Design features for social learning in transformative transdisciplinary research

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ORIGINAL ARTICLE

Design features for social learning in transformative transdisciplinary research

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Abstract
This article analyses social learning in transdisciplinary research processes by a systematic comparative analysis of 20 completed or nearly completed projects in the field of sustainable development. This article considers the social learning generated by transdisciplinary processes in a broad way. It looks how social learning is embedded in the practical interaction processes between new scientific knowledge, practitioners' life-world experiences and social experimentation. The analysis finds that three factors in particular play an important role in social learning: the clarification of the normative orientations, the co-construction of the research question and practical problem situation, and the balancing of power asymmetries. While a single criterion may not allow increasing social learning alone, the analysis supports the hypothesis that a combination of these three criteria systematically increases the strength of the social learning generated. Other factors, such as active facilitation modes and the presence of collective interest advocacy organizations, only play a strong role as a condition for generating social learning in some specific types of transdisciplinary research.

Keywords Transdisciplinarity · Transformative research · Social learning · Sustainability transitions · Facilitation

Introduction

Many scholars consider transdisciplinarity as a useful research approach in the field of sustainable development for its ability to deal with complex socio-ecological interdependencies (Jahn 2008; Popa et al. 2015; Bieluch et al. 2017; Ott 2017). Despite the existence of a large diversity of definitions, the literature seems to converge on some general traits: "Transdisciplinarity is a critical and self-reflexive research approach that relates societal with scientific problems; it produces new knowledge by integrating different scientific and extra-scientific insights; its aim is to contribute to both societal and scientific progress" (Jahn et al. 2012). In other terms, transdisciplinarity aims at contributing to societal transformations by producing hybrid scientific and socially relevant knowledge, which is rigorous from an academic perspective, relevant to challenging societal problems and produces social learning through knowledge co-production with societal actors (Carew and Wickson 2010).

Due to complex socio-ecological interdependencies, sustainability problems are often of an uncertain, unstable, and indeterminate nature. Moreover, they often concern interrelations amongst human actors with diverging value perspectives, which interdisciplinary processes struggle to handle. Problem solving in such a context can be enabled by the social learning dimension that transdisciplinarity has to offer, since it provides space for openness for dialogue and common understanding by re-assessing background assumptions and values of actors and researchers in a critical manner (Hadorn et al. 2006; Wickson et al. 2006; Popa et al. 2015).

However, different methods and tools for research framing and collaborations between scientists and practitioners are mobilized in transdisciplinary research, without a clear knowledge about their relative impact on the level of social learning (Wickson et al. 2006; Hegger et al. 2012; Lang et al. 2012; Macho et al. 2013). To contribute to this debate, this article presents a systematic comparative analysis of 20 completed or nearly completed transdisciplinary research

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projects in the field of sustainable development. The analysis focuses on a number of aspects of transdisciplinary processes that have been highlighted as being important in stimulating a high level of social learning. The main hypothesis is that by a combination of co-construction methods that explicitly address normative agendas and orientations, and appropriate governance of power relations amongst social actors and scientists, transdisciplinary research projects may contribute to generating effective social learning on sustainability issues.

The article is organized as follows. The next section presents the core dimensions of collaborative research framing and governance of research partnerships that have been highlighted in the literature as important drivers of social learning. The third section presents the data collection and the research method. Sections four and five present and discuss the results of the comparative analysis.

Key process features contributing to social learning outcomes in transdisciplinary research for sustainability

Social learning outcomes

Social learning is acknowledged as a key output of transdisciplinary research. Usually, the term refers to what extent information feedback loops from social actors have allowed to modify—or at least call into question—the vision of the practical problem situation to be solved, perspectives on social values, and assumptions of a research process (Hadorn et al. 2006; Blackstock et al. 2007; Popa et al. 2015).

In this article, we consider the social learning generated by transdisciplinary collaborative processes in a broad way. We explore the reframing of objectives and value perspectives, but also the resulting social interaction processes between researchers and practitioners. In particular, we consider the contribution of transdisciplinary research in effectively integrating practitioners' perspectives in the social learning according to the pragmatist theory presented by Popa et al. (2015). In this perspective, social learning is envisioned as an "open-ended process of inquiry geared towards a broadening of the community of practice through social innovation and experimentation" (Ibid.). Following the pragmatist approach, indicators of social learning should, therefore, be considered at two levels:

1. social learning through mobilizing existing reflexivity within the process, also called *deliberative reflexivity*, which relates to how much the understanding of the practical problem situation and the formulation of the research question have been discussed by all the actors and called into question through argumentation on the values, the epistemic criteria and societal objectives;
2. social learning through generating and transforming reflexive capacities, also called *pragmatist reflexivity*, which refers to how much the practical process of collaborative problem solving and experimentation have created new actor competences and built new capacities to critically assess values and the understanding of the practical problem situation.

Popa et al. argue that developing pragmatist reflexivity is crucial in the long term, as it considers the building of practical competences and capacities for taking part in the social learning process by all the concerned actors.

Scholars of social learning have provided more precise definitions that allow to evaluate whether deliberative and pragmatist social learning has occurred and to what extent. However, as underlined by Reed et al. (2010), researchers often conflate social learning with other concepts such as participation or the reaching of certain behavioral outcomes. Even though the latter can be set in motion or promoted by social learning, multiple other factors often also play a role in explaining behavioral change such as public policies or economic factors amongst others.

To identify specific social learning outcomes resulting from collaborative processes, Reed et al. define social learning as a process that satisfies three conditions, respectively, related to (1) the degree of learning, (2) the social scale of the learning and (3) the mode through which the learning occurs. Based on these three conditions, social learning occurs if

1. a change in understanding has occurred in the individuals involved.
2. the change goes beyond the individual and becomes situated in wider social units and communities of practice.
3. it results from the exchange of ideas, arguments and information in these social networks.

In a pragmatist perspective, the first criterion should include both learning on the cognitive aspects (assumptions related to values, epistemologies; cf. Lenoble and Maesschalck 2016, ch. 5) and the practical aspects (re-assessment of the practical problem situation that is the starting point of transdisciplinary research, cf. Hadorn et al. 2008). The second criterion, as underlined by Reed et al., specifies the "social scale" of the learning: learning processes need to become embedded in communities that link inquiry to practical life-world problems. In transdisciplinary research partnerships, this embedding can be the result of linking scientific reflections to practitioners' real-life world experiences and social experimentations, or by linking the learning outcomes to new initiatives in other organizations and

communities, during or after the research projects have been completed. In the context of transdisciplinary research, the third criterion does not allow to distinguish social learning levels amongst the projects, as they are all based on a mode of communicative rationality.

Process features contributing to social learning

To be successful, transdisciplinary research needs at least to result in a certain level of mutual agreement amongst the participants. Such agreement does not imply a consensus amongst all participants, even if participants in transdisciplinary research often do reach consensus on core issues. Nevertheless, the process should at least lead to an agreement on a common framework, through which the diverging values, perceptions and goals of the participants can be integrated.

As shown in particular through the extensive fieldwork by Judith Innes, David Booher and their colleagues, reaching agreement in collaborative dialogues depends on the satisfaction of two main clusters of conditions (cf. for an extensive review, Innes and Booher 2003; Innes 2004). First, the dialogue needs to satisfy conditions of rationality and fairness of communication. These conditions include well-known features such as access to transparent, fully shared and reliable information, active and authentic involvement of all participants on an equal footing, and the inclusion of all relevant stakeholders. Second, in addition to these conditions of "authentic dialogue", their research on collaborative dialogue has shown the need to include narrative and interpretative elements that are distinct from the search for the best argument envisioned by the scholars of communicative rationality, such as Jürgen Habermas (1984). These narrative and interpretative elements are important to build a common perspective, in which participants can recognize themselves, in the presence of strong scientific uncertainties and social controversies over norms and values.

Most of the features analysed and reviewed by Innes and Booher also play a role in transdisciplinary research. The remainder of this section reviews the most important of the conditions of rational and fair communication processes and for improving narrative/interpretative mutual understanding that are discussed by scholars of transdisciplinary research, as illustrated in Fig. 1.

Creating mutual understanding on research objectives and normative backgrounds

Openness of the co-construction process While scholars emphasize that there is no unique method in transdisciplinary research, most scholars nevertheless underline that co-constructing the definition of the practical problem situation and the framing of the research question reinforce the capacity to reach a high level of social learning (Popa et al. 2015). In particular, as underlined by Lang et al. (2012), co-construction by researchers and practitioners should ideally integrate both concerns for scientific innovation and concerns for societal problem solving. The integration of these two concerns needs to be implemented in the three main stages of the research process: (1) collaborative problem framing and collaborative building of the research team; (2) knowledge co-production; and (3) re-integration of the produced knowledge into both scientific and societal practice.

In practice, however, science still often tends to dominate the problem framing in sustainability research (Wuelser and Pohl 2016). For this reason, scholars of transdisciplinary research emphasise the importance of involving

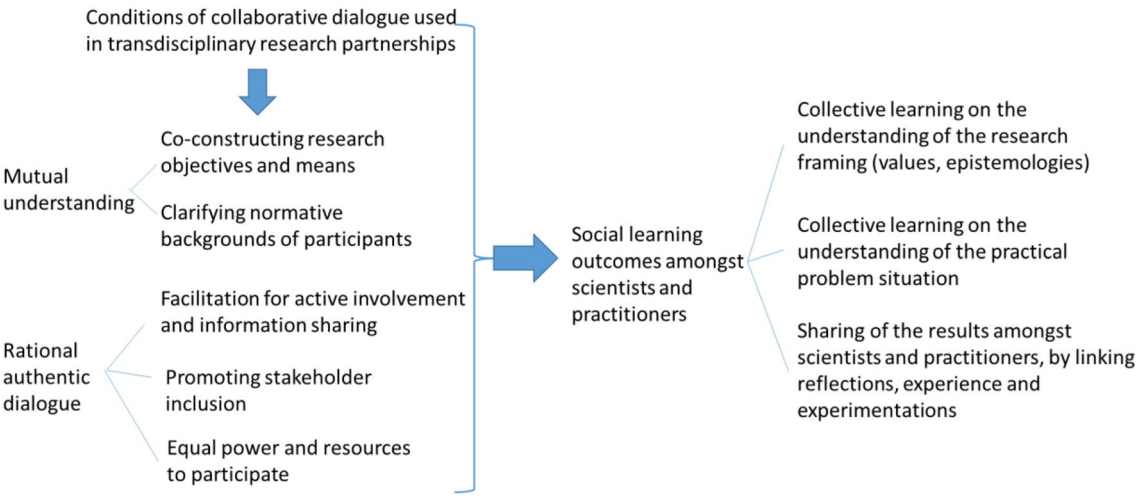

Fig. 1 Conditions for organizing collaborative dialogues (adapted from Innes 2004, p. 7) and their possible impact on social learning outcomes (adapted from Reed et al. 2010, as discussed in "Social learning outcomes") at the end of the project cycle

non-academic knowledge more seriously in various stages of the research process and when deciding upon the selection of the participants and the research methodology. This is especially valuable to allow actors with various background representations and interests to deliberate on the nature and the definition of the research questions as well as on the possible outcomes, objectives and means to reach them (ComMod 2005; Hegger et al. 2012; Cornell et al. 2013). While some projects involve citizens directly, others will only involve representatives of those citizens or at least impacted actors. In sum, a diversity of actors is necessary in the co-construction phase to widen the variety of knowledge inputs and the spectrum of views that allow the problem to be identified in its complexity.

Clarifying the normative background Taking a transformation-oriented research agenda forward in sustainability science requires an inquiry into sustainability values (Miller et al. 2014). Indeed, in its core, sustainability is a fundamental ethical concept, raising questions regarding the value of nature, responsibilities for future generations and social justice (Norton 2005).

As shown by Schmieg et al. (2018), the task of making the normative perspectives explicit is still a new and challenging research field in sustainability science. In particular, to take into account the interactions between various norms, researchers need to address normative requirements at various levels, ranging from the individual level of personal ethics, through the meso-level of organizational and social norms, to the macro-level of broad socio-technological orientations. Such a multi-level approach requires understanding the complexity of normative perspectives both in scientific and extra-scientific discourse.

Importantly, rendering the normative background explicit aims to avoid misconceptions of the process by the participants (Cornell et al. 2013, p. 68). Furthermore, this clarification may contribute to finding a middle ground between the values and preferences held by different interest groups, since they are able to understand each other's perspectives and motivations (Hadorn et al. 2006; Lang et al. 2012). More generally, using symmetrical communication processes and ensuring constant transparency on the respective normative agendas is fundamental to establishing the necessary trustful relationships and the acknowledged legitimacy within the partner team (Höchtl et al. 2006; Pahl-Wostl et al. 2008; Norton 2015).

Creating the conditions of a rational authentic dialogue

The presence of active facilitators Scholarly literature on transdisciplinary research reveals several degrees of intensity in the activity of facilitators. At the lowest degree, facilitators play the role of an active coach, by seeking to involve all the actors in the debate. They intervene in the process for instance through gathering relevant information (Berkes 2009; De Vente et al. 2016) or by observing the exchanges occurring between the affected partners of the process and relaying these observations through reports. At a higher degree, facilitators can be more active by accompanying every stakeholder group in identifying and sharing their knowledge as well as their expectations and interests in relation to the identified common goal (Njoroge et al. 2015; Bieluch et al. 2017, p. 89). In those cases, facilitators can be designated as knowledge brokers (Meyer 2010; Dedeurwaerdere et al. 2015). In this latter role, they can also serve as active conveyers when different actor groups struggle to understand each other, and they can help to stimulate the collaboration when it becomes entangled (Mattes et al. 2015, p. 260). Finally, in some cases, facilitators lead goal-oriented interventions and act as change agents (Wittmayer and Schäpke 2014). This means that they have an active role in the collaboration process by taking initiatives to lead the whole group forward, with the view to drive the process towards the shared goals of the research project.

The presence of Collective Interest Advocacy Organizations (CIAOs) Inclusive representation of the most important stakeholder groups, which promotes the collective interest issues associated with the sustainability problem (labelled hereunder "Collective Interest Advocacy Organizations", CIAOs), is an important factor in improving the social legitimacy of the process. In particular, Collective Interest Advocacy Organizations might participate as non-academic partners in transdisciplinary research, for instance to represent affected populations or to provide expertise based on their involvement in the case. By the term 'collective interest', we refer both to the substantial aspects of the common good promoted by these organizations, such as various local and global public goods, and to the process aspect of fairness and equity in reaching these goals. Therefore, collective interest in the context of sustainability transitions represents not only rights such as animal rights, nature protection or the right to a healthy environment, but also procedural rights that are embodied for instance in basic human rights. CIAOs often focus on one or several specific rights with the desire to make these respected (Conrad and Hilchey 2011, p. 277).

The presence of actors such as CIAOs, with a strong normative orientation towards fostering sustainability transitions, often contributes to encouraging the transformational aspect of the research. Their presence does not mean that they systematically take initiatives and lead interventions, but that they reinforce the consideration of sustainability goals in the research process (Mattes et al. 2015).

Balancing asymmetries in power and resources Various asymmetries in power and resources may constitute an obstacle to social learning. In an academic context, the lack of participation in transdisciplinarity as a research field is often due to a lack of funding for this type of research. However, it might also result from difficulties to publish results that go beyond a single discipline and build a career as a researcher (Lang et al. 2012; Dedeurwaerdere 2013). A lack of resources and time constraints can also impact the way that a transdisciplinary process is led and on its duration (Carew and Wickson 2010). Thus, when starting a transdisciplinary project, it is necessary to pay close attention to the resources (time, money, human resources, and knowledge) available to all the participants. In addition, the research question may be influenced by actors with a strong private normative agenda that is not oriented towards the general interest, or that is not shared by all of the project participants (Berkes 2009; Mattes et al. 2015). Paying attention to stakeholder networks and interests is, therefore, strongly advocated by scholars in transdisciplinary research (Latour 1996; Schön et al. 2007; Fisher et al. 2011; Scholz 2011).

Materials and methods

To better understand the impact on social learning of the various dimensions of collaborative dialogues between researchers and practitioners, our research team led semi-directed interviews in 20 completed or nearly completed research projects in the field of sustainable development considered as transdisciplinary by their main investigators (see Table 1). The interviews were conducted between 22 May 2017 and 11 December 2017.

Projects were selected out of a large population of transdisciplinary projects presented at events of three international research networks: "The 8th International Sustainability Transitions Conference" (2017) in Gothenburg; the "2017 International Trans-Disciplinary Conference" in Luneburg, and the projects gathered under the umbrella "Action Science and Development" of the French Agency for Agricultural Research INRA. Within this population, projects were selected based on the following criteria: (1) projects that were conducted on a territorial scale of a town or a region; (2) initially funded for a time frame of 1–4 years; (3) which involved affected territorial actors with divergent interests and normative backgrounds; and (4) with the aim of producing a societal change or shared knowledge on sustainability issues at stake. The final list of case studies was selected after preliminary research on each case, and after a first, non-recorded, informal discussion. The sample contains both failed and successful social learning processes, evaluated according to the coding scales presented below.

All interviews were coded based on the six levels of performance ('no', 'low', 'medium', 'quite', 'very' and 'extreme'), both for the social learning outcomes and for the process features of the collaborative dialogue (related to the conditions for creating mutual understanding and organizing a rational and fair dialogue).

The construction of the process features was based on the literature review presented above and on the general principles of parsimony (limiting the number of variables to a reasonable amount, as compared to the number of cases) and orthogonality (focusing on criteria that have a high degree of distinctiveness). To maintain a low total number of variables, several distinct, but closely related, features were grouped into a same variable (see "Appendix" for the detailed coding scales):

1. *Openness in the co-construction of the research question*: the more the methodology for collaboration and the collaborative tools allowed the involved practitioners to participate in the framing of the research question, the scientific research method, the objectives and in the selection of stakeholders, the more the process is considered as open to the co-construction of the research question;
2. *Clarification of the normative background*: the more the goals behind the research process were openly discussed through the mechanisms of collaborative dialogue and the more techniques were put into place to exchange about values, to understand each other's perspectives, and to clarify the expectations and views on the normative agenda by influential actors in the problem field, the more the normative background is to have been explicitly clarified;
3. *Activity of the facilitation mode*: the more facilitators had a normative stance for driving the process towards sustainability goals, and the more they led interventions to bring information and ideas to the process, the more the facilitation mode is qualified as active;
4. *Active presence of CIAOs*: the more groups defending the rights of actors and non-humans impacted by the issue at stake were intervening in the process to drive it toward a common good, the stronger is the active presence of CIAOs;
5. *Balancing distribution of power* (*resources/powerful actors*): the more power disparities and resource limitations were kept in balance by adaptation or taking advantage of the situation, the stronger the criterion.

Similarly, the outcome variable "social learning outcomes at the end of the project" was evaluated for every case study according to six levels ('no', 'low', 'medium', 'quite', 'very' and 'extreme') corresponding to the degree of social learning that resulted from the process at the end of the research

Table 1 Overview of the cases (presented by case number). All information refers to the status at the interview date

n°	Name, country, duration, advancement	Researchers partnered with	Conference presentations and articles under review	Published peer reviewed articles
I	Sustainable coffee, Burundi, 4 years, 100%	Farmers, a coffee company and an organic insecticide company to empower workers and produce more sustainable coffee	Rosenberg et al. (2017)	Rosenberg et al. (2018)
II	Land use, France, 3 years, 100%	Breeders, veterinarians and an NGO to test the environmental impact of land use in farming	Lepetitcolin et al. (2015); Lacombe et al. (2016)	Gressier et al. (2013); Hazard et al. (2016)
III	Transition toolbox, France, 4 years, 100%	Agro-stakeholders and regional authorities to co-create a transition toolbox	Bergez and Audouin (2017)	
IV	Forestry conflicts, Thailand, 1 year, 100%	Inhabitants and influent stakeholders to discuss forest management and access to resources through a role playing game		Barnaud and Van Paassen (2013); Barnaud et al. (2013); Barnaud (2013)
V	Hens farming, Germany, 5 years, 65%	Organic farmer cooperative to discuss various forms of hens farming through the creation of an Internet site	König et al. (2015), (2017)	Rogga et al. (2017); Busse and Siebert (2018)
VI	Cultural landscape, Germany, 5 years, 65%	A biosphere reserve and the tourist sector to develop measures preserving the cultural landscape facing climate change	König et al. (2015), (2017)	Rogga et al. (2017); Busse and Siebert (2018)
VII	Merging knowledge, Poland, 1,5 years, 100%	NGO, people with life experience in poverty (PLEP) and social workers to co-produce local and European recommendations to improve the situation of PLEP and practitioners		
VIII	Sustainable heating I, Ukraine, 1,5 years, 100%	A city council, heating companies, NGOs and local stakeholders to reduce pollution due to heating systems	Pereverza et al. (2017a)	Pereverza et al. (2017b)
IX	Sustainable heating II, Serbia, 1,5 years, 100%.	A city council, public heating companies, NGO, consumers, natural gas company, regional chamber of commerce to reduce pollution due to heating systems	Pereverza et al. (2017a)	Zivkovic et al. (2016); Pereverza et al. (2017b)
X	Youth integration, Sweden, 3 years, 75%	An NGO, a municipality, an unemployment office and private actors to coordinate local strategies to provide youth with better social conditions		
XI	Sustainable island, Greece, 4 years, 100%	Environmental NGOs, local authorities, local cooperatives, farmers, lawyers, ministries and other stakeholders to accompany the sustainable development of an island	Noll et al. (2017); Petridis (2017)	Fischer-Kowalski et al. (2011); Petridis (2012), (2016); Petridis et al. (2013), (2017); Petridis and Fischer-Kowalski (2016); Petridis and Huber (2017)
XII	Bottom-up district development, Germany, 3 years, 75%	A bottom-up creative cluster for the city and society's development, a district forum and academic faculties to foster the organisation of district development and local knowledge production	Augenstein et al. (2016); Wanner and Reinkenhoff (2017); Wanner and Best (2017); Hilger et al. (2017), (under review)	Wanner et al. (2018)

Table 1 (continued)

n°	Name, country, duration, advancement	Researchers partnered with	Conference presentations and articles under review	Published peer reviewed articles
XIII	Housing vacancy, Germany, 3 years, 75%	An owner association, inhabitants, municipality and a private actor to reduce housing vacancy	Hilger et al. (2017), (under review)	Rose et al. (2017); Wanner et al. (2018)
XIV	Energy targets, Belgium, 1 year, 100%	Citizens, political actors, private companies and environmental NGOs to co-produce recommendations to make the territory "zero-net energy"	Daccache et al. (2016)	
XV	Power lines I, Germany, 3 years, 100%	Transmission line operators, an NGO, citizens, municipalities and landlords to plan a power line project	Späth and Ceglarz (2017)	
XVI	Power lines II, France; 3 years, 100%	Transmission line operators and citizens to plan a power line project	Späth and Ceglarz (2017)	Späth and Scolobig (2017)
XVII	Power lines III, United-Kingdom, 3 years, 100%	Transmission line operators and NGOS to plan a power line project	Späth and Ceglarz (2017)	
XVIII	Power lines IV, Norway, 3 years, 100%	Transmission line operators, NGOs, energy companies and landlords to plan a power line project	Späth and Ceglarz (2017)	Späth and Scolobig (2017)
XIX	Detecting pollution, France, 2 years, 100%	Various users of a marine environment to co-plan a strategy to detect pollution in the golf area	Dron et al. (2017)	Boudjellaba et al. (2016)
XX	Fostering transition, Germany, 1 year, 100%	NGOs, representatives of municipality and university to co-create a collaborative space for local actors to work on city sustainability		Bernert et al. (2016)

partnership or at an advanced stage at the date of the interview (see "Appendix" for the detailed coding scales). We consider high levels of social learning if

- the collaboration effectively resulted in a challenge of the status quo of the understanding of the practical problem situation (visible through a change in representations of the system, of social norms or power structures), and
- the collaboration effectively resulted in an internal challenge of the research question (visible through a change in epistemological principles, objectives and values that guide the research), and
- the generated knowledge was shared amongst the participating researchers and practitioners in a community of inquiry and practice, visible through outputs that link scientific reflection, practitioners' experiences and social experimentation

Three important limitations of the chosen methodology need to be kept in mind, when analysing the results. First, the coding scheme used in the paper is initially built from an extensive literature review. Nevertheless, after a first qualitative coding of several interviews, these criteria were fine-tuned several times through iteration loops with the information from the cases, to test the parsimony and consistency of the variables and indicators. Second, the interviews might contain some biases related to the specific positions and interests of project Principal Investigators (PI's). Therefore, the information from the audio recordings of the interviews with the PI's and the interview reports was triangulated with project reports and on-line documentation, conference presentations and posters, and published journal articles (see Table 1). All interview reports, and the resulting analysis, were submitted for review to the project PI's (with a 95% response rate on this request for review). Third, the sample selection targeted finalized, nearly finalized or well-advanced long term transdisciplinary research projects, where in depth knowledge of the cases could be gathered. Further, the selection aimed to reach sufficient heterogeneity amongst the cases. However, there was no explicit guidance on a thematic focus. As a result, some fields of sustainability research are better represented then others.

Finally, to respect the confidentiality of the in depth interviews, the article only presents aggregated and comparative research results, or information that can be sufficiently anonymised.

Analysis of the results

The analysis of the 20 case studies using the coding scales allows mapping out the importance of the various drivers of social learning (see Table 2). This section presents the comparative analysis of the sample and discusses the implications of the results.

Social learning outcomes

As discussed in the theory section above, high levels of social learning outcomes of transdisciplinary research projects are associated to both high learning outcomes on the cognitive aspects (assumptions related to values, epistemologies) and high learning outcomes on the practical aspects (re-assessment of the practical problem situation that is the starting point of transdisciplinary research). To qualify as social learning, these outcomes need to become shared knowledge of a community of inquiry (joint reflection) and practice (linkages with life-world experiences and social experimentations).

For instance, case XI "Sustainable Island" has a very high score on social learning. In this case, scientists and practitioners' collaborative dialogues led to a strong reframing of the perceived problems of the Island in relation to long-term sustainability perspective. The result of this reframing also appropriately takes into account the practical real-life problems of the participating inhabitants. Moreover, the process has led to the creation by the inhabitants of a new association dedicated to implementing the shared vision resulting from the project. Similarly, in case XIX, which also received a very high score, the research work on marine pollution leads to considering more long-term sustainable development issues in the Golf of Fos-sur-Mer (France) and on an increased involvement of citizen scientists in collecting data and samples on these issues. Moreover, the involved citizens discussed the results of the analysis of pollution samples with the scientists with the view to jointly evaluating the practical implications and programming of further work.

In contrast, the case XIII on "Housing vacancy" only resulted in low social learning. In this case, even though a common vision emerged amongst the inhabitants, the owner association and the municipality, the process failed to challenge the various sustainability values of the participants. In addition, even though some reciprocal learning occurred between researchers and practitioners, no shared community of inquiry and practice resulted from these learning efforts. As a result, no strong linkages emerged between the common vision, the experience of the problem-situation by the inhabitants and new social experimentations.

Analysis of the contribution of single process criteria to social learning outcomes

Openness of the co-construction of the research question

For the criterion *openness of the co-construction of the research question*, we observed an upward parabolic

Table 2 Overview of the results of the coding (ranked by social learning level)

	Openness of the co-construction of the research question	Clarification of normative backgrounds	Activity of facilitation	Presence of CIAOs	Balancing distribution of power	Social learning
IV	5	6	6	1	6	6
V	6	6	5	5	5	6
XI	6	5	2	6	6	6
XIX	5	5	3	6	6	6
III	4	4	4	2	4	5
VI	6	6	5	5	3	5
VII	3	5	5	3	4	5
XIV	3	3	4	4	5	5
II	5	4	4	5	3	4
IX	3	4	3	4	3	4
XII	3	4	4	6	3	4
XX	4	4	4	6	6	4
VIII	2	4	3	3	2	3
X	5	2	4	5	3	3
I	2	3	6	6	3	3
XIII	3	2	5	1	1	2
XV	1	2	1	1	1	1
XVI	1	2	2	1	1	1
XVII	1	2	1	1	2	1
XVIII	1	2	1	2	1	1

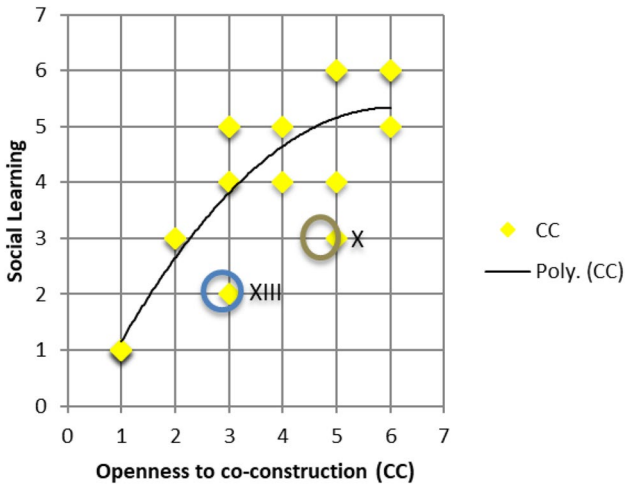

Fig. 2 Distribution of the 20 case studies on the graph indicating the level of *openness to the co-construction of the research question* (CC) in relation with *social learning*

tendency between this criterion and *social learning,* as shown in Fig. 2. Only two case studies XIII (point 3;2) and X (5;3) diverge from this general tendency with an *openness of the co-construction* level higher than *social learning* (see Fig. 2). We did not see any case that reached a 'very' high *social learning* level (≥ 5) with a 'low' or 'no' *openness of the co-construction of the research question* (≤ 2). Further, two cases VII (3;5) and XIV (3;5) had a 'medium' *openness to co-construction* but reached 'very' high *social learning*.

These results show that the more actors were involved in the framing of the various aspects of the research protocol—mainly the research question, the method, the objectives and the selection of possible additional stakeholders—the more they were likely to contribute with new perspectives that foster social learning. For instance, in case V, 'Hens farming' (6;6), the practitioners and the researchers co-selected the theme, the actors to involve and the transdisciplinary method. Additionally, they used a boundary object: the co-creation of a website. This drove the partners to co-explore various forms of hens farming in sustainability, to develop a sense of group feeling and to reframe their strategies several times to reach out to as many actors as possible with the website and diffuse the created knowledge. In case XIX, 'Detecting pollution' (5;6), representatives of fishermen and boaters contacted a research institute to measure the contamination of a golf's recreational area. Together, they reframed the research question several times, co-selected a methodology to collect data on contamination and constantly discussed scientific and political implications. This led to the generation of a contamination map and a citizen-collected database; this allowed a better understanding and trust to be built between the partners (researchers and

boaters organizations) and to create an eco-citizen institute for research on local contaminations.

Nevertheless, cases VII (3;5) and XIV (3;5) show that it is possible to reach high levels of *social learning* even when the *openness of the co-construction of the research question* level is medium. For instance, in case VII on 'Merging knowledge' with people with life experience of poverty, the empowerment of vulnerable groups was at the heart of the research partnership, but the co-construction of the research question was limited in the initial steps. In the first stages, researchers played a major role in designing the research project, the actors to involve and the method to use. Empowerment came progressively when the vulnerable groups realized that they were truly listened to and that they could contribute and ask for changes within the transdisciplinary process. In this case, we could consider that co-construction came later in the process after a phase of trust building, and still generated a 'very' high level of *social learning*. Conversely, the cases X (5;3) and XIII (3;2) show that the *openness of the co-construction of the research question* is sometimes not sufficient to reach high levels of *social learning*. Even though the general trend is consistently in the upward direction, these exceptions indicate the need to look at other criteria and to explore how these may interact with the co-construction process. In particular, these latter cases have a very low score on two other criteria that play an important role in promoting social learning (*clarification of normative background* and *rebalancing of power asymmetries*), as it will be shown below.

Clarification of the normative background

For the criterion *clarification of the normative background*, we observed an increasing linear tendency with the *social learning* level (see Fig. 3). Only one point, XIV (3;5), diverges from this general tendency. However, overall, the more the background was clarified, the higher were the chances to reach a high level of *social learning*. Additionally, we did not see any cases that reached a 'very' high *social learning* level (≥ 5) with 'no' or 'low' 'clarification of the normative background' (≤ 2).

The observed relationship indicates that *social learning* is promoted when the partners of the transdisciplinary research can openly discuss the normative goals that are pursued by the social actors in the problem situation, and when various tools are used to exchange about these normative perspectives. In case IV, 'Forestry conflict' (6;6), the initiators were very clear about their objective to empower vulnerable groups. Thanks to this clarification, actors could decide whether or not to be involved in the partnership. This constituted a basis for trustful interactions between the involved actors, who realized that they had common interests and needed to collaborate with each other to solve the

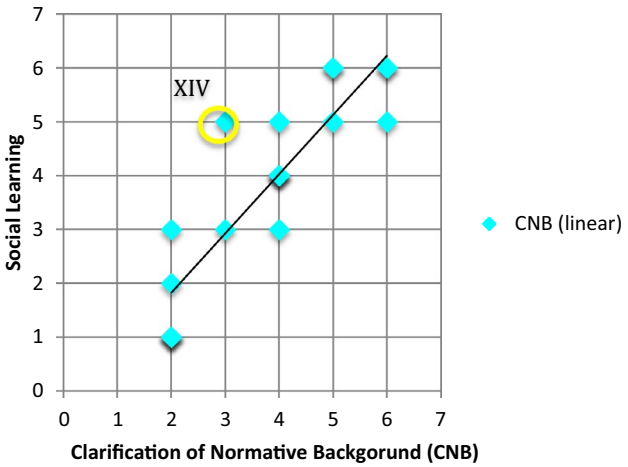

Fig. 3 Distribution of the 20 case studies on the graph indicating the level of *clarification of the normative background* (CNB) in relation with *social learning*

forest management issues. In this case and others, the use of role-playing games to simulate various agricultural models based on various value systems can contribute to the clarification of normative backgrounds. For instance, in the case V 'Hens' (6;6), the role-playing game not only allowed farmers to test various breeding systems, but also gave them the space to express their concerns when being confronted with alternative ones. While potentially contributing to a change in visions over farming, the game reinforced the trust and team building between partners.

Nevertheless, case XIV on 'Energy targets' (3;5) illustrates a case with a 'very' high level of *social learning* but a 'medium' *clarification of the normative background*. Indeed, in this case, the lack of clarification drove to some misunderstandings concerning the extent to which the current strategic orientations of the regional authorities could be challenged. However, from this misunderstanding, the participants developed a strong group identity and cooperated to propose policy recommendations that were more adapted to their territory within the long-term timeframe of climate change than policy makers had initially envisaged. At the same time, this case ranks high on all the other criteria, which may contribute to the high social learning observed.

Activity of the facilitation mode

The results show no general relationship between the criterion *activity of the facilitation mode* and the *social learning* level, with some clear cases of 'very' high level of *social learning* in spite of 'low' *facilitation activity* and the reverse. In particular, three clusters appear (see Fig. 4):

- The first cluster of isolated cases gathers the cases XI (2;6) and XIX (3;6), which reached an 'extremely' high

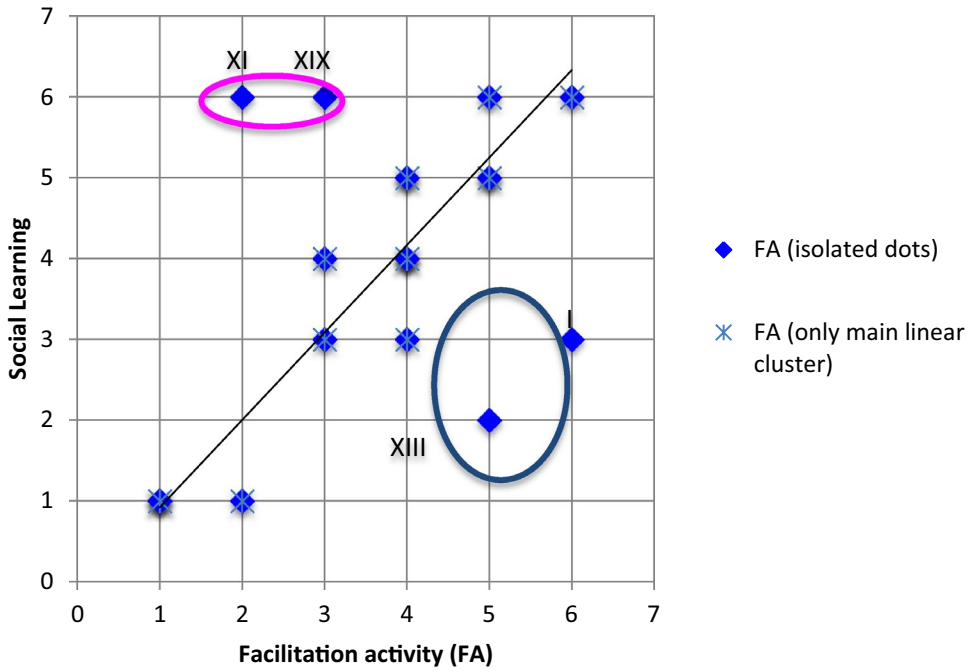

Fig. 4 Distribution of the 20 case studies on the graph indicating the level of facilitation activity (FA) in relation with social learning

social learning level despite 'low' and 'medium' levels of *facilitation activity*.

- The second cluster of isolated cases is formed of the cases XIII (4;2) and I (6;3), which had high levels of *facilitation activity* (≥ 5) but did not reach high levels of *social learning* (≤ 3).
- A sub-cluster of the remaining 16 case studies with a positive linear relationship between the *facilitation activity* and the *social learning* levels.

While looking at those clusters in detail, the cases XI 'Sustainable Island' and XIX 'Pollution detection' show a weak level of facilitation activity by the researchers who officially held this role. At the same time, these cases rank very high on all the other criteria, which compensates for this weakness (cf. Table 1). In particular, these cases are characterized by the presence of certain collective interest organizations that took a strong normative stance during the process.

In the cases that constitute the second cluster, facilitators had a strong stance over the form that the process should take, but they did not manage in fully empowering the affected actors and involving them in the social learning. In the case I 'Sustainable coffee', facilitators were researchers who pre-identified what sustainability should look like; their vision remained dominant throughout the process. In case XIII 'Housing vacancy', the facilitator also had a strong vision of sustainability, and the lack of financial resources and strong constraints of time, lack of participation and lobbying from influential actors drove the facilitator to adopt an extremely directive facilitation mode.

The remaining cluster supports the hypothesis of an increasing linear relationship between the *facilitation activity* and *social learning*. For instance, in cases IV (6;6) and VII (5;5), the facilitators had a strong stance on the transdisciplinary process and led many of the interventions. In both cases, they intended to empower disadvantaged groups. In the case IV on 'Forestry conflict', the facilitators sought to bring the various actors on a common ground where they acknowledged their common interests; developed a trustful group feeling; questioned the place of powerful actors and of the most affected actors; and co-explored solutions for the forest management. In case VII on 'Merging knowledge', the facilitators brought the various actors to discuss in plenary sessions and in subgroups composed of their peers to empower the less confident group of participants. For this group, separate workshops were organised to support a subgroup (persons who experienced poverty) in parallel to the general transdisciplinary process. Throughout the process, the groups of actors not only co-produced political recommendations but also changed their visions and representations about the other groups, to the point of becoming friends. The subgroup of socially vulnerable persons took initiatives by making suggestions and requests to the NGO to improve its functioning.

However, too few cases were observed in this third cluster to draw a strict conclusion on the relationship between the *facilitation activity* and *social learning*, and the numerous outliers indicate that the criterion *facilitation activity* should probably be deconstructed into a subset of criteria, within a research protocol with a larger number of cases. Some

indications in that direction are given in the discussion section below.

Active presence of collective interest advocacy organizations

The analysis of the criterion *active presence of collective interest advocacy organizations (CIAOs)* reveals two clusters of cases (see Fig. 5):

- The first cluster gathers cases with a 'no' or 'low' *presence of CIAOs* (≤ 2). Six reached 'no' and 'low' levels of *social learning* (≤ 2): XV (1;1); XVI (1;1); XVII (1;1); XVIII (2;1) and XIII (1;2). Two other cases show high levels of *social learning* (≥ 5), case IV (1;6) and III (2;5).
- The second cluster gathers the cases where CIAOs were at least involved at a 'medium' level (≥ 3). In this cluster, case studies are spread sparsely on the graph, but with at least a social learning level ≥ 3.

As shown by these results, the lack of an *active presence of CIAOs* corresponds both to cases with no *social learning* and with substantial *social learning*. For instance, in case III 'Transition toolbox' (2;5), the partners in the transdisciplinary research process managed to reach a 'very' high level of *social learning* despite the 'low' *active presence of CIAOs*. In case IV, 'forestry conflicts', a well-balanced and active facilitation, in particular empowering the disadvantaged group to participate actively, drove the process to an 'extremely' high level of *social learning*.

On the other hand, all the cases with a high *active presence of CIAOs* (≥ 3) reached at least a 'medium' level of *social learning* (≥ 3). These results are interesting because CIAOs are often mobilized for the socio-ecological transition through NGOs or groups of affected actors (Portney 2013). This result indicates that their presence, above a certain threshold, may ensure a minimum level of *social learning* in the process. This may, therefore, encourage powerful actors to engage with civil society and disadvantaged groups in transformation processes and to accept the role that the latter have to play (Barnaud and Van Paassen 2013). Nevertheless, there is no further systematic relationship, which indicates that other factors play a larger role to increase the *social learning* beyond this minimum level.

Balancing the power distribution (resources/powerful actors)

The relationship between an increase in *active balancing of the power distribution* (in relation to resources and/or influence of powerful actors) and *social learning* reveals an upward parabolic tendency (see Fig. 6).

Several of the analysed cases illustrate the importance of *balancing the power distribution* for preventing the blockage of the *social learning* processes. For instance, interviewees in two cases mentioned an unanticipated lack of resources and time constraints as the most restrictive barrier to the process. The latter affected both the implementation of the selected transdisciplinary methods and the building of trustful relationships (cases XII and XIII). In two other cases, the interviewees insisted on how much the balancing of the power asymmetries would have been hampered without these resources (cases V and VI). In case XIV on 'energy targets', a participant tried to drive the process to their own

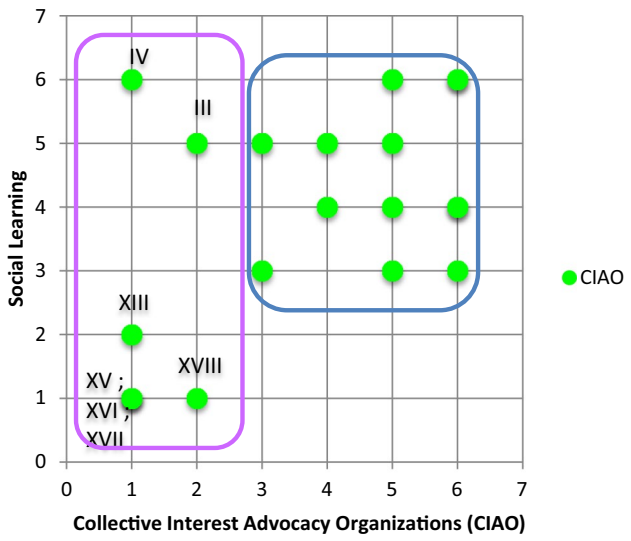

Fig. 5 Distribution of the 20 case studies on the graph indicating the level of *active presence of collective interest advocacy organizations* (*CIAOs*) in relation with *social learning*

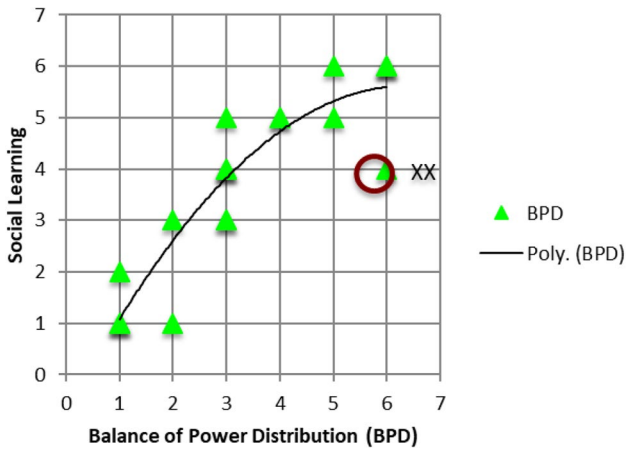

Fig. 6 Distribution of the 20 case studies on the graph indicating the level of *balancing of the power distribution* (*BPD*) in relation with *social learning*

advantage, but the participants affected by the issue at stake rejected them for not being "part of the group". This active intervention also led the group to clarify their roles and their common goal. Case XX is an exception to the overall trend, as one would expect a high level of social learning. However, in this particular case, there was at the beginning of the project already a very high level of homogeneity and in depth understanding of all the members of the project team on the sustainability concepts and the understanding of the practical problem situation. So there were very few learning needs amongst the participants.

In some other cases, a powerful actor drove the entire process (case I, XV, XVI, XVII, XVIII), with detrimental effects on *social learning*. For instance, in case XV on the research on 'Power lines Germany', a group of actors from civil society exercised the main influence over the process and disrupted it. Although the various cases faced different issues and challenges, the criterion shows a robust impact on *social learning*.

Combining the criteria to promote *social learning*

The analysis of the individual criteria revealed case studies that diverged from the general observed trends. In many cases, this was related to a low performance on the other criteria that showed a consistent positive relationship with *social learning* in transdisciplinary partnerships. To better understand those specific cases, we combined the results of the three criteria that show a systematic positive relationship with *social learning*: *openness of the co-construction of the research question* (referred as *CC*), *clarification of the normative background* (referred as *CNB*) and *balancing of the power distribution* (referred as *BPD*).

The results show a robust linear relation between the sum of the three criteria and *social learning* (see Fig. 7). This means that the cases which were divergent from the general tendencies in the individual criteria analysis can nevertheless generate strong *social learning* if they have a strong performance on the two other criteria. For instance, case VI (15;5) had 'medium' level of *balancing of power distribution* but reached a 'very' high level of *social learning*. Indeed, it presented 'extremely' high levels of methodological *openness of the co-construction of the research question* and *clarification of the normative background*. Cases III (12;5), VII (12;5) and XIV (11;5) indicate that a combination of 'medium' to 'very' good levels of the three criteria may also allow to reach a 'very' high *social learning*.

Case X (10;3) and XIII (6;2) indicate that medium–strong *openness of the co-construction of the research question* alone do not allow to fully compensate for lower levels of *clarification of the normative background* and *balancing power distribution*.

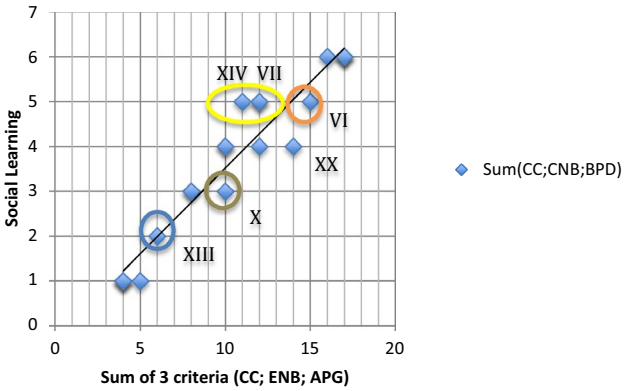

Fig. 7 Distribution of the 20 case studies on the graph indicating the sum of three criteria [*openness of the co-construction of the research question* (*CC*); *clarification of normative backgrounds* (*CNB*) and *balancing of power distribution* (*BPD*)] in relation with *social learning*

Discussion

The comparative analysis of the 20 transdisciplinary research projects supports the hypothesis that a strong combination of three criteria (*openness of the co-construction of the research question*, *clarification of the normative background* and *balancing the power distribution*) increases the *social learning* level. Moreover, as illustrated in the Figs. 2, 3 and 6, *clarification of the normative background* had the strongest correlation with social learning, followed by the *openness of the co-construction of the research question* and the *balancing the power distribution*. The participatory dimension and the active facilitation on the contrary are not systematically increasing social learning.

These results of the comparative analysis are in line with the analysis of various possible roles of participation in transdisciplinary research (Bieluch et al. 2017), and they are consistent with the lessons from the general literature review by Hadorn et al. in the *Handbook of Transdisciplinary Research* (Hadorn et al. 2008). As underlined in the *Handbook*, mutual learning on life-world perspectives from practitioners and scientists is considered by most authors as an essential process feature to achieve transdisciplinary knowledge integration, while the role of stakeholder participation is much more debated (Ibid., p. 29).

At present, no fully developed framework exists for systematically addressing the challenge of normative clarification in transdisciplinary research partnerships. However, for effective social learning to happen, participants need to clarify the normative backgrounds early on in the research process. Some well-known tools can be adapted for such an early normative assessment in transdisciplinary research processes, such as collaborative scenario building and evaluation (Brand et al. 2013), ex-ante discussion of desirable

and undesirable impacts (Pohl and Hadorn 2007, p. 59) or analysis of opportunities for policy evolution and innovation (Reichardt and Rogge 2016; Schmidt et al. 2012).

Many scholars have analysed the various dimensions and features of co-construction of research questions in transdisciplinary research. Lang et al. (2012) review possible solutions to the various obstacles encountered in co-construction processes in transdisciplinary partnership researches. Some of the design principles summarized in this paper can readily be adapted to improve co-construction processes (Ibid., pp. 29–35). First, successful co-construction requires the building of common language, objectives and understanding in the team of researches and stakeholders, to make the process truly collaborative. Second, to reach knowledge that is both relevant and credible for real-world problem solving, participants should assign early on clear roles to the different researchers and stakeholders according to their knowledge and practical/theoretical expertise. Third, evaluation criteria should be defined that both address the scientific and the societal dimensions of the problem situation.

The analysis of power asymmetries in the research partnerships shows the importance of a continuing awareness by all participants of potential distortions that can arise from unequal access to resources and influence. Indeed, the actions to undertake for rebalancing power are not limited to actions for fostering symmetry amongst the participants, such as in the case of the intervention of a neutral facilitator or through constructing a common reference to values in the general interest. In addition to this recourse to well-known tools to enhance power balance, creating more transparency for those power asymmetries that are difficult to change, or critically examining the social legitimacy of research demands and objectives formulated by influential civil society or institutional actors, is shown to be equally important (cf. also Barnaud and Van Paassen 2013; Barnaud et al. 2016). In both cases, however, whether it is in a perspective of increasing symmetry or the creation of a better common understanding of residual asymmetries, the collaborative dialogue should allow the participants to construct an adhesion to joint construction and inclusive governance of the research partnership.

The work of Innes and Booher on collaborative dialogues provides some possible explanation of this finding on the participation of collective interest organizations. As underlined in their work, stakeholders in successful collaborative dialogues should not only be diverse, but also they should be interdependent with the view to build reciprocal relationships that is the glue of continuing collaborative work (Innes and Booher 2003, p. 40–42). This condition of interdependency is clearly satisfied in the case of the collaboration between practitioners and scientists trying to understand the same practical problem situation. However, in the case of collective interest advocacy organizations, the stakeholders often do not primarily search for tools to increase understanding, but they aim to increase the social credibility of their message and their impact on policy makers. In the latter case, the mutual interdependency criterion is not necessarily satisfied.

The ambiguous role of active facilitation on the increase in social learning can also be better understood in the light of the scholarly literature. Indeed, as underlined in the introduction, the main social interaction processes in scientific research are based on deliberative processes, which is in line with the third condition of Reed et al. (2010) discussed in "Social learning outcomes". As a result, the scientific researcher's role might overlap with the facilitator's role, as the researcher often intervenes in transdisciplinary research with requests for information transparency and distributing the roles for participants in the process. However, when this is the case, as shown for instance in the work by Michel Etienne on participatory modelling (Simon and Etienne 2010), the role of the "scientist–facilitator" needs to be clearly distinguished from the interventions of the "scientist–expert". Indeed, as shown in his analysis of participatory modelling, the social prestige and the symbolic power of the "scientist–expert" is likely to disturb the neutral position of the facilitator. Similarly, in some situations, such as cases XI (Sustainable Island) and XIX (Pollution Detection), it is not the official facilitator but the CIAOs that took on the role of "change-agent" (Wittmayer and Schäpke 2014), while the official facilitators remained in the passive mediation and information dissemination role. In such cases, it is important to prevent power asymmetries through an appropriate balance between the two roles (Rosendahl et al. 2015).

Nevertheless, to disentangle the precise contribution of these different actors that can play the roles of the facilitator, further in-depth research is needed. In particular, a larger sample would be needed (which would allow to introduce more variables) or a more focused analysis could be developed specifically for the various features of this single criterion.

Some limitations of the research methodology discussed in "Materials and methods" also hint at further research needs. First, as discussed above, the choice of the substantial sustainability topics was left quite open in the sample selection. The resulting sample is mainly focused on sustainability issues related to territorial transition processes, agriculture and forestry, and environmental problems. Other issues, such as ecological modernization and change in consumption behavior remain underrepresented. Further research is needed to see if the findings of this paper also apply to the latter fields where issues of large-scale capital investment and up-scaling of behavioral change play an important role in fostering sustainability transitions. Second, additional research is needed to further analyse the actor networks that drive the projects, beyond the role of the project

principal investigators. Such research on the actor networks might shed some more light on the possible role of project funders in monitoring the implementation of some of the process criteria identified in this paper, the strategies available to researchers to better articulate their participation in transdisciplinary research to existing and new curricula, and the capacity building features of research centers and associations.

Conclusion

The analysis of 20 case studies according to five process criteria identified in the literature allows for a deepening of our understanding on how it is possible to enhance social learning in the design of transdisciplinary research. The general activity level of facilitation did not reveal any systematic relationship to enhance social learning. On the other hand, the active presence of normative actors pushing toward issues of collective interest is consistently correlated with a medium level of social learning, but achieving higher levels remains dependent on a series of other factors. In contrast, the openness of the co-construction of the research question, the clarification of the normative background and the balancing of power distribution (in relation to access to resources or influential actors) are systematically related to higher levels of social learning, especially when these criteria are combined. The strongest relationship amongst these three factors is observed with the criterion *clarification of normative background*.

While some of the results of the systematic comparative analysis in this paper are only indicative in view of the sample size of 20 case studies, the analysis nevertheless strongly supports the hypothesis that a combination of co-construction methods that explicitly address normative agendas and an appropriate governance to balance power distribution (time, money, human resources, knowledge or influence) provides a robust mechanism for fostering social learning on sustainability issues through transdisciplinary research. An interesting path to take the research agenda of this paper forward is, therefore, to investigate the combination of these criteria, by examining the temporal process of their interaction and occurrence in the research process in single-level case studies, or using the results of this exploratory research to build larger sample surveys.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Appendix: Criteria and coding scheme

Criteria	Level
Openness of the co-construction mode	Participating actors were co-selected by the various affected actor groups, the method to adopt was co-selected by those groups, they discussed together the objectives through a lot of workshops and alternative tools than discussion have been used (such as picture representations, narratives, etc.) = extremely open (6) Participating actors were co-selected by the various affected actor groups, the method to adopt was co-selected by those groups, they discussed together the objectives through a lot of workshops, no specific technic to go beyond the tool of discussion OR One specific actor group initiated the process and selected the actors to involve, the method to adopt was co-selected by those groups, they discussed together the objectives through a lot of workshops and alternative tools than discussion have been used = very open (5) One specific actor group initiated the process and selected the actors to involve, the method to adopt was co-selected by those groups once selected, workshops to co-define and discuss research questions = quite open (4) One specific actor group initiated the process and selected the actors to involve, the method to adopt was selected by a specific actor group, but workshops to discuss and co-reframe a research question OR group of affected actors co-selected the participating actors and method to adopt but research question quite framed by a specific actor group = medium openness (3) One specific actor group initiated the process and selected the actors to involve on a really selective way, the method to adopt was selected by a specific actor group, the organization of the workshops to discuss a research question already framed by the researchers = low openness (2) One specific actor group initiated the process and selected the actors to involve in a really selective manner, the method to adopt was selected by a specific actor group, workshops to get information from non-expert groups on a question already framed, mainly use of data from questionnaires or interviews and no real discussion workshops = not open (1)
Clarification level of the normative background	Normative orientations and agendas openly discussed and use of tools to make actors understand each other's viewpoint, history etc. = extremely explicit (6) Normative orientations and agendas openly discussed and clear attention to explicit them all along the process = very explicit (5) Normative orientations and agenda openly discussed in some phases and was quite explicit but some elements were not clearly made explicit because judged not necessary OR this clarification was not the first priority of the transdisciplinary process even though judged really important = quite explicit (4) Normative orientation and agenda was quite explicit but many elements were sometimes not explicit enough = medium clarification (3) Normative background and agenda from any actor seem not really explicit, but not clearly hidden by any of them neither = low clarification (2) Normative background from most actors remained hidden, purposely or not = not explicit (1)
Activity level of the facilitation mode	Facilitators have strong normative stance shared with the practitioners and lead a lot of interventions to involve the participants, drive the transdisciplinary process towards a goal that has been co-defined = extremely active (6) Facilitators have a strong normative stance shared with the practitioners and lead intervention when necessary to bring the project forward in the collaboration process toward this goal OR Facilitators do not have a specific strong stance but lead a lot of interventions by researching and provide information and space for discussion = very active (5) Facilitator do not have a strong stance on the shared goals (or try not to show it) apart from making the collaboration process happening democratically, leads interventions to involved the participants when necessary = quite active (4) Facilitators do not have a strong stance apart from making the collaboration process happening democratically, no strong interventions as proposing ideas = medium activity (3) Facilitators do not have a strong stance in the process, do not lead intervention and are passive to answer the demand of practitioners and ensuring speaking turns = low activity (2) Facilitators are really open to any stance that the project can take, do not lead interventions and are passive to answer the demand of practitioners and ensuring speaking turns = not active (1)
Presence of collective interest advocacy organizations (labeled: CIAO)	CIAO initiated the project, led a lot of interventions, and drove interventions for a follow-up of the process toward "collaboration for common goals in the general interest" (labeled below: CG) = extremely strong presence (6) CIAOs initiated the project, led a lot of interventions but reduced their interventions after a certain period (often realized that their vision was not creating a process towards CG) or did not propose a specific follow-up; or CIAOs did not initiate the project but use the project as a way to lead a lot of interventions for CG and propose to lead interventions for a follow-up process = very strong presence (5) CIAOs did not initiate the project but use the project as a way to lead interventions for CG, but do not propose to lead interventions for a follow-up process; or good collaboration in the project without specific presence of CIAOs during the process but CIAOs propose to lead an intervention for a follow-up project = quite strong presence (4) No actor was strongly pushing to reach CG initially but empowerment appeared and some actors decided to push more and get more active for CG but did not propose a follow up; or low amount of non-influential actors tried to be CIAOs but did not manage to influence strongly the all group by their vision = medium presence (3) No actor strongly pushed to reach CG but some common collaboration accepted by all and efforts made from involved actors to bring the project forward without leading interventions = low presence (2) No actor was specifically pushing the process to reach CG, most actors were focused on their interest = no presence (1)

Criteria	Level
Balance of power distribution (BPG)	Good management of the process by availability of the resources (time, money, knowledge or participation) to all and well-thought strategies to balance power distribution = extremely good balance (6) Good management of the process by availability of the resources to all, strategies to balance power distribution but some powerful actors involved have had a larger influence on the orientation of the goal (ex. policy based or action based) or resources have lacked for a follow-up project; or no specific need for balancing any power imbalance = very good balance (5) Good management of counter-influential actors but one resource (time, money, knowledge or participation) was limiting the process for some actors and some powerful actors involved have had a larger influence on the orientation of the goal or some resources (time, money, knowledge or participation) were limiting the process for some actors but the project adapted to this limitation = quite good balance (4) Good management of some resources but some non-influential actors tried to influence the project to their advantage; or no specific counter-influential actors but some resources limiting and preventing from a follow-up project = medium balance (3) No specific actor tried to influence the project to their advantage but some resources were very limiting for some actors and no strategy found to counter that; or many or powerful actors tried to influence the project to their advantage and resources were not too limiting and no strategy found to counter that = low balance (2) Very strong constraints in terms of different resources (time, money, knowledge, participation), an actor obstructed the process or an actor even prevented the process from happening and no strategy found to counter that = no balance (1)
Social learning level	Challenge of the status quo of the understanding of the practical problem situation [visible through a change in representations of the situation (the causal relationships, the social norms, the power structures)] + internal challenge of the research question (epistemological and questioning of research objectives and sustainability values) + social sharing of the results amongst researchers and practitioners (by linking scientific reflection, practitioners experience and social experimentation): all present to a high degree or more = extremely good social learning (6) Challenge of the status quo of the understanding of the practical problem situation + internal challenge of the research question + social sharing of the results: some present to a moderate degree or more and with an average score over the three criteria of high learning = very good social learning (5) Challenge of the status quo of the understanding of the practical problem situation + internal challenge of the research question + social sharing of the results: all three criteria fulfilled to some degree and with an average score over the three criteria of moderate learning = quite good social learning (4) Challenge of the status quo of the understanding of the practical problem situation + internal challenge of the research question + partial social sharing of the results: all three criteria fulfilled to some degree, but only weak social sharing of the results (third criterion) = weak social learning (3) None of the aspects changed, but real collaboration existed to initiate the learning process on the change in understanding of practical problem situation and research questions = very low social learning (2) None of the aspects = no social learning (1)

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