3 Assuring understandability
	4.2.4 Not only explicating uncertainty but also incomplete knowledge (ignorance)
	4.2.5 Revealing the conditions (who finances the project by what type of contract)

Roles of Participants

In a Td process, different roles are assigned to the practitioners for representing certain stakeholder groups. These roles relate to the roles and codes of conduct because they specify the expectations of each participant towards the process and the roles of the other participants. According to Parsons's theory of social systems (Parsons 2017/1951), roles are genuinely value oriented; this is the origin of contestation and conflict. Parsons also stressed the integrative value of common roles and their need for "carrying collective responsibility" (p. 135). Actually, the CCC and the role assignments are inputs for designing the social structure. Leadership, management, the facilitator, representatives of different domains of science, and the stakeholder perspective taken by practitioners are assigned (depending on the decisions of the group). In Td processes, this allocation should be functionally related to the goal (the guiding question) of the study.

The conception of roles provides a "differentiationist" (Shinn 2005) perspective (2.1). The actors take different perspectives. Accepting the otherness of the other calls for self-reflection, which "… requires us to go beyond and outside simple and reductionist unitary visions of society" (Seligman and Weller 2020, p. 184). Scientists and practitioners are seen in two different types of roles representing different modes of knowledge and values. Simplified, practitioners follow practical goals (e.g., maintaining the viability of a company or an NGO), and scientists serve the public good of developing consistent and, if possible, empirically validated knowledge and theories that may serve all stakeholders (2.2; see SI 1). Some participants may wear more than one hat: A practitoner might serve as spokesperson for a specific interest group, runs his or her own business and is engaged as member of a political party. On the academic side, a professor at a public university might also own a consulting firm, or a member of public administration may have had a former research career. For such cases, the allocation of a primary role for each participant is necessary. The process of knowledge integration in Td processes relies on triangulation based on a thorough representation of different roles, interests, etc. This helps to clarify which knowledge and perspectives are included, which are missing, and how integration takes place (Scholz 2018).

The model of co-leadership (2.2) by, usually, one or two scientists and practitioners is a consequence of this conception. The DiDaT project, for instance, was led by two representatives of science (i.e., two distinct experts from the natural/engineering and social sciences) and two practitioners (one digital-industry pioneer and one leading voice for an NGO) (Scholz et al. 2021b). In many cases, the authentic, intense, and thus costly involvement of practice can be attained only if the practitioners take equal-process ownership. One task of the science leaders is to ensure, for instance, that state-of-the-art scientific knowledge is applied. For their part, the practice leaders have to ensure practitioners that a range of values, knowledge, etc. from practice (stakeholders) is sufficiently incorporated. Likewise, scientists and practitioners should be evenly represented on the steering board and guided by clear rules and competences. Otherwise, motivating high-profile scientists and practitioners to participate will prove difficult. Equal process ownership of scientists and practitioners is a unique selling point of transdisciplinarity (Scholz and Steiner 2023b).

The specific functions and roles of facilitators (2.3) are described in detail above (see the first Chapter). Although there seems to be an increasing demand for the capability of facilitation, there are few educational programs to meet this need, to the best of our knowledge. Yet the facilitator's skills are crucial for realizing the CCC, so special training for the facilitators in a Td project is typically necessary.

The rule of science serving the public good (2.4) means that scientists serve all stakeholders equitably and do not favor some above others or give preference to certain interests. This requires that all stakeholders refer to a shared common good, e.g., the improvement of a country's resilience (e.g., the DiDaT project), which is considered beneficial to all stakeholders.

Let us reflect on the role of scientists. They sometimes consider themselves as activists and become stakeholders (Loorbach 2014; Scholz 2017b; Wittmayer and Schäpke 2014). But this should be done in an open manner. In the DiDaT project (Scholz et al. 2021b), a university professor admitted that he held a position serving agriculture in general and was continuously involved in consultancy for a large agriculture and food association. Thus, he wanted to participate as a stakeholder for agricultural actors rather than as a scientist.

