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td-net
Network for Transdisciplinary Research

Questions to evaluate inter- and transdisciplinary research proposals

Proposed by td-net

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Summary

Currently there are no widely established and approved criteria and procedures to evaluate inter- and transdisciplinary research. Based on the state of the discussion at td-net and in the scholarly literature the present report suggests a number of questions to evaluate inter- and transdisciplinary research proposals (Tab. 4). The questions place emphasis on the quality of synthesis and integration. They differ depending on which of the three major purposes of inter- and transdisciplinary research is being foregrounded: fundamental understanding, problem solving or reflection-in-action.

1 Introduction

In a recent analysis of approaches to interdisciplinarity, Huutoniemi *et al.* conclude that currently there is no established set or approved procedure of how to evaluate inter- and transdisciplinary research:

> "Despite the decades-long scholarly work on the concept of interdisciplinarity, no general interdisciplinarity indicator useful for science policy purposes has been accepted. Most research councils and science administrators agree on the basic vocabulary at the conceptual level […] but there is no consensus on how to measure interdisciplinarity in practice." (Huutoniemi *et al.*, 2010, 81)

For inter- and transdisciplinary research Klein even states that „[e]valuation […] remains one of the least-understood aspects" (Klein, 2008a, 116). This is not because criteria are missing but, on the contrary, because there is a variability of criteria and indicators of inter- and transdisciplinary research (Klein, 2008a; Boix Mansilla, 2006). The variability of criteria and indicators mirrors the ongoing and still open debate on the nature of inter- and transdisciplinary research. Defining inter- and transdisciplinary research requires identifying its specific characteristics. Such specific characteristics – like the collaboration of disciplines or the participation of societal actors – are not only needed to identify and classify inter- and transdisciplinary research, but also as a background against which to evaluate it. Hence, the question of how inter- and transdisciplinary research is defined goes hand in hand with the question of how it can be evaluated. Moreover, "[c]ompeting formulations of interdisciplinarity also shape competing assumptions about quality" (Huutoniemi, 2010, 309).

Table 1 Three approaches to interdisciplinary research (Huutoniemi, 2010, 312).

	Mastering multiple disciplines	**Emphasizing integration and synergy**	**Critiquing disciplinarity**
Epistemic assumptions about interdisciplinary research	Enriching disciplinary knowledge production by cross-fertilization	Alternative, integrative model of knowledge production	Diverting narrowly focused disciplinary trajectories; redefining knowledge
Scholarly standards	Standards of contributing disciplines are combined	Standards of contributing disciplines cannot be by-passed, but new criteria of ID expertise are needed	Standards of contributing disciplines are transformed in the act of interpenetration; emphasis on external criteria
Valuation context	Relevant disciplinary communities	Integrative research environment	Knowledge production – consumption system with permeating boundaries
Policy implications	More flexibility in current evaluation and funding mechanisms	Choices among modes of research support; specific mechanisms for promoting IDR	Reassessment of the governance of knowledge production
Proponents	Most funding organizations and academic institutions	Interdisciplinary organizations and practitioners	Theorists of science in society; critical interdisciplinarities

Table 1 recaps the three approaches to interdisciplinary research and its evaluation that Huutoniemi *et al.* (2010, 312) identified. Most funding organisations and research institutes promote the approach of "mastering multiple disciplines". In this view, interdisciplinary research means to enrich disciplinary knowledge production by cross-fertilisation of disciplinary research. An evaluation would be based on the respective disciplinary standards, i.e. a good project would have to fulfil standards of several disciplines in parallel. In contrast, the column in the middle shows a concept of interdisciplinarity "emphasizing integration and synergy" promoted mainly by interdisciplinary organisations and practitioners for whom interdisciplinary research is an alternative, integrative model of knowledge production that integrates knowledge from different disciplines. An evaluation has to combine existing disciplinary standards with new standards. The new standards have to assess the specific quality of synthesis and integration. Finally, the promoters of "critiquing disciplinarity" hold the view that interdisciplinary research requires going beyond disciplines to establish knowledge production systems with permeating boundaries. Accordingly, evaluation of interdisciplinary research cannot be based on existing standards but requires transforming them into new kinds of standards.

The questions to evaluate inter- and transdisciplinary research proposals (see Tab. 4, page 13) take as their starting-point the view characterized in the middle raw of Table 1, emphasizing integration and synergy. We propose questions to specifically assess the quality of integration in inter- and transdisciplinary research proposals. These questions complement – but do not replace – the standards assessing the disciplinary quality of proposals.

The questions to evaluate inter- and transdisciplinary research proposals are grounded in a literature survey on the evaluation of inter- and transdisciplinary research. They are formulated for a reviewer who, by answering the questions, assesses the quality of integration in inter- and transdisciplinary proposals. The questions are introduced as follows: In section 2, different concepts of inter- and transdisciplinary research are distinguished depending on their purpose. In section 3, the literature on evaluating inter- and transdisciplinary research is reviewed. In section 4, the questions we propose are formulated and briefly explained. Section 5 concludes with a brief comment on how the questions could be used. The appendix includes different sets of questions from other publications or surveys.

td-net's proposition is the result of a short-time study (ca. 20 workdays). The proposed questions are based on the state of the discussion within td-net and on the state of the discussion in the quoted literature. They are, however, not based on a systematic and all-encompassing review of the current literature, nor on an empirical analysis of the practice of evaluating inter- and transdisciplinary research. Such an analysis would be a major undertaking. Furthermore – according to our understanding of the relation between studies on and the practice of evaluation – the proposed questions offer no ready-made solutions for the evaluation of inter- and transdisciplinary research. They are suggestions that have to be tested in the practice of evaluation in order to check and improve their quality and suitability.

2 Concepts of inter- and transdisciplinary research

There is at present no widely accepted definition of interdisciplinary and transdisciplinary research. The terms are used with different meanings depending on thematic and cultural contexts. What is widely accepted, however, is that transdisciplinary research goes beyond interdisciplinary research but there is no consensus on how and to which extend (Pohl and Hirsch Hadorn, 2007b, 70-95). In the US American context of public health research, for example, transdisciplinary research differs from interdisciplinary research in the degree to which it attempts integration of theories, concepts and methods:

> "Interdisciplinarity is a process in which researchers work jointly, but from each of their respective disciplinary perspectives, to address a common problem. Transdisciplinarity is a process by which researchers work jointly to develop and use a shared conceptual framework that draws together discipline-specific theories, concepts, and methods to address a common problem." (Stokols *et al.*, 2003, 24).

Furthermore, a project becomes 'more transdisciplinary' the more disciplines, methods and analytical scales (molecular, cellular, individual, social, global) it includes (Mitrany and Stokols, 2005).

In Europe, and specifically in the German-speaking countries, another definition has gained currency during the last two decades. Accordingly, transdisciplinary projects differ from interdisciplinary ones by making non-academics participate in the research process:

> „Interdisciplinary research here denotes the integration-oriented cooperation of scientists from at least two disciplines with the aim to work on common questions and the achievement of shared results. Transdisciplinary research, in turn, here denotes interdisciplinary cooperation, involving not only scientists but also practitioners from beyond the realm of science (e.g., the users) in the research work." (Defila and Di Giulio, 1999, 13)

The question of how inter- and transdisciplinary research is defined is crucial for evaluation. To evaluate means to compare a project proposal to a – more or less explicitly defined – ideal inter- or transdisciplinary project. If the above US American definition of transdisciplinary research is taken as baseline, then the quality of a proposal depends on how it integrates methods and theories and on the diversity of disciplines and analytical scales involved. If the above European definition of transdisciplinary research is taken as baseline, the quality depends above all on whether and how non-academic actors participate in the research process.

The debate about the 'right' definition of inter- and transdisciplinary research still continues. Recently some scholars have gone beyond this dispute and started to identify and structure the plurality of understanding and how these depend on specific thematic and socio-cultural contexts (Klein, 2006; Pohl and Hirsch Hadorn, 2007b, 70-95; Huutoniemi *et al.*, 2010; Klein, 2010a; Klein, 2010b; Bunders *et al.*, 2010; Hirsch Hadorn *et al.*, 2011). Note that this curiosity towards exploring the plurality of understandings is – in contrast to arguing for the right one – in line with core values of an inter- and transdisciplinary ethics (Stokols, 1998) and with the transdisciplinary principle of "open encounter" (Giri, 2002; Pohl and Hirsch Hadorn, 2007b).

In the following, we will base our understanding of inter- and transdisciplinary research on the broad definition given by the National Academies of Sciences *et al*. (NAS/NAE/IOM, 2005, 188).

> "Interdisciplinary research (IDR) is a mode of research by teams of individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond of the scope of a single discipline or area of research practice." (NAS/NAE/IOM, 2005, 188).

The definition places integration at its core, the one characteristic that is largely accepted as specific to inter- and transdisciplinary research (Klein, 2008b; Pohl *et al.*, 2008; Jahn *et al.*, 2006; Bammer, 2005; van Kerkhoff, 2005; Huutoniemi *et al.*, 2010). By stressing integration – without defining its quality and the diversity of concepts, theories, disciplines and scales integrated – the definition includes the US American understanding quoted above. Integration accordingly takes place between disciplines or bodies of specialized knowledge. If the "bodies of specialized knowledge" include knowledge of thematic-scientific fields as well as of non-academic experts – such us farmers, managers or civil servants – then this definition includes the European understanding of transdisciplinary research as well.

Boix Mansilla (2006, 19) identifies three general qualities of such inter- and transdisciplinary research. It is

- purposeful, i.e. a means to a certain end;
- based on validated expertise;
- integrative, i.e. interrelating the expertise to meet the purpose.

Hence, integration of disciplinary knowledge or of bodies of specialized knowledge is not an end in itself but a means that should optimally serve the project's specific purpose. Evaluating inter- and transdisciplinary research therefore means to assess in how far the expertise included as well as the way of integration are adequate and relevant for the project's specific purpose. The evaluation of an inter- and transdisciplinary approach has thus to start with the identification of a project's purpose. Subsequently three purposes of inter- and transdisciplinary research are distinguished. The definition of the National Academies of Sciences *et al*. already includes two (Hirsch

Hadorn *et al.*, 2011): (a) to advance fundamental understanding and (b) to solve problems. The third purpose is that of (c) reflection-in-action (Schön, 1983).

2a Fundamental understanding

One major purpose of inter- and transdisciplinary research is to advance fundamental understanding. This is a common purpose of disciplinary research, too. In inter- and transdisciplinary research, however, information, data, techniques, tools, perspectives, concepts, and/or theories of several disciplines are combined to advance fundamental understanding of an issue that requires collaboration. Examples of such collaborations are to combine bio-medical and psychological methods and expertise to explore emotions, or biologists and chemists exploring the influence of toxic compounds on the dispersal of species in aquatic habitats. The intellectual products of such collaborations "include the generation of new hypotheses for research, integrative theoretical frameworks for analyzing particular problems, novel methodological and empirical analyses of those problems, and, ultimately, evidence-based recommendations for public policy". (Stokols *et al.*, 2003, 22).

Resting upon the definition given by Stokols *et al.* (Stokols *et al.*, 2003; Mitrany and Stokols, 2005), interdisciplinary research guided by the purpose of fundamental understanding differs from transdisciplinary research by (a) the degree or intensity of integration and (b) the diversity of disciplines, methods and scales (molecular, cellular, individual, social, global) included. The questions to evaluate pilot-project proposals in "Transdisciplinary Research in Energetics and Cancer" (Appendix A3) base the assessment of inter- and transdisciplinarity on these aspects (see specifically questions VI and VII). In this view, the more analytical scales a project integrates and the more diverse its methods and disciplines, the more it is transdisciplinary. Within the aim of fundamental understanding, a distinction can thus be made according to the diversity of disciplines, methods and analytical scales included, "diversity" standing for the number as well as the distinctiveness of methods, analytical scales and disciplines (*cf*. Wagner *et al*.). In Figure 1 a distinction is made between detailed fundamental understanding – including a low diversity of methods, disciplines and analytical scales – and comprehensive fundamental understanding with a high diversity.

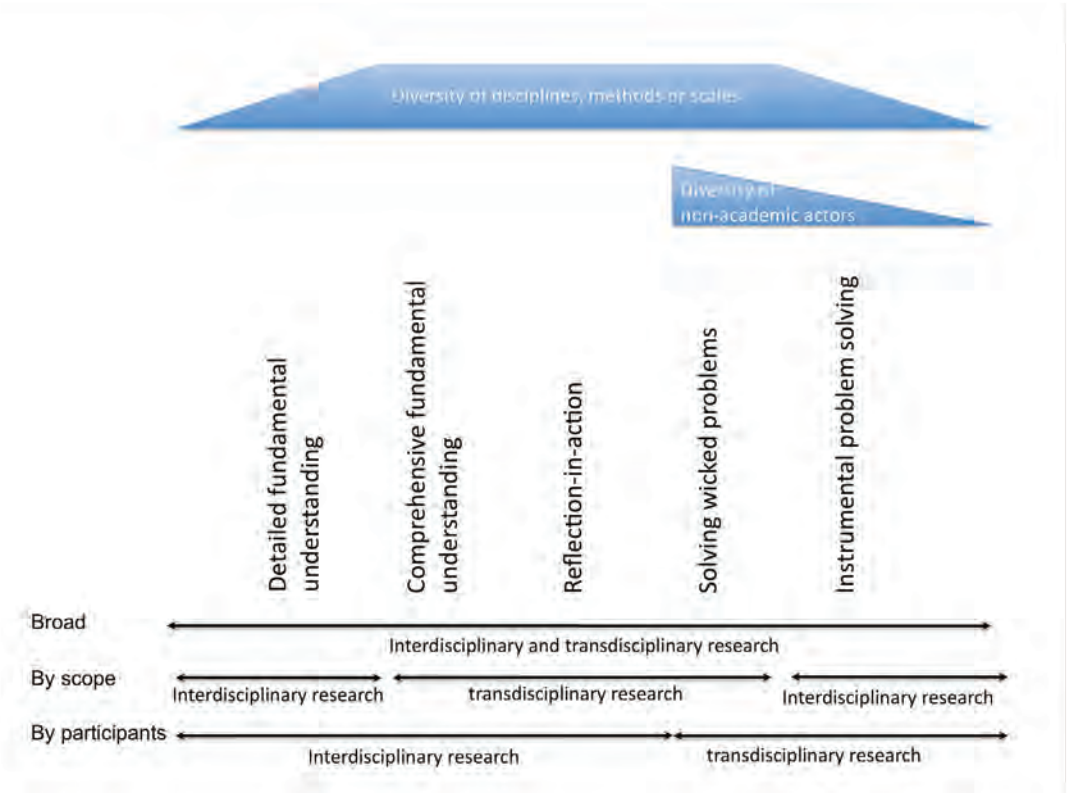

Figure 1 Purposes of inter- and transdisciplinary research

Note that a discipline is not demarcated by sharp, but by fuzzy boundaries:

> „Disciplines conventionally include a number of subfields located at a distance from each other – conceptually, methodologically and normatively. [...] This development means that the term "discipline" can no longer be used without critical reflection on its meaning. To put the matter succinctly, is atomic physics a subdiscipline of physics? Or is atomic physics the discipline and physics a supradiscipline? Is the recipient of a Ph.D. in Arctic biology from the University of Alaska really practising the same discipline as someone receiving a degree in mathematical biology from the University of Chicago or a degree in radiation biology from the University of Rochester"(Swoboda 1979 as quoted in Klein 1996, 53)

As a consequence, the border between disciplinary and interdisciplinary research (the left margin of Figure 1) becomes fuzzy, too. Additionally the border may change over time (Huutoniemi *et al.*, 2010, 82): A combination of biology and chemistry was once interdisciplinary research and is nowadays part of the field of biochemistry. A project using nanomaterials to investigate membranes of cells may be an interdisciplinary project today and part of the field or discipline of nanomedicine in the near future.

2b Problem solving

> "To discover what holds the world together is now, as always, a grand enterprise. But the task of holding it together is certainly no smaller, and the sciences have a contribution to make to this task too […]" (Mittelstraß, 1993, 154)

A second purpose of inter- and transdisciplinary research is problem solving. Often the expression "real-world problem solving" is used to stress that the problems are not only of interest to scientists but to non-academic actors as well. Typical examples of problem solving are the development of a new airplane, of a medical treatment system for nomadic people or a way for dealing with natural hazards. For the purpose of problem solving, developing and testing a prototype solution may be part of the research process.

Concepts, methods and theories of problem-driven inter- and transdisciplinary research have been recently developed in the field of environmental and sustainability research mainly (Klein *et al.*, 2001; Lawrence and Després, 2004; Wickson *et al.*, 2006; Pohl and Hirsch Hadorn, 2007b; Hirsch Hadorn *et al.*, 2008; Bergmann *et al.*, 2010). In particular in the German-speaking countries the discussion on transdisciplinarity stressed the inclusion of non-academic actors as the defining factor to distinguish inter- from transdisciplinary research. In this understanding, a science-industry collaboration to develop a new drug is as transdisciplinary as a project on land transformation in alpine regions, including actors of the private and the public sector as well as of civil society.

Like in the case of fundamental understanding, a distinction can be made depending on the diversity of non-academic actors involved. If one non-academic partner participates (a company, for instance) who has a specific idea of the problem and the expected solution – a robot, a remedy, an analytic device – the problem is well defined. Subsequently, this will be called "instrumental problem solving". If the problem is a "wicked" problem (Kunz and Rittel, 1972; Rittel and Webber, 1973), i.e. if the social actors differ in how they define the problem of land transformation, for example, and what they see as a good solution, then the specific definition of the problem may change during the research process. td-net refers to the problem-solving of such wicked problems – including deliberations about values – as transdisciplinary research.

> "Transdisciplinary research is research that includes cooperation within the scientific community and a debate between research and the society at large. Transdisciplinary research therefore transgresses boundaries between scientific disciplines and between science and other societal fields and includes deliberation about facts, practices and values." (Wiesmann *et al.*, 2008, 435).

Instrumental and wicked problem solving are on the right side of Figure 1. Instrumental problem solving is characterized by a small number of disciplines, methods, scales and non-academic actors. Wicked problem solving includes diverse non-academic actors and disciplines, methods and scales. The demarcation between instrumental and wicked problem solving is, however, not sharp but fuzzy.

2c Reflection-in-action

A third purpose of inter- and transdisciplinary research is to critically review and change current practices and developments in the making. Klein uses the term “critical interdisciplinarity” for an attitude that interrogates “the dominant structures of knowledge and education with the aim of transforming them, raising questions of value and purpose” (Klein, 2010a). Placing stronger emphasis on the change of practices based on critical reflection, Schön (1983) uses the expressions “the reflective practitioner” and “reflection-in-action”. Critical interdisciplinarity and reflection-in-action can be traced back to the two-cultures divide described by Snow (1964; 1959): the action-driven disciplines like engineering or medical science, on the one side, and the reflection driven disciplines like the humanities, the arts, or the risk sciences, on the other side. Even if the call for reflection-in-action is well known, concrete projects are rare. One reason is that the two cultures are usually very sceptical of collaboration. The action driven disciplines see the reflection driven disciplines as preventing them from progress and restricting their curiosity-driven research. The reflection-driven disciplines are afraid of being instrumentalised as henchmen of the action-driven disciplines. Integration ideally takes place by critically reviewing and adapting current practices and technologies as reflection-in-action (Schön, 1983). Examples would be studies on the risk of nanotechnology that feed back to the development of new products or ethical studies on animals and stem cells that constrain animal and stem cell research.

Reflection-in-action is placed in the middle of Figure 1. This is to emphasise its bridging position between fundamental understanding and practical problem solving. Reflection-in-action typically joins heterogeneous disciplines, such as linguistics and medicine.

The three purposes of inter- and transdisciplinary research are not mutually exclusive. Reflection-in-action may be instrumental to support problem solving. Researchers may base the development of a new technical device on a better fundamental understanding. And reflection-in-action as well as problem solving may both help, in the end, to come to a better fundamental understanding of an issue. However, since inter- and transdisciplinary research is always a means to a certain end, the evaluation of a project proposal has still to rely on a specific purpose or, alternatively, on a combination of purposes. The purposes will be taken up again in section 5.

3 Possibilities to evaluate inter- an transdisciplinary research

Even if there are no established and approved criteria and procedures to evaluate inter- and transdisciplinary research, a number of scholars study such evaluations and propose criteria. Currently Frodeman and Holbrook are carrying out a comparative analysis of how, among other features, broader societal impact is evaluated by US and European founding agencies, including the US National Science Foundation and the European Commission’s Framework Programmes (Frodeman *et al.*, 2010; Holbrook, 2010a, 2010b). A special issue of *Research Evaluation* assembles a number of studies investigating the current practice of evaluation of broadly defined interdisciplinary research (Laudel and Origgi, 2006). These studies yield a number of insights, chief among them that (a) reviews usually result in contradictory assessments (Langfeldt, 2006); that (b) the intellectual breadth of a proposal is typically mentioned as a positive quality and missing disciplinary grounding typically as a negative one (Lamont *et al.*, 2006, 46); that (c) applications joining disciplines that do not interact much are more likely rejected than applications joining disciplines that collaborate on a regular basis (Langfelt, 2006, 34); that (d) that reviewers who have to evaluate projects that are not within their field of expertise often use indirect measurements (patents, publications, reputation, awards) or refer to and trust in other experts (Boix Mansilla, 2006; Lamont *et al.*, 2006). Klein (2008a) summarizes the results of these and further studies on evaluation in seven generic principles for evaluating inter- and transdisciplinary research (see Appendix A1).

For transdisciplinary research a number of specific questions for evaluation have been developed over the last years (Defila and Di Giulio, 1999; Bergmann *et al.*, 2005; TREC, 2006; Späth, 2008, see Appendix A2-A5). The questions give an impression of what it means that different concepts of transdisciplinary research lead to alternative evaluation criteria. The US American approach, for instance, bases the assessment on the diversity of disciplines, methods and scales (molecular, cellular, individual, social, global) (TREC, 2006). The questions developed by Defila

and Di Giulio within the frame of the Swiss Priority Program Environment consider the involvement of the users as especially relevant (Defila and Di Giulio, 1999). Finally, Bergmann *et al.* developed criteria for formative evaluation within the frame of the German program Social-ecological Research (Bergmann *et al.*, 2005). They do not propose specific questions for the evaluation of research proposals but see their questions as a tool for formative self-evaluation[1]. The questions correspondingly focus on how the research relates to a real-word problem and on the quality of the social learning processes taking place.

There is no specific reason why the already existing evaluation criteria and questions should not be used and explored as they are. For the present purpose they will be used as resources to identify the specific questions that help to assess integration and synthesis, depending on the projects purpose. For any set of criteria that is used more broadly, however, there is an urgent need to empirically study and evaluate how the theoretically postulated criteria work in the practice of evaluation.

From the view of a panel that has to assess inter- and transdisciplinary research there are at least four elements of the evaluation process that could be changed or adapted:

- The composition of the panel of experts
- The assortment of external reviewers
- The design of the review process
- The questions the reviewers have to answer

In the following, a number of challenges of evaluation and measures to address them are summarized. The challenges and measures are taken from recent literature of scholars analysing evaluations of inter- and transdisciplinary projects or proposing questions and criteria, including those specifically depicted in the Appendix. Table 2 briefly summarizes how the panel, the reviewers and the process could be adapted to face the evaluation of inter- and transdisciplinary research. Table 3 suggests what the reviewers should be asked such as they focus their attention on assessing integration and synergy.

Table 2 Adapting panel, reviewers and process for evaluating inter and transdisciplinary research

Element	Measures
Panel	– Include evaluators with different disciplinary expertise – Make the panel a mix of specialists and generalists (Feller, 2006; Boix Mansilla, 2006) – Include interpreters as intermediaries in the panel (Laudel, 2006; Boix Mansilla *et al.,* 2006)
Reviewers	– Include evaluators with different expertise – Take specialists and generalists as reviewers (see text) – Adapt the reviewers to the purpose (Langfeldt, 2006, 39)
Process	– Make the selection of reviewers and of the criteria of evaluation a joint process of reviewers, the panel and the applicants (Klein, 2008a; Laudel, 2006; Bergmann *et al.,* 2005; Huutoniemi, 2010, 314) – Adapt the process to the purpose (Langfeldt, 2006, 39)

One of the obvious measures for a panel as well as for the reviewers is to mix experts of different disciplines or with expertise in different bodies of specialised knowledge. A less obvious measure is to invite experts with different kinds of expertise in terms of specialisation and broadness. A panel therefore could be a mix of specialists and generalist and include interpreters – experts who are able to explain a specific approach or method in an easy understandable language to other members of the panel. The different kinds of expertise are also used in the review process of the journal “GAIA - Ecological Perspectives for Science and Society”. Each paper is reviewed by specialists and by a so-called “Gegenleser” (counter-readers). The counter-reader has to assess the quality of the paper in terms of integration and contribution to real-world problem solving. Finally Langfeldt (2006, 39) mentions the measure to adapt the reviewers to the purpose.

1 „According to Striven, the best way to illustrate the distinction between formative and summative evaluation is through the analogy given by Robert Stake: «When the cook tastes the soup, that’s formative evaluation; when the guest tastes it, that’s summative evaluation»“ (Chen 1996, 122).

Other scholars suggest changing the process of evaluation. Usually a proposal is submitted, checked for its readiness to be reviewed, then reviewed and decided upon based on the reviews. In an alternative process, the applicants together with the panel first select the reviewers. The reviewers and the applicants then meet and discuss before the proposal is submitted. The first submission is followed by a critical discussion of reviewers, panel members and the submitting researchers. Laudel describes such a process using the example of the German "Sonderforschungsbereiche" (Laudel, 2006). The measure of organising the process of evaluation in a participatory way is proposed by a number of scholars (Tab. 2). One reason for this procedure is the plurality of standards of validation and the plurality of goals of inter- and transdisciplinary research (Boix Mansilla, 2006; Klein, 2008a; Chen and Rossi, 1980; Chen, 1996), which the panel and its limited number of experts cannot cover. A discussion with the applicants and the reviewers as part of the evaluation serves to efficiently specify the applicants' and the reviewers' goals and standards of evaluation and to crosscheck whether both consider the same standards and goals as relevant.

The aim of this paper is to provide questions for evaluation integration and synergy. The composition of the panel of experts, the assortment of external reviewers as well as the design of the review process are elements that can hinder or support such an evaluation. At the end of the day, however, the reviewing evaluator's attention has to be directed to integration and synthesis. According to the following proposition for evaluation, such integration and synthesis includes the following aspects among others:

> "Evaluation of transdisciplinary research has to go beyond traditional reference systems. It should include qualifying integration and collaboration of disciplines and stakeholders, the recursive design of the research process, and the way the project is based on, and can provide input to, scientific knowledge and societal problem handling."(Wiesmann *et al.*, 2008, 439).

Table 3 summarizes questions and recommendations that scholars give to assess those aspects. The aspects are – referring to the purposes distinguished in section 2 – circumscribed as: integration; broadness of approach; reflective learning process; problem solving capacity. Taking up Klein's evaluation principle No 4 (Appendix A1) – the interactions of social and cognitive factors in collaboration – Table 3 concludes with questions on management and leadership.

Table 3 Questions and measures emphasising integration and synergy

Challenge	Questions/Measures
Broadness	– How many and how diverse disciplines are involved? – How many and how diverse methods are used? – How many and how diverse different scales (molecular, cellular, individual, social, global) are investigated? (Stokols *et al.*, 2003; Mitrany and Stokols, 2005) – How many and how diverse social actors are involved (Hirsch Hadorn *et al.*, 2006)
Integration	"At a minimum, all applicants proposing interdisciplinary projects should also address the following generic questions: – Why is an integrative approach necessary? – What kind of integration is proposed? – What fields, approaches, and methods will be integrated? – How will integration be carried out, from both intellectual and organizational standpoints? – What is the level of preparedness of participants, including prior experience in integrating knowledge? – Is the integration feasible in terms of scope as well as material and human resources?" (Bruun *et al.*, 2005, 164) – "Have the methods intended for consensus building and integration been presented clearly? – Do the methods intended for consensus building and integration appear to be suitable to achieve the intended results and products?" (Defila and Di Giulio, 1999) – "Do the methods envisioned, the interfaces of transdisciplinary collaboration, the form of integration in practice, and the form of results and products in the project fit the solution strategy sought for the project goal? – Does the structuring of the project (work steps, connection between modules, integration steps, etc.) correspond to sensible processes of generating and integrating knowledge in research process and to the requirements of the participating actors? – Have means and opportunities for the specific tasks of coordinating, integrating, and organizing a transdisciplinary research project been planned – Are suitable methods used or have they been developed to conjoin contributions of knowledge from participating scientific fields and practice" (Bergmann *et al.*, 2005) – Does integration start form a position of open encounters of the perspectives? – Are means of integration and forms of collaboration defined? (Pohl and Hirsch Hadorn, 2007a) – Is the integration balanced in weaving perspectives together into new whole? – Is the project attending to pluralism of values and interests? (Klein, 2008a)
Reflection and learning?	– Is there enough time to reflect (Loibl, 2005) – Does the project foresee phases of reflection and possibilities of adaptation? (Pohl and Hirsch Hadorn, 2007a) – "Are there regular reflections on the cooperation in the team and on the implementation plans for knowledge integration? If applicable, are conclusions drawn from this? – "Are the planned procedures of self-reflection and quality assurance used ("revision points") and, if applicable, are adjustments made (procedure, structure, products)? (Bergmann *et al.*, 2005)

Continued from last page (Table 3)

Challenge	Questions/Measures
Problem-solving	– "Has the problem been sufficiently described? – Has the relevance of the problem been convincingly presented? – Has a convincing case been made for the fact that only inter- or transdisciplinary research can make the promised contribution towards resolving the problem? – Does it become sufficiently clear what the contribution towards resolving the problem is to be? – Were the users sufficiently involved in the wording of the objectives and questions? – Has it been made sufficiently clear how the practical implementation of the results and products shall be assured?" (Defila and Di Giulio, 1999) – "Do the disciplinary composition and the competence in the team permit the treatment of the essential aspects of the problem or of the study? – Is the competence of the practice partner appropriate to the everyday life problem and its solution (relevant knowledge, role in the projects, possibilities for implementing results)? – Does the project take up an everyday life problem, and how is this problem relevant? – Is the everyday life problem adequately translated into scientific questions? Is the current state of knowledge taken into consideration and can the research question be regarded as innovative in relation to this state of knowledge – Can the results make a contribution to solving the everyday life problem?" (Bergmann *et al.*, 2005) – Has the real-world problem been adequately identified and structured? – Is the contribution of the research project to the real world problem embedded in an analysis of the current situation? (Pohl and Hirsch Hadorn, 2007a) – Is the project designed such as the existing power structures are not reproduced but challenged (Loibl, 2005) – Is there a sensitivity to a variety of possible impacts of the project (Klein, 2008a)
Management, social and leadership skills	– "Does the project structure (organisation chart, task distribution) appear to be suitable for consensus building, integration and networking between the sub-projects? – Does the manner in which external participants are to participate appear to be appropriate to the objectives of the overarching project? (Defila and Di Giulio, 1999) – Are the participants committed to the following core values of an inter- and transdisciplinary ethics (Stokols, 1998; Mitrany and Stokols, 2005; Gray, 2008): – inclusive rather than exclusionary thinking, – broad-gauged, contextually oriented theorizing and research methodological pluralism, – optimism and stamina, – a welcoming orientation toward new perspectives, – the cultivation of good will and cross-disciplinary tolerance. – Are procedures planed to manage tension in a balanced way (Klein, 2008a) – "establish degrees of flexibility in ranking of leaders, disciplines, and topics in the conduct, sequencing and re-sequencing of research activities; – assess resilience in responding to changing conditions that require re-thinking basic premises (theoretical or methodologic), as well as effectiveness in communicating those changes to different constituencies; and – assess team effectiveness in bridging multiple contexts within the same geographic site or across sites." (Kessel and Rosenfield, 2008, 232)

Based on Table 3 a number of questions for evaluating inter- and transdisciplinary research proposals are suggested in the next section.

4 Questions for evaluation

In the following a number of questions are proposed to evaluate inter- and transdisciplinary research proposals. The questions are targeted to a reviewer who is asked to assess a proposal for its specific inter- and transdisciplinary qualities, emphasizing integration and synergy. The suggested questions draw on Table 3 and are summarized in Table 4.

The first challenge mentioned in Table 3 is the broadness of the approach. Broadness means the number and the diversity of disciplines, methods and analytical scales (molecular, cellular, individual, social, global) that are combined in an inter- or transdisciplinary project. As depicted in Figure 1, this broadness is one of the means to further distinguish proposals within the purpose of fundamental understanding (Stokols *et al.*, 2003; Mitrany and Stokols, 2005) and of problem solving (Hirsch Hadorn *et al.*, 2006; Hirsch Hadorn *et al.*, 2011). Hence, a first question is

Q1 How divers are the disciplines, methods, scales of analysis and possibly the social actors involved?

The question supports classifying proposals according to their specific purpose. Whereas a high diversity is a sign of inter- and transdisciplinarity, a low diversity – a project combining a small number of disciplines, methods, analytical scales and societal actors alike – may be a sign that a project is not inter- or transdisciplinary research at all. A second question related to broadness is thus

Q2 If the project has a low diversity, does it still fall into the category of inter- and transdisciplinary research?

The second challenge mentioned in Table 3 is integration, the widely accepted core challenge of inter- and transdisciplinary research (Klein, 2008b; Pohl *et al.*, 2008; Jahn *et al.*, 2006; Bammer, 2005; van Kerkhoff, 2005; Huutoniemi *et al.*, 2010). The measures and questions gathered in Table 3 basically centre around the questions of whether there is a good reason for an integrative approach, whether the applicants have concrete ideas (methods, tool) about how to make the integration happen and how the proposed integration is assessed in terms of suitability and a balanced weaving of perspectives. Three corresponding questions for evaluation are:

Q3 How innovative and how suitable is the combination of disciplines and fields of expertise for the specific purpose?
Q4 How elaborate is the approach to integration?
Q5 How balanced is the weaving of disciplines or fields of expertise?

The third challenge is reflection and learning. Reflection and learning is a challenge since the combination of disciplinary perspectives and maybe perspectives of social actors requires – compared to a collaboration of researchers with a similar background – much more time for mutual understanding and learning, and possibly a reframing or adjustment of the planned integration and collaboration. The questions in Table 3 basically propose to ask for the readiness and preparedness for learning and adaptation:

Q6 How elaborate is the approach to self-reflection and adaptation?

The challenge of learning and reflection is specifically relevant for the purpose of reflection-in-action. The purpose of reflection-in-action is to critically review a current practice in order to change it. Therefore the success of the project strongly depends on relationship of those who reflect and those who act. Assessing the quality of reflection-in-action requires thus an answer to the following question:

Q7 How likely is the project to substantially interrelate reflection and action?

The challenge of problem solving in Table 3 is discussed with regard of whether the problem requires an inter- or transdisciplinary approach, whether the problem and the projects contribution are sufficiently elaborated and whether the project and its participants are considered to be able to make a change. As the first of those questions is already discussed in Q3, the further questions for evaluation are

Q8 How elaborate is the problem and the project's specific contribution to its solution?
Q9 How likely is the project to make a substantial contribution to problem solving?

Finally the questions on management, social and leadership skills ask whether the management structures seem to match and support the project's goals and whether the involved researchers and partners will be open minded, if necessary ready to fundamentally revise their scientific perspective, able to collaborate in possibly changing hierarchies and to bear and manage tensions. Two last questions for the evaluation are thus

Q10 How well do the management structures match and support the project's goal and combination of disciplines and fields of expertise?

Q11 How do you assess the applicant's collaborative skills (open mindedness, self-reflection, dealing with changing hierarchies, ability to bear and manage tensions)?

Table 4 Suggested questions for evaluating inter- and transdisciplinary research

No	Question	Effect
Assessing broadness to further classify proposals		
Q1	How diverse are the disciplines, methods, scales of analysis and/or social actors involved?	The question further distinguishes the purpose of a project within the classes "fundamental understanding" and "problem solving". A high diversity is typical for "comprehensive understanding" and "wicked problem solving".
Q2	If the project has a low diversity, does it still fall into the category of inter- and transdisciplinary research?	The question asks the reviewer to reconsider the projects classification as inter- and transdisciplinary research based on the projects diversity.
Assessing integration		
Q3	How innovative and how suitable is the combination of disciplines and fields of expertise for the specific purpose?	The question asks the reviewer to assess originality and suitability of the combination of disciplines and fields of expertise for the specific purpose.
Q4	How elaborate is the approach to integration?	The question assumes that an elaborated approach to integration is a sign of high inter- and transdisciplinary quality.
Q5	How balanced is the weaving of disciplines or fields of expertise?	The question assumes that an integration that balances disciplines or fields of expertise is a sign of high inter- and transdisciplinary quality.
Assessing reflection and learning		
Q6	How elaborate is the approach to self-reflection and adaptation?	The question assumes that planned stages of learning and self-reflection and the possibility to adapt the project based on this is a sign of high inter- and transdisciplinary quality.
Q7	How likely is the project to relate reflection and action?	The question asks the reviewer to assess whether the project will connect reflection and action.
Assessing problem solving		
Q8	How elaborate is the problem and the project's specific contribution to the problems solution?	The question assumes that an elaborated understanding of the problem and of the projects contribution to its solution is a sign of high inter- and transdisciplinary quality.
Q9	How likely is the project to make a substantial contribution to problem solving?	The question asks the reviewer to assess whether the project will support problem solving.
Assessing management, social and leadership skills		
Q10	How well do the management structures match and support the project's goal and combination of disciplines and fields of expertise?	The question assumes that an elaborated management structure is a sign of high inter- and transdisciplinary quality.
Q11	How do you assess the applicant's collaborative skills (open mindedness, self-reflection, dealing with changing hierarchies, ability to bear and manage tensions)?	The question assumes that applicants who are committed to core values of an inter- and transdisciplinary ethics are a sign of high inter- and transdisciplinary quality.

5 Further use of questions

The questions to evaluate inter- and transdisciplinary research proposals are based on the assumption that an evaluation has to combine existing disciplinary standards with new standards. The new standards – as suggested in Table 4 – have to assess the specific quality of synthesis and integration (*cf*. Tab. 1, page 2).

Inter- and transdisciplinary research are means to certain ends or purposes. Hence, each evaluation of inter- and transdisciplinary research should start with the purpose. In section 2 three such purposes were distinguished: Fundamental understanding, reflection-in-action and problem solving. For the former and the latter a further distinction can be made depending on the diversity of disciplines, methods, analytical scales and societal actors involved (Figure 1, Q1 Q2).

Table 5 summarizes the question we suggest for evaluating the quality of inter- and transdisciplinarity depending on the purpose. The questions on integration (Q3, Q4, Q5), on the elaboration of the approach towards learning (Q6) and on management and social and leadership skills (Q10, Q11) can be used for all purposes. For the purpose of reflection–in–action (Q7) as well as for problem solving (Q8, Q9) the possible impact can be assessed in addition.

Table 5 Questions for evaluation depending on the purpose (Questions in bold address the respective purpose).

Purpose	**Fundamental understanding**		**Reflection-in-action**	**Problem-solving**	
	Detailed	Comprehensive		Wicked	Instrumental
Suggested questions for evaluation	Q3, Q4, Q5, Q6, Q10, Q11		Q3, Q4, Q5, Q6, **Q7**, Q10, Q11	Q3, Q4, Q5, Q6, **Q8, Q9**, Q10, Q11	

The questions are suggestions from the perspective of practitioners and theorist of inter- and transdisciplinary research. They are, however, not ready for being implemented as such in a form for reviewers. Depending, amongst others, on the specific targets of the reviewing panel, on the panel's understanding of inter- and transdisciplinary research, on its current practice of reviewing and on pragmatic considerations, a panel should select the most suitable questions and if necessary reformulate them. In other words, the proposed questions are – considering the state of inter- and transdisciplinary research and its evaluation – of an exploratory character. Their use and implementation should be seen as an experiment that has to be observed in order to learn about the questions and to fine-tune them.

6 Appendix

Appendix A1
Seven generic principles of evaluation (Klein, 2008a)

Principle number	Evaluation principles	Key insights
1	Variability of goals	**Variances**: size, scope, scale, level and subsystem, degree of integration in multidisciplinary–interdisciplinary–transdisciplinary environment **Multiple goals**: for example, epistemologic or methodologic forms, product development, pragmatic problem solving *Range of stages*: ex ante, intermediate, ex post
2	Variability of criteria and indicators	**Two major approaches to quality assessment**: conventional metrics; indirect, field-based, and proxy criteria vs. primary or epistemic measures of warranted interdisciplinary knowledge in the substance of the work **Expanded indicators**: for example, experimental rigor, aesthetic quality, new explanatory power, feedback to multiple fields, enhanced research capabilities, changing career trajectories, new public policies and treatment protocols, long-term impacts and unforeseen consequences
3	Leveraging of integration	**Key factors**: balance in weaving perspectives together into new whole, reaching effective synthesis, antecedent conditions for readiness **Criteria for leveraging and evaluating integration**: organizational, methodologic, and epistemologic components; strategies that promote communication and consensus; generative boundary objects
4	Interactions of social and cognitive factors in collaboration	**Requirements**: for example, calibrating separate standards, managing tensions among conflicting approaches, clarifying and negotiating differences among all stakeholders, compromising, communicating in ongoing and systematic fashion, engaging in mutual learning and joint activities
5	Management, leadership, and coaching	**Requirements**: managing tensions in balancing acts, consensus building, integration, interaction, common boundary objects, shared decision making, coaching the process **Categories of leadership tasks**: cognitive, structural, and processual
6	Iteration and feedback in a comprehensive and transparent system	**Requirements**: attuning a pluralism of values and interests, iterative work to insure collaborative inputs, transparency to include common stakeholding, feedback to the mission in a dynamic framework, mobility of participants, interaction and communication patterns
7	Effectiveness and impact	**Expanded indicators**: sensitivity to variety of goals in Principle 1 and variety of criteria and indicators in Principle 2; inclusion of unpredictable long-term impacts, returns on investment, value-added

Appendix A2
Questions to evaluate transdisciplinary research proposal (ex ante) (Defila and Di Giulio, 1999, 18-19)

Possible answers: Yes/No

Presentation of the societal problem

1. Has the problem been sufficiently described?
2. Has the relevance of the problem been convincingly presented?
3. Has a convincing case been made for the fact that only inter or transdisciplinary research can make the promised contribution towards resolving the problem?

Objectives and questions

4. Does it become sufficiently clear what the contribution towards resolving the problem is to be?
5. Do the objectives of the overarching project correspond with the objectives of the research program?
6. Do the scientific objectives follow from the problem-related objectives?
7. Do the questions serve the purpose of reaching the objectives and do they follow from those?
8. Are any essential sub-projects missing to reach the objective, and/or to answer the questions? If so, which ones?
9. Do all the intended sub-projects follow from the objectives and questions of the overarching project? If not, which ones do not?
10. Do the objectives of the overarching project appear to be attainable?
11. Is the overarching project original? If so, in what way? If no, why not?

Involvement of users and external participants

12. Were the users sufficiently involved in the wording of the objectives and questions?
13. Do the objectives and questions justify the participation of external participants?
14. Has the contribution to be made by external participants been presented with sufficient clarity?

...

Integration/Synthesis

1. Have the methods intended for consensus building and integration been presented clearly?
2. Do the methods intended for consensus building and integration appear to be suitable to achieve the intended results and products?

Scientific quality

1. Are the objectives of the overarching project based upon the current state of knowledge?
2. Does the research activity have internal logic? Does each step follow from the preceding one?
3. Has work in the sub-projects been harmonized?
4. Does the schedule appear to be realistic?

Transfer of knowledge and technology (concept of implementation)

1. Has it been made sufficiently clear how the practical implementation of the results and products shall be assured?
2. Has it been made sufficiently clear how the results shall be transferred into (continuing) education?
3. Has it been made sufficiently clear how the results shall be disseminated?
4. Can the planned activities be realised with the available resources?

Project organisation/Project management

Internal organisation

1. Are the tasks and competences clearly distributed (organisation chart, task specifications)?
2. Does the project structure (organisation chart, task distribution) appear to be suitable for consensus building, integration and networking between the sub-projects?

External organisation

3. Does the manner in which external participants are to participate appear to be appropriate to the objectives of the overarching project?
4. Are the contracts with external participants regarding the contribution expected from them sufficiently clear and binding?
5. Is the procedure for establishing missing contacts clear?
6. s the infrastructure required for the overarching project available?
7. What is the correlation between input and expected results and products?
8. Have the means applied for been sufficiently justified?
9. Do the means applied for appear to be sufficient?
10. Does the correlation of means applied for, own means, and means from third parties appear to be adequate?

Competence of the management of the overarching project

1. What is the extent of previous input (previous achievements) of the management of the overarching project to the contents of the overarching project, and how does its competence rate?
2. How does the management of the overarching project rate as regards the implementation of the intended methods for consensus building and integration?
3. How does the management of the overarching project rate as regards project management (previous input, education and training)?

Appendix A3
Transdisciplinary Research in Energetics and Cancer, Evaluation of Pilot Project Proposals (TREC, 2006)

III. Indicate all **disciplines represented in the proposal** by marking the numbered checkboxes at the left side of the table below. Consider a discipline represented if it is mentioned as part of the project or is implied in the project description.

IV. For each discipline represented in the proposal, indicate all **levels of analysis** mentioned or implied as part of the project background, data collection, intervention, or analysis.

		A. Molecular & Cellular	B. Individual	C. Group & Interpersonal	D. Organizational & Institutional	E. Community & Regional	F. Societal & National	G. Global
13. ☐	Biology	☐	☐	☐	☐	☐	☐	☐
14. ☐	Chemistry	☐	☐	☐	☐	☐	☐	☐
15. ☐	City, Regional, & Urban Planning	☐	☐	☐	☐	☐	☐	☐
16. ☐	Economics	☐	☐	☐	☐	☐	☐	☐
17. ☐	Education	☐	☐	☐	☐	☐	☐	☐
18. ☐	Epidemiology	☐	☐	☐	☐	☐	☐	☐
19. ☐	Genetics	☐	☐	☐	☐	☐	☐	☐
20. ☐	Geography	☐	☐	☐	☐	☐	☐	☐
21. ☐	Health Behavior & Health Education	☐	☐	☐	☐	☐	☐	☐
22. ☐	Medicine	☐	☐	☐	☐	☐	☐	☐
23. ☐	Nursing	☐	☐	☐	☐	☐	☐	☐
24. ☐	Nutrition	☐	☐	☐	☐	☐	☐	☐
25. ☐	Physiology & Exercise	☐	☐	☐	☐	☐	☐	☐
26. ☐	Psychology	☐	☐	☐	☐	☐	☐	☐
27. ☐	Pharmacology	☐	☐	☐	☐	☐	☐	☐
28. ☐	Sociology	☐	☐	☐	☐	☐	☐	☐
29. ☐	Statistics	☐	☐	☐	☐	☐	☐	☐
30. ☐	Other #1 (specify):	☐	☐	☐	☐	☐	☐	☐
31. ☐	Other #2 (specify):	☐	☐	☐	☐	☐	☐	☐

V. Indicate all **methods of analysis** mentioned or implied as part of the project background, data collection, intervention, or analysis (select all that apply):

		Qualitative		Quantitative	
		A. Laboratory	B. Field observation	C. Laboratory	D. Field observation
32.	**Experiment** (random assignment to conditions created by variable manipulation)	☐	☐	☐	☐
33.	**Quasi-experiment** (use naturally-occurring variables for nonrandom assignment to groups)	☐	☐	☐	☐
34.	**Nonexperiment** (observe without manipulation)	☐	☐	☐	☐

VI. Indicate your subjective rating of the proposal regarding its **type** of cross-disciplinary integration (select one):

35.

	Type	Definition of cross-disciplinary integration type	Example of cross-disciplinary integration type
☐	(1) Unidisciplinary	***Unidisciplinarity*** is a process in which researchers from a *single discipline* work together to address a common research problem.	A team of pharmacologists collaborate on a laboratory study of the relationships between nicotine consumption and insulin metabolism.
☐	(2) Multidisciplinary	***Multidisciplinarity*** is a *sequential* process whereby researchers in different disciplines work *independently*, each from his or her own discipline-specific perspective, with a goal of eventually combining efforts to address a common research problem.	A pharmacologist, health psychologist, and neuroscientist each contribute sections to a multi-authored manuscript that reviews research in their respective fields pertaining to the links between nicotine consumption, changes in brain chemistry and caloric intake induced by nicotine, and physical activity levels.
☐	(3) Interdisciplinary	***Interdisciplinarity*** is an *interactive* process in which researchers work *jointly*, each drawing from his or her own discipline-specific perspective, to address a common research problem.	A pharmacologist, health psychologist, and neuroscientist conduct a collaborative study to examine the interrelations between patterns of nicotine consumption, brain chemistry, caloric intake, and physical activity levels. Their research design incorporates conceptual and methodological approaches drawn from each of their respective fields.
☐	(4) Transdisciplinary	***Transdisciplinarity*** is an *integrative* process by which researchers work jointly to develop and use a shared conceptual framework that *synthesizes and extends* discipline-specific theories, concepts, and/or methods to create *new* models and language to address a common research problem.	A pharmacologist, health psychologist, and neuroscientist conduct a collaborative study to examine the interrelations between nicotine consumption, brain chemistry, caloric intake, and physical activity levels. Based on their discussions, they develop a neurobehavioral model of the links between tobacco consumption, brain chemistry, insulin metabolism, physical activity, and obesity that integrates and extends the concepts and methods drawn from their respective fields.

VII. Indicate your overall subjective rating of the proposal regarding the **scope of transdisciplinary integration**. In other words, indicate the breadth or extent to which there is integration of analytic levels, analytic methods, and discipline-specific concepts (circle one number):

36.

1 2 3 4 5 6 7 8 9 10

None Moderate Substantial

VIII. Indicate your overall subjective rating of the **general scope of proposal**. In other words, indicate the breadth or extent to which there is inclusion of various disciplines represented in the proposal, investigators from different disciplines, analytic levels, and analytic methods (circle one number):

37.

1 2 3 4 5 6 7 8 9 10

None Moderate Substantial

Appendix A4
Questions on basic quality criteria for transