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Ten Reflective Steps for Rendering Research Societally Relevant

While the goal of transdisciplinary research is to be relevant to society, specific instructions for accomplishing this remain implicit. We propose to improve this situation by means of a 10-step approach aimed at stimulating explicit reflections around ways to render research more societally relevant.

Christian Pohl, Pius Krütli, Michael Stauffacher

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Abstract
Today, there is an increasing need for researchers to demonstrate the practical value their research can generate for society. Over the past decade, experts in transdisciplinary research have developed numerous principles, methods, and tools for making research more societally relevant. If researchers are unfamiliar with transdisciplinary research, they may miss opportunities to adapt these principles and tools to their research projects. We are developing a 10-step approach for joint use by transdisciplinarity experts and researchers about how to best align their research projects with the requirements of transdisciplinarity. We have successfully applied this approach in numerous workshops, summer schools, and seminars at ETH Zurich and beyond. Ten questions guide discussions between transdisciplinarity experts and researchers around research issues, identify and review the societal problems addressed, identify relevant actors and disciplines, and clarify the purpose and form of the interaction with them. The feedback we have obtained clearly indicates that the 10-step approach is a very useful tool: It provides a systematic procedure for thinking through ways to better link research to societal problem solving.

Keywords
10-step approach, actor involvement, functional-dynamic interaction, interdisciplinarity, science-society interface, sustainability research, teaching, thought styles, transdisciplinarity, wicked problems

How to Go Transdisciplinary

Ten years ago, when we were invited to present the transdisciplinary (td) research approach in PhD schools or at conferences, questions mainly concerned the definition of transdisciplinarity and how it differs from interdisciplinarity or multidisciplinarity. A few years later, the questions had changed and focused on how td research should be conducted, and how to align other types of research projects with the td approach. This shift of interest required a different kind of contribution, one that would act as a bridge between td research methods and other research projects. A number of publications provide general transdisciplinarity principles and present case studies (Pohl and Hirsch Hadorn 2007, Hirsch Hadorn et al. 2008, Carew and Wickson 2010, Lang et al. 2012), or provide guidelines for research for sustainable development (Wiesmann and Hurni 2011, Pintér et al. 2012, Helming et al. 2016). In addition, methods and tools have been proposed regarding how to address specific challenges of td research (Bergmann et al. 2012, Gaziulusoy and Boyle 2013, Vogel et al. 2013). The online toolboxes described in *GAIA's* series on *Toolkits for Transdisciplinarity* present such methods regularly (e. g., Bammer 2016). The problem with these abstract principles and practical tools is that researchers who are not familiar with td research do not know how to adapt or integrate them to their research project. How and by whom could this integration and adaptation be accomplished?

In 2011 two of the authors held a summer school on td research at the TsamaHUB Centre of the University of Stellenbosch in South Africa. We were invited as transdisciplinarity experts to help align PhD candidates' and postdocs' research projects with the principles and practices of td research. We decided to organize >

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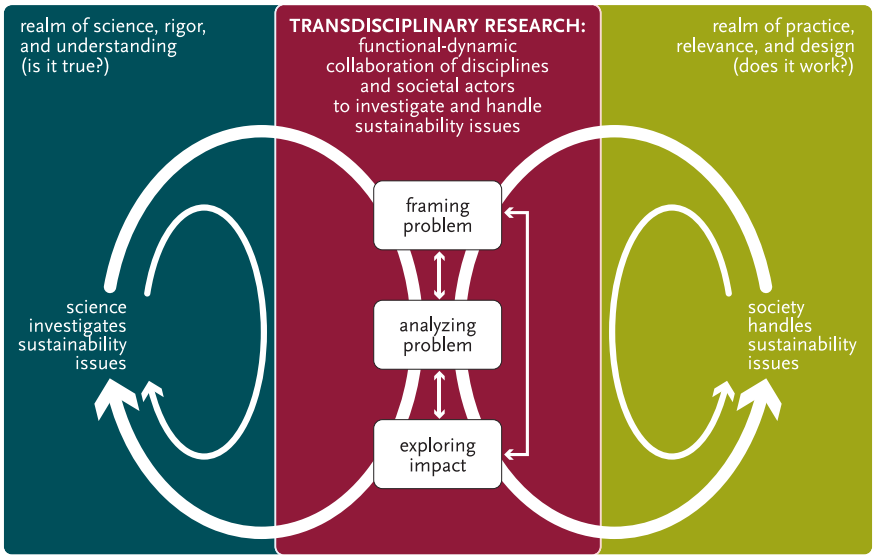

FIGURE 1: The transdisciplinary research process connects scientific knowledge production and societal problem handling (larger round arrows). Often the two processes are not explicitly related (smaller round arrows). The transdisciplinary research process consists of the stages of framing the problem, analyzing the problem, and exploring the project's impact. Projects run through the stages in different orders (thin straight and angled arrows). During these stages researchers of different disciplines collaborate and involve societal actors in a joint research and learning experience. The intensity of collaboration and involvement is functional-dynamic, i. e., it varies depending on the purpose of the specific stage (figure 4, p. 50). Two rationalities (thought styles) meet and have to be balanced in this process: the thought style of science searching for truth and the thought style of practice interested in workability (based on Bergmann et al. 2005, Pohl and Hirsch Hadorn 2007, Krütli et al. 2010, Jahn et al. 2012); see also *www.transdisciplinarity.ch/e/Transdisciplinarity*.

the integration and adaptation tasks as a co-production of knowledge by both the researchers and the transdisciplinarity experts. The research question of each project was the starting point: first, the researchers were asked to think about how their research question related to the societal problem they wanted to help solve. Second, they were to reflect about which disciplines and what societal actors should be involved to help embed the project in science and society. To make the process interactive, we alternated between short theoretical inputs and longer phases during which participants related what they had just heard to their own research projects. We provided the participants with flipchart sheets and asked them to document their reflections about the steps we went through.

In Stellenbosch, this process consisted of six steps and it took a week. In the meantime, it consists of ten steps and we are able to carry it out in one day. We have used the 10-step approach widely. It is part of the CCES (Competence Center Environment and Sustainability) winter school *Science Meets Practice* (Stauffacher et al. 2012) as well as of our *Seminar on Transdisciplinary Research for Sustainable Development* at ETH Zurich. We have used it with td research, with applied and (use-inspired) basic research projects, with PhD students from natural science, social science and humanities, as well as with researchers from international research programmes. The 10-step approach goes beyond the above-mentioned tools and adds to approaches like Schiffer and Hauck's *Net-Map* (2010) in three respects: 1. it connects the analysis of how a research question relates to a societal problem with reflections about the disciplines and the societal actors that are or ought to be involved, 2. it facilitates analyses not only of the societal actors in terms of their power, interests, and expertise, but also of the researchers from various disciplines, and 3. it provides a structure for a joint reflection by transdisciplinarity experts and researchers about their projects.

The presentation of the 10-step approach is structured as follows. First, we briefly outline our understanding of the td research process. We then present for each step 1. how we introduce it, 2. what we ask researchers to do, and 3. what we expect them to learn. To conclude, we briefly review our previous experiences.

The Transdisciplinary Research Process

When we developed the 10-step approach we were guided by a specific understanding of the td research process. This understanding was not stable, but evolved over the last decade. Before we start with the ten steps, we usually convey this understanding to the participants and compare it to more linear concepts or models of the science-society linkage, such as technology transfer, speaking truth to power (Wildavsky 1987, Jasanoff and Wynne 1998), or public understanding of science (Lewenstein 2002).

Building on the work of Bergmann, Jahn and colleagues (Bergmann et al. 2005, Jahn et al. 2012), we understand the td research process as an attempt to link two processes of knowledge production: 1. a societal process, in which actors try to understand and tackle a particular societal issue, 2. a scientific process, in which scientists design and conduct research on the societal issue. In figure 1 this societal issue is sustainable development.

We reframed the societal process as the realm of "practice", emphasizing the rationality of relevance and workability (see figure 1, right side). The challenge of a td research process is to provide links between "science" and "practice". This is necessary because researchers and practitioners typically perceive and handle sustainability issues by different rationalities – in the words of Ludwik Fleck (1979), by different "thought styles".

The scientific thought style (see figure 1, left side) is driven by questions about how things are and how they function, for example, whether a statement about climate change is true and whether it is based on rigorous argumentation and evidence. Although truth and rigor are key elements of research, disciplines might have different perceptions of what they exactly mean, how closely

they can be approximated, and what is seen as acceptable evidence for truth. In addition, disciplines rely on diverse ways of producing evidence, such as standardized controlled experiments, models fitted to historical data, mathematical proofs, series of interviews that are stopped if information reaches saturation, or arguments that are true if they follow the rules of formal logic.

Society is designing solutions for a societal issue – like an energy or transport system – in the thought style of practice. Here the question is not "Is it true?" but "Is it the right approach to the issue at stake?" and "Does it work?". Sub-groups of society will answer these questions differently. Rittel (1971) calls such design problems "wicked" or "ill-behaved". They are wicked because:

"For design problems there is no criterion which would determine whether a solution is correct or false. These are meaningless labels which cannot be applied to solutions of design problems. Plans are judged as good, bad, reasonable, but never correct or false. And a plan that looks good to Mr. A may be most objectionable to Mr. B." (Rittel 1971, p. 19).

Recently scholars in the field of sustainable development have started to conceptualize societal issues as "wicked problems" in Rittel's sense (Brown et al. 2010, Pintér et al. 2012, Neßhöver et al. 2013, Gaziulusoy et al. 2016). For instance, Mr. A could regard nuclear energy as a means against global warming, while Mrs. B could be mostly concerned about the nuclear waste problem. Mr. A and Mrs. B do not differ in their assessment of the solution because one is right and the other wrong, but because they value certain aspects of the solution differently. Both persons base their assessment on their specific rationality or thought style.

The 10-Step Approach

The purpose of the 10-step approach is to critically review to what degree and in what way(s) a research project is embedded in the realms of science and practice. The steps are organized into three main stages (see table 1):

TABLE 1: Overview of the 10-step approach.

STEP	DESCRIPTION	RATIONALE	MIGHT LEAD BACK TO STEP
	MATCHING RESEARCH QUESTION AND SOCIETAL KNOWLEDGE DEMAND		
1	Formulate a research question and classify research as basic, applied, or transdisciplinary.	This step helps the researchers to recognize that there are two different realms, and that positioning one's own research between them might cause tension.	
2	Distinguish between research question and societal problem; make links between both.	This step makes the researchers reflect about what the societal problem actually is, and if and how their own research contributes to solving a societal problem.	1
3	Specify the societal problem identified in step 2 and relate it to the policy cycle (problem framing/policy development/implementation/evaluation; figure 2, p. 46).	This step makes researchers aware that a societal problem is dynamic, that society is heterogeneous, and that different groups may perceive problems differently. It identifies the (primary) target group(s) the research should address.	1, 2
4	Identify knowledge needed by (primary) target group(s); check whether the knowledge needed is what research may provide.	This step makes the researchers reflect on different forms of knowledge their project could provide, and compare it to the knowledge needed by their (primary) target group(s).	1, 2
	IDENTIFYING DISCIPLINES AND SOCIETAL ACTORS AND PLANNING WHO TO INVOLVE, WHEN, AND HOW		
5	Identify disciplines and societal actors to be involved in the research project.	This step specifies and extends steps 3 and 4 to the world of societal actors and disciplinary researchers. It increases awareness of relevant expertise and decision power available elsewhere.	
6	Clarify the role of societal actors and disciplines vis-à-vis your own research (question); identify paths of interaction (informing, consulting, co-producing).	This step helps the researchers to place their research in a broader context by linking it to other disciplines and societal actors.	5
7	Actor constellation: moderated role-play placing societal actors and disciplines around a research question. The closer the actors/disciplines are to the research question, the more relevant they are for the research.	This step allows individuals and the group as a whole to reflect about the relevance of specific societal actors and disciplines for an exemplary research question.	5, 6
8	Clarify expectations and interests of the societal actors and disciplines involved.	Researchers must substantiate why societal actors and other disciplines need to be involved. This makes the vague notions of involvement and interaction (see steps 5, 6) more explicit and concrete.	5, 6
9	Design a plan on why to involve which societal actors and disciplines at different stages of the research project.	This step encourages reflections about who to involve/collaborate within one's research project depending on the desired societal impacts. It helps to understand that collaboration is dynamic over time.	
	REFLECTING ABOUT THE IMPACT		
10	Think about lessons learned from going through steps 1 to 9.	This step triggers a reflection on the nine steps and their potential impact on one's research work. It helps to identify potential weaknesses in the research project.	

1. The goal of steps 1 to 4 is to match the project's research questions with society's current knowledge base and the need for a solution to the problem.
2. The goal of steps 5 to 9 is to identify the most relevant disciplines and societal actors, and to figure out how they can be involved in the project.
3. Step 10 serves to emphasize the importance of reflecting about the impact of the 10-step approach on the research project.

To trace how the participants implement the ten steps, and to create a starting point for discussing and exchanging reflections, we provide each participant with a flipchart and a pen. We ask the participants to divide the flipchart into ten boxes. To obtain comparable flipcharts we ask them to do this by drawing an empty table with five rows and two columns. We use one cell for every step, starting with the top left cell. Timewise, the exercise usually takes a working day (six to eight hours), depending on how much we elaborate on the theoretical input, and how eager the participants are to discuss.

1 Formulate Your Research Question(s)

Researchers frame sustainability issues through the thought style of a particular discipline, of a particular societal group, or through mixing several thought styles (Wuelser and Pohl 2016). To make participants aware of their own and alternative framings, we discuss how problems are differently framed in basic, applied, and transdisciplinary research according to the typology proposed by Hirsch Hadorn et al. (2006). We furthermore introduce figure 1 and relate it to the three framings: *basic research questions* are usually framed in the scientific thought style, *applied research questions* are influenced by the thought style of practice, and *td research questions* mix both thought styles.

Task

Participants are asked to formulate their research question(s) in a short sentence. They also have to state whether they consider their research question as basic, applied, or td and why they think so.

Learning Outcome

By formulating the research question(s), the participants anchor the ten steps in their own research project. Considering whether the question is framed as basic, applied, or td research helps to position the project in the spectrum from science to practice.

2 Formulate the Societal Problem You Want to Help Solve

The second step asks participants to clearly separate their research question from the societal problem they aim to help solve, and to think about how the research question and the societal problem are connected. Referring to figure 1, we show different paths of how a research question can relate to a societal problem. The following example of basic science linking the left side in figure 1 with the right side may demonstrate this: your research might be on 1. the light-reflection behavior of a particular cloud particle. Your results might be taken up by a 2. climate modeller, who provides new insights for 3. the next IPPC assessment report. This then will change 4. a formulation in the report's summary for policy makers, which might influence 5. the design of the climate policy in your country.

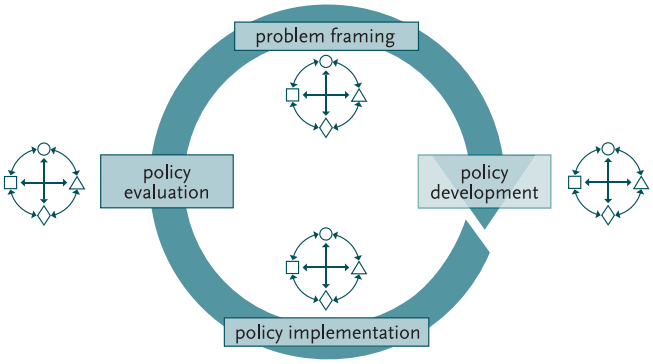

FIGURE 2: A simple four-stage approach to the policy process. A policy process and its outcome is the result of the continuous interplay of actors from the public sector (triangle), the private sector (diamond), civil society (circle) and academia (square) (Wuelser et al. 2012, p. 86).

Task

Participants are asked to document the societal problem they want to help solve with their research. If they do not understand the question, we explain that this is what they usually write in the section *societal relevance* in a research proposal. Furthermore, we ask them to clarify via what path their research will become societally relevant.

Learning Outcome

Learning outcomes differ depending on whether the research is basic, td or applied. Participants conducting (use-inspired) basic research usually describe a general societal problem. For example: a specific gene modification in corn helps to fight world hunger; and society or policy makers (as a fuzzy entity) are in charge of addressing world hunger. Asked to clarify the impact path, participants start to reflect more in detail about who could be interested in the research. In the case of genetically modified corn it might be a company interested in selling corn seeds. In that case the economic thought style becomes important and research that was originally framed from a basic science perspective might be reframed to include aspects relevant from an applied perspective.

For participants considering their projects as applied or td, the intended effect of step 2 is to distinguish between the research question and the societal problem to be solved, or to specify both. In td projects both often seem to be the same at first. Sometimes participants realize in step 2 that what they formulated as research question in step 1 was actually the societal problem, making them reformulate the research question. Such iterations between the steps happen often and we encourage them to allow for more intense learning (see table 1, rightmost column).

3 Specify the Stage of the Policy Cycle

In step 3 participants develop a differentiated understanding of

3

the societal problem identified in step 2. We introduce a four-stage model of the "policy cycle" shown in figure 2. The policy cycle is a simplified model – a heuristic device (deLeon 1999, p. 24) – of a society's process of formulating and implementing a policy. The four most general stages in the policy cycle are: 1. *problem framing,* when society becomes aware of a problem and disputes what the problem is about and for whom it is a problem at all; 2. *policy development,* when discussions start regarding how the problem should be addressed, and what the goal of addressing the problem is; 3. *policy implementation,* when society discusses the policies or measures to be taken, and implements them; and 4. *policy evaluation,* when discussions start about how far the implemented policies help to handle the problem (Jann and Wegrich 2007, Wuelser et al. 2012).

Task

Participants are asked to analyze the policy cycle of the societal problem they identified in step 2 and to describe at what stage(s) it actually is. We make them aware that "society" is a heterogeneous entity, and that it might be more fruitful to answer the question separately for different sub-groups of society. Also, we ask them to think about what knowledge each group needs, given the stage they are at.

Learning Outcome

Participants have to clarify where they think the societal problem identified in step 2 is in the policy cycle. Furthermore, the insight that the policy cycle might be at different stages for different sub-groups of society helps them to specify which of the sub-groups is/are their primary target group(s), as well as each group's knowledge demand.

4

Clarify the Form of Knowledge Required[1]

The goal of step 4 is that participants align the knowledge they produce with the knowledge required by their primary target group(s). For that purpose, we introduce the three types of knowledge as suggested by ProClim (1997):

- knowledge about what is *(systems knowledge)*,
- knowledge about what should be *(target knowledge)*,
- knowledge about how we come from where we are to where we should be *(transformation knowledge)*.

We then go through the stages of the policy cycle and discuss the relevance of each type of knowledge for each stage using climate change as example. During 1. the stage of problem framing, systems knowledge is required to explain how humans change the climate system. For policy development, stage 2, target knowledge becomes important: should we mitigate climate change, should we adapt to it? What is the long-term vision of sustainable development, and who should decide on which path to follow? 3. Policy implementation requires transformation knowledge: what kind of technical, political, educational, or economic measures should be implemented to address climate change? Finally, for policy evaluation, stage 4, systems and target knowledge are required to check whether the policy interventions changed the situation in the desired direction. If needed, the policy cycle starts over again by examining and improving the original problem framing. Note that, in general, all forms of knowledge are involved, but one of them might be of particular relevance for the specific stage.

When going through the stages we explain that depending on the type of knowledge different disciplines are required: (use-inspired) basic social and natural sciences in the case of systems knowledge, the humanities and all kind of assessment methodologies for target knowledge, and policy analysis, engineering, economics, and behavioral sciences for transformation knowledge.

Task

Participants are asked to reformulate the research question(s) from step 1 in three different ways: addressing systems, target, or transformation knowledge. We provide the participants with the following example:

- How does migration affect the sustainable development of rapidly growing cities? *(systems knowledge)*
- How would a sustainable development of rapidly growing cities affected by migration look like? *(target knowledge)*
- What technical, legal, social, cultural, or other means could hinder the negative – and promote the positive – impact of migration on the sustainable development of rapidly growing cities? *(transformation knowledge)*

We furthermore ask the participants to think about which of the three research questions will answer the knowledge demand of the target group(s) identified in step 3.

Learning Outcome

The first effect is that participants realize that their research provides a specific type of knowledge (typically systems knowledge, according to our experiences), and that they could frame their research question differently. Second, the comparison between the knowledge their research provides and the knowledge demand of target groups identified in step 3 fundamentally challenges the framing of their research when both do not overlap. This is, for instance, the case when transformation knowledge would be needed, but the current focus is on systems knowledge.

5

Identify Relevant Disciplines and Societal Actors

In step 5 the participants explicitly name the disciplines and representatives of civil society, the private and the public sector they plan to involve in their project. To start, we introduce Ludwik Fleck's theory of thought styles and thought collectives (Fleck 1979, 2011), and td research as a process of collective learning and exchange between different thought collectives (Pohl 2011). Fleck's thought styles and thought collectives are helpful to realize that what at first >

1 This step is described as the three types of knowledge tool in td-net's toolbox for co-producing knowledge: *www.naturwissenschaften.ch/topics/co-producing_knowledge/methods/three_types_of_knowledge_tool*.

looks like a problem of language and understanding is in fact a mismatch between disciplinary or professional assumptions about how reality should be framed and what the relevant or irrelevant aspects are.

Task

Participants are asked to write down the six to ten most important societal actors and/or disciplines for their project. We remind them that disciplines and societal actors can be relevant for several reasons such as their interest, power, or expertise regarding the issue at stake or the project (Reed et al. 2009, Wuelser et al. 2012).

Learning Outcome

Participants become more explicitly aware of who they consider the most important societal and scientific actors for their project. Asking for the six to ten most important societal actors and/or disciplines forces the participants to prioritize. Furthermore, a total of six to ten is a workable number of disciplines and societal actors, also for the remaining steps.

Position Disciplines and Societal Actors in Relation to the Research Question

In step 6 participants make the importance of each societal actor and discipline for their research explicit and describe how they plan to interact with them. To specify the interaction with disciplines and societal actors, we introduce Rowe and Frewer's (2005) distinction of three types of public engagement. Based on the direction of information flow, Rowe and Frewer proposed the following types (each symbolized with a different arrow):

- to inform (→),
- to consult (←),
- to coproduce knowledge (↔)[2].

Task

Participants place the research questions in the middle of cell 6 of their flipchart. They position the disciplines and societal actors identified in step 5 around the research question. The closer the societal actors and disciplines come to the research question, the more relevant they are for the research. And the closer they come to each other, the more they have in common in relation to the research. Once all disciplines and actors are placed, participants are asked to specify the dominant flow of information for each of them. They connect the actors and disciplines to the research question, selecting one of the three arrows introduced above.

Learning Outcome

The step reveals the participants' current mental picture of the most important societal actors and disciplines. Furthermore, the arrows show the intended flow of information, to, or from the disciplines and actors, or the co-production of knowledge.

Carry out an Actor Constellation[3]

In step 7 the group critically reflects one participant's mental picture of the most important actors and disciplines as developed in step 6: we ask for a volunteer willing to present his/her results during a 30-minute role-play session involving about ten participants (figure 3).

Task

1. The volunteer names her/his research question and all disciplines and societal actors identified in step 5. The moderator asks another participant to note each of them on a card. Each of these roles is then assigned to one of the participants.
2. Those playing a role may ask the volunteer questions about the discipline or actor they represent.
3. The volunteer places the participant representing the research question in the middle of the room, and each participant representing a discipline or societal actor around it, according to what s/he has prepared in step 6. The volunteer explains the reasons for the positions assigned to each discipline and actor.
4. Once all the representatives placed, each participant looks for missing societal actors and disciplines. Additionally, the representatives comment on their own positions. The constellation usually changes as a consequence of the evolving discussion.

Learning Outcome

A first clarification takes place when those who play a role are asked whether they know whom they represent (see above, number 2). Typically, this triggers a process of role clarification. For instance, someone might first be designated "the government" and then it becomes obvious that two actors, rather than one, were implicitly assigned this role: the governmental agencies of environment and of energy, for instance.

The second clarification happens when all actors are placed and start to argue about where they were placed. A first effect is, when looking around to see who is involved, that missing societal actors or disciplines are detected. A second effect is that participants start to argue about who is more important for the research and should thus move closer to the research question. A third effect is that actors start asking what benefits (or harms) they would derive from the collaboration. This is because volunteers tend to place actors and disciplines as means to an end, whereas those who play a role reflect on their own reasons of being involved.

Clarify Disciplines' and Societal Actors' Expected Contributions

Step 8 serves to clarify the researchers' expectations concerning the interaction with societal actors and disciplines. Referring to Krütli et al. (2010, p. 863) we introduce the following key questions that should be answered in order to design an adapted interaction format for a project: who initiates the interaction? Who participates? Why participation? Regarding which issues and when? By

2 Rowe and Frewer (2005) call the third type "public participation".

3 This step is described as actor constellation in td-net's toolbox for co-producing knowledge: *www.naturalsciences.ch/topics/co-producing_knowledge/methods/actor_constellation_final*. The term "actor" includes both societal actors and disciplines (scientific actors).

which method(s)? In addition, we introduce Fiorino's (1990) distinction between three reasons for interaction:

- *substantive* (i. e., those to be involved have relevant expertise),
- *normative* (i. e., the democratic principle requires that those affected have a say),
- *instrumental* (i. e., by interaction one hopes for more legitimized decisions).

Task

We ask participants to review the most important disciplines and societal actors positioned in step 6, and for each discipline and actor to specify if interaction is wanted for substantive, normative, and/or instrumental reasons.

Learning Outcome

The step helps in clarifying who should be involved and why. In addition, participants may learn about which scientific or societal actor carries essential knowledge for the project, who might have power to impact relevant societal decisions, or who might lose by certain societal decisions and thus needs to be involved.

9

Plan the Functional-dynamic Interaction

The aim of step 9 is to develop a detailed plan for whom to involve and how. We introduce the functional-dynamic approach to participation as proposed by Stauffacher et al. (2008) and Krütli et al. (2010): no process of a complex decision problem requires a single level of interaction only; it will rather span different levels at different points in time. Therefore, the intensity of interaction between scientific and societal actors depends on the phase, goals, and content of the process and its context. And the various interaction intensities reflect the dynamic involvement of the different groups addressed.

Task

We ask participants to define about ten essential project steps for their research project and then decide for each step what societal actors or disciplinary experts they need or want to interact with and in what way (inform, consult, coproduce). We ask them to sketch the dynamics of this interaction across time (similarly to figure 4, p. 50). We suggest they use distinct lines for different actors and disciplines if the interactions follow different dynamics.

Learning Outcome

A nuanced understanding of the interaction with other disciplines and societal actors emerges: participants start thinking and talking in detail about each of their essential project steps and the potential or need for interacting. This helps to identify possible flaws in the project set-up retrospectively or to plan interaction for subsequent project steps. Set-up flaws may include a lack of interaction at the start of the project when aiming at a shared problem understanding, or too intense and demanding interaction with a too diverse set of disciplines or actors during intensive data analyses or during the paper-writing period. A too intense or broad participation can be rooted in the frequently found belief "the more participation the better". Step 9 seriously challenges this believe and replaces it by a more reflected understanding. In addition, a more efficient and effective set-up for future interaction becomes obvious.

FIGURE 3: Carrying out an actor constellation in Stellenbosch, South Africa. The volunteer (dark blue shirt) and the moderator (light blue shirt) are in the center, the research question (how to improve livelihoods in informal settlements?, grey shirt) is facing the moderator. Around the research question there are two circles of relevant (starting with the women left of the moderator) and less relevant (starting with the man right of the volunteer) societal actors and disciplines. The other participants observe and comment on the exercise.

Think about Main Lessons Learned

10

The aim of the last step is to reflect about how steps 1 to 9 might influence the research project.

Task

Inspired by the most significant change technique (Davies and Dart 2005)[4], we ask participants to think about how the process of working through steps 1 to 9 might change the focus or the procedure of their research. They have to prepare a short statement (one minute max) to share the main insights gained. If time and meeting space allow, this can best be organized as a poster session, so that a lively exchange develops within the group about what everybody learned, and what impact this would have on their on-going and future research.

Learning Outcome

A first effect is that participants realize how different the individual learning insights triggered by the 10-step approach are. A second effect is that we, as the providers, compare our intended learning outcomes with the benefits that the participants derive from the ten steps, helping us to further develop the approach. >

4 This method is described as the most significant change tool in td-net's toolbox for co-producing knowledge: *www.naturalsciences.ch/topics/co-producing_knowledge/methods/most_significant_change*.

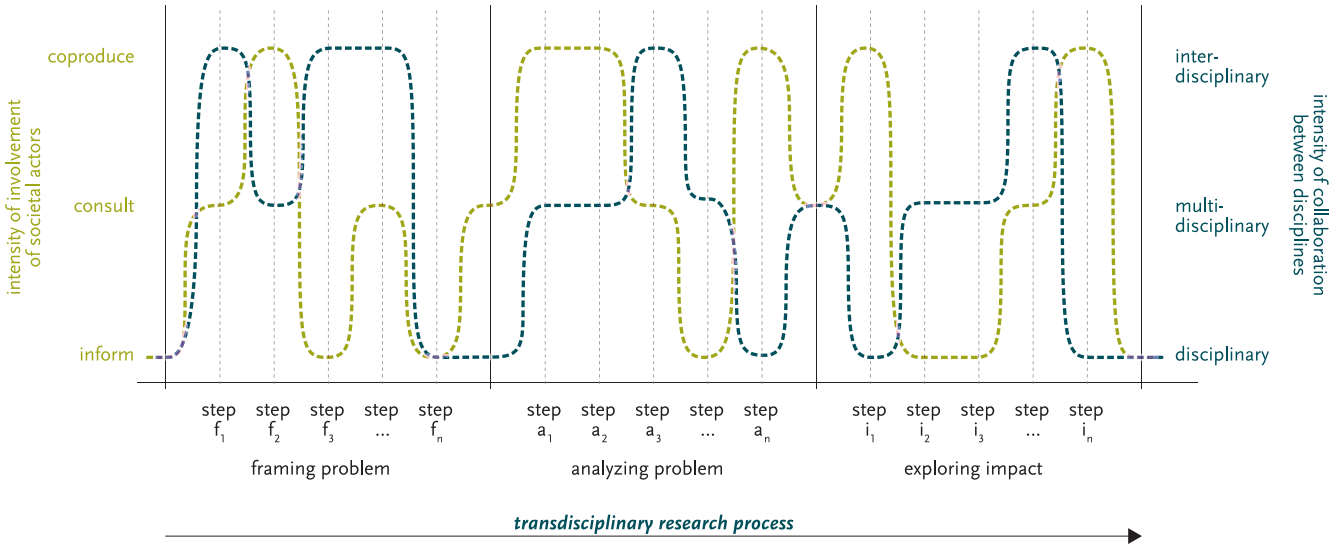

FIGURE 4: Functional-dynamic approach to collaboration in a hypothetical project. The intensity of involvement of societal actors ***(light green dotted line)*** and of the collaboration between disciplines ***(dark green dotted line)*** varies over the transdisciplinary research process. It depends on the stage, goals, and content of the process as well as its context (further developed based on Stauffacher et al. 2008 and Krütli et al. 2010).

Conclusion

In addition to the feedback we receive throughout the ten steps, we regularly evaluate the significance of the approach as an element of the CCES winter school *Science Meets Practice*. Based on these sources of feedback we conclude the following:

- *The 10-step approach provides a structure for systematic thinking about how research can be linked to societal problem solving.* Such a structured reflection is new to most researchers. The ten steps were always evaluated as one of the most valuable and insightful parts of the winter school.
- *Which particular steps are considered most valuable is not predictable.* Every time we go through step 10, we are surprised by the variety of steps that the participants think are the most relevant. It seems likely that the value of each step depends on the specific context of a given project – whether it follows a basic, applied, or td approach, whether it mixes several forms of knowledge, and how far the researcher's td thinking is developed.
- *The 10-step approach can be used during different stages of a project.* When designing the ten steps, we thought the approach would be particularly helpful during the early stages of a project, when research questions are being framed. However, we have learned from our participants that it can also be used to critically rethink a project near its end, and to design a follow-up project in a way that is more aligned with the td approach.

We also face challenges and open questions with the 10-step approach:

- *Basic researchers who are not interested in societal problem solving see no benefit in the ten steps.* A small number of participants does not perform the approach enthusiastically. This starts with step 2, when describing the societal problem. Those participants usually argue that they do basic research and are not interested in societal relevance. In such cases the approach might not be useful. However, basic researchers who are curious about the possible relevance of their research to societal problem solving find the ten steps valuable.
- *Should supervisors, societal actors and funders participate in the ten steps?* Up until now we most frequently applied the 10-step approach with the researchers who actually conducted the research. This is because researchers might not yet be clear on whom to involve in what role. As a side effect, the reflection on what disciplines and societal actors to involve is more free and less influenced by the requirements of funders, supervisors, or specific societal actors. However, in a transdisciplinary mind-set the project should be further developed in collaboration with those concerned. How to deliberate between space for free thinking and involvement of disciplines and societal actors from early on, is a question to be explored.

The 10-step approach provides guidance for systematically thinking through how research can be better linked to societal problem solving. However, it should not be seen as a fixed procedure. We invite those who use it to add further steps if indicated (for instance to discuss the stage of problem framing in different disciplines), to explore alternative methods in individual steps, or to walk through the steps in an alternative order.

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References

Bammer, G. 2016. Toolkits for Transdisciplinarity: Toolkit #6. *GAIA* 25/4: 229.

Bergmann, M., T. Jahn, T. Knobloch, W. Krohn, C. Pohl, E. Schramm. 2012. *Methods for transdisciplinary research: A primer for practice.* Frankfurt am Main: Campus.

Bergmann, M. et al. 2005. *Quality criteria for transdisciplinary research. A guide for the formative evaluation of research projects.* Frankfurt am Main: Institute for Social-Ecological Research (ISOE).

Brown, V. A., J. A. Harris, J. Y. Russell. 2010. *Tackling wicked problems through the transdisciplinary imagination.* London: Earthscan.

Carew, A. L., F. Wickson. 2010. The TD wheel: A heuristic to shape, support and evaluate transdisciplinary research. *Futures* 42/10: 1146–1155.

Davies, R., J. Dart. 2005. The "most significant change" (MSC) technique: A guide to its use. www.mande.co.uk/docs/MSCGuide.pdf (accessed February 28, 2017).

deLeon, P. 1999. The stages approach to the policy process: What has it done? Where is it going? In: *Theories of the policy process: Theoretical lenses on public policy.* Edited by P. A. Sabatier. Boulder, CO: Westview. 19–33.

Fiorino, D. J. 1990. Citizen participation and environmental risk – A survey of institutional mechanisms. *Science, Technology & Human Values* 15/2: 226–243.

Fleck, L. 1979. *Genesis and development of a scientific fact.* Chicago: University of Chicago Press.

Fleck, L. 2011. *Denkstile und Tatsachen. Gesammelte Schriften und Zeugnisse.* Edited by S. Werner et al. Berlin: Suhrkamp.

Gaziulusoy, A. I., C. Boyle. 2013. Proposing a heuristic reflective tool for reviewing literature in transdisciplinary research for sustainability. *Journal of Cleaner Production* 48: 139–147.

Gaziulusoy, A. I., C. Ryan, S. McGrail, P. Chandler, P. Twomey. 2016. Identifying and addressing challenges faced by transdisciplinary research teams in climate change research. *Journal of Cleaner Production* 123: 55–64.

Helming, K. et al. 2016. Research for a sustainable development. Criteria for socially responsible research processes. *GAIA* 25/3: 161–165.

Hirsch Hadorn, G., D. Bradley, C. Pohl, S. Rist, U. Wiesmann. 2006. Implications of transdisciplinarity for sustainability research. *Ecological Economics* 60: 119–128.

Hirsch Hadorn, G. et al. (Eds.). 2008. *Handbook of Transdisciplinary Research.* Dordrecht, NL: Springer.

Jahn, T., M. Bergmann, F. Keil. 2012. Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics* 79: 1–10.

Jann, W., K. Wegrich. 2007. Theories of the policy cycle. In: *Handbook of public policy analysis – Theory, politics and methods.* Edited by F. Fischer, G. J. Miller, M. S. Sidney. Boca Raton, FL: Taylor & Francis. 43–62.

Jasanoff, S., B. Wynne. 1998. Science and decisionmaking. In: *Human choice and climate change.* Edited by S. Rayner, E. L. Malone. Volume 1. Columbus, OH: Battelle. 1–87.

Krütli, P., M. Stauffacher, T. Flüeler, R. W. Scholz. 2010. Functional-dynamic public participation in technological decision-making: site selection processes of nuclear waste repositories. *Journal of Risk Research* 13/7: 861–875.

Lang, D. J. et al. 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science* 7: 25–43.

Lewenstein, B. V. 2002. Editorial: A decade of public understanding. *Public Understanding of Science* 11: 1–4.

Neßhöver, C. et al. 2013. Improving the science-policy interface of biodiversity research projects. *GAIA* 22/2: 99–103.

Pintér, L., P. Hardi, A. Martinuzzi, J. Hall. 2012. Bellagio STAMP: Principles for sustainability assessment and measurement. *Ecological Indicators* 17: 20–28.

Pohl, C. 2011. What is progress in transdisciplinary research? *Futures* 43/6: 618–626.

Pohl, C., G. Hirsch Hadorn. 2007. *Principles for designing transdisciplinary research – proposed by the Swiss Academies of Arts and Sciences.* Munich: oekom.

ProClim. 1997. *Research on sustainability and global change – Visions in science policy by Swiss researchers.* Bern: Swiss Academy of Sciences (SAS).

Reed, M. S. et al. 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management* 90/5: 1933–1949.

Rittel, H. 1971. Some principles for the design of an educational system for design. *Journal of Architectural Education* (1947–1974) 25/1/2: 16–27.

Rowe, G., L. J. Frewer. 2005. A typology of public engagement mechanisms. *Science, Technology, & Human Values* 30/2: 251–290.

Schiffer, E., J. Hauck. 2010. Net-Map: Collecting social network data and facilitating network learning through participatory influence network mapping. *Field Methods* 22/3: 231–249.

Stauffacher, M., T. Flüeler, P. Krütli, R. W. Scholz. 2008. Analytic and dynamic approach to collaboration: A transdisciplinary case study on sustainable landscape development in a Swiss prealpine region. *Systemic Practice and Action Research* 21/6: 409–422.

Stauffacher, M., C. Zingerli, P. Fry, C. Pohl, P. Krütli. 2012. Science meets practice: A winter school offers new perspectives. *GAIA* 21/2: 145–147.

Vogel, A. L. et al. 2013. The team science toolkit: enhancing research collaboration through online knowledge sharing. *American Journal of Preventive Medicine* 45/6: 787–789.

Wiesmann, U., H. Hurni (Eds.), with an international group of co-editors. 2011. *Research for sustainable development: Foundations, experiences, and perspectives.* Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern, Volume 6. Bern: Geographica Bernensia.

Wildavsky, A. 1987. *Speaking truth to power – The art and craft of policy analysis. 9th edition.* New Brunswick, NJ: Transaction.

Wuelser, G., C. Pohl. 2016. How researchers frame scientific contributions to sustainable development: a typology based on grounded theory. *Sustainability Science* 11/5: 789–800.

Wuelser, G., C. Pohl, G. Hirsch Hadorn. 2012. Structuring complexity for tailoring research contributions to sustainable development: a framework. *Sustainability Science* 7/1: 81–93.

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