Importance of Funding Arrangements

The type of funding contract (2.5) between scientists and private and public funders affects at least those who have been involved in the contracting and are, thereby, responsible for a Td project. This is particularly of interest from a legal perspective when it comes to conflicts or claims by the funders. However, this dimension is completely or at least insufficiently addressed in the transdisciplinary literature. To simplify this, we distinguish between sponsoring (which allows the Td process to be independent with respect to results and methods) and contract-based service research. In principle, the latter is incompatible with the principles of transdisciplinarity that refer to a joint problem definition for running a Td project.

Generally, there are written and/or oral contracts for project leaders and hired project staff, at least those whose pay comes from the funds, and for members of NGOs, small start-ups, and others whose participation may be partially compensated by project funds. There are also contracts (of the sponsorship, research collaboration, service, etc. type) with funders or community, government, and/or private organizations for what data can be used and how it may be used and what resources can be used and how. All participants should be made aware of these contracts; such disclosures are an important and integral part of the process. They are also critical to the credibility of the socially robust orientations that form the outcomes of these processes.

We believe that an open sponsorship (defining only the type of activities related to which subject) is far superior to contract-based funding, which specifies the products (Scholz 2020). The multiple complexity of Td processes implies that even the subject of research may be altered in an unpredictable way. The key is that the independence of the science in the analysis, evaluation, and projection toward sustainable transitioning is better served if sponsorship is the primary mode of financing. This preference does not hold true only for private funding. Public funding (e.g., from ministries) is sometimes associated with political goals (such as decreasing or discouraging migration), which may bias a resilience assessment of certain scenarios. We have stressed the legal implications of the Td process that continue to be ongoing problems for many projects. Regarding participants, we have to acknowledge that some members will have formal contracts, whereas others (i.e., generally few) will participate on an honorary basis. The problems discussed above with access to data, etc. may be resolved only if the roles and functions of all participants with all responsibilities and rights are clarified.

Rules of Communication

The building of a protected discourse arena and the rules for maintaining it, including rules for sanctioning and penalizing deviant behavior (e.g., if sensitive data are misused) should be part of the CCC. This supports the formation of trust, a vital component of collaboration (Harris and Lyon 2013). Trust among the participants is an important enabler for collaboration. Td projects should be designed not only for careful analysis but also for exploring new, groundbreaking ideas that often emerge by thinking outside the box, by critical evaluation, or by the unconventional reframing of the transdisciplinary problem. The introduced Chatham House Rule (3.1) is an important means. Sometimes, even preliminary statements made in meetings must be protected. The conception of a protected Habermas discourse arena (Healey 1997, 2009) should be used as a component of transdisciplinary CCC.

To preserve this arena of confidentiality and trust, two rules are essential: "Do not cope with day-to-day politics" (but only with issues underlying them; 3.2) and "Stay in the precompetitive domain with respect to businesses, NGOs, and other activities" (3.3). These rules require strict adherence in order to reduce any interest-driven bias in the construction of SoROs. Cundill et al. (2019) reflected on the building of a collaborative space for sustainable transitioning. The authors stressed that "relational features" such as trust formation are most essential, particularly as actors with different powers are collaborating. To avoid conflicts when communication rules and other aspects of the CCC are not followed, participants should sign a document that lays out the most important items of a CCC, given a specific project, thus signifying their agreement.

Outcomes

The multiple complexity of Td problems makes transdisciplinarity a means of strategic management that does not provide push-button solutions. Moreover, the outcomes are addressed to all stakeholder groups. Thus, orientations rather than solutions (which are a product of consultancy; Mobjork 2010) are the outcomes.

SoROs (4.2), as defined some years ago, include features that are directly relevant to how collaboration should be achieved. As stated in the introduction, SoROs are based on a process that "generates processes of knowledge integration of different types of epistemics (e.g., scientific, and experiential knowledge, utilizing and relating disciplinary knowledge from the social, natural, and engineering sciences) (Scholz and Steiner 2015a).

This is explicitly presented in 4.2.1 and 4.2.2. These two rules and the request for an understandable language (4.4.3) are the pillars of social robustness. But honest communication of the limits of knowledge (4.4.4) and of the constraints (e.g., how much time and resources are available; 4.2.5) under which a Td process operates is also part of building trust and the successful uptake of results.

Discussion

Td process include scientists and practitioners with the aim of producing SoROs and action-oriented knowledge for understanding and resolving complex, societally relevant, and poorly understood (ill-defined) problems. For coping with such problems,

transdisciplinarity has evolved as a powerful methodology and novel form of practicing science with and within society. A transdisciplinary team may be considered a new type of social entity characterized by specific social rules, norms, and roles. We introduce a CCC that can be used in Td processes as an organizational tool for supporting a transdisciplinary team to reach goal attainment. The proposed CCC in a Td process serves three objectives, products, and outcomes:

(1) *Capacity-building*: The capacity-building of the participants and, subsequently, of science and practice is a major objective. A Td process empowers practitioners to make better and more-sustainable decisions and scientists to generate improved theories for understanding complex real-world dynamics. Both sides learn how they may better benefit from each other. The collaboration, co-design, co-problem transformation, etc. by a group of scientists and practitioners creates, in the sense of Durkheim, social rules of interaction and decision/leadership, rules, norms, and roles as novel social facts. A CCC supports the group process to, in turn, support the construction of groundbreaking SoROs (see Table 1, 4), i.e., for sustainable transformations.
(2) *A functional toolkit*: Table 1 summarizes the components of a CCC and offers a functional toolkit for knowledge integration. This is done when taking a differentiationist perspective that distinguishes between knowledge, functions, and the roles of scientists and practitioners, leaders, steering boards, working groups, facilitators, etc. All roles have different functions, responsibilities, and liabilities. They include descriptions and directions regarding the roles that each participant is expected to play, resulting in a proper and diverse spread of perspectives of knowledge and values that allow for the construction of SoROs. A special characteristic of the presented type of transdisciplinary is that scientists are viewed as serving the public good. All stakeholders should be empowered to gain access to the best available state-of-the-art knowledge in the respective scientific fields. The participating scientists are challenged to abstain from their normative, advocacy, activist goals – to the extent possible (Scholz 2017b; Scholz and Wellmer 2021). Further, to avoid a Td project simply following the normative ideas from (private or public) funders, sponsorship is the preferred means of funding for Td processes.
The new roles, responsibilities, verbal or written commitments on collaboration, access to data, utilization of results, etc. among the participants from practice and science raise many legal questions. This legal aspect has been widely neglected in the practice of Td processes and represents a gap in the literature that future studies should address.
We suggest that the CCC toolkit (Table 1) for Td processes can be applied in two ways. Table 1 can be used as checklist to provide the components of an ideal CCC that should be addressed. But it is also a tool for planning. After choosing a case and knowing the objective of a Td process, one can identify the most important tools, i.e., characteristics of a Td process, to reach the envisioned achievement of the targeted objectives under the given circumstances.
(3) *Creating a discourse arena:* A Td process may be considered an extension of the Chatham House Rule. This refers not only to how ideas and outcomes of the deliberations will be communicated but also includes how sensitive issues (e.g., day-to-day policy or issues relevant to the direct economic competition among participating stakeholders) should be handled.
Naturally, the exact rules of any CCC have to be specified, situationally or culturally adapted, and negotiated among the participants of a transdisciplinary process. Yet they should not only be an important part of the practical implementation of a Td project but also a main topic of theoretical reflection about the structure and design of Td processes.

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Declarations

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Consent for Publication Both authors agree on the content and have the permission to name the institutions to which they have been affiliated when writing this paper.

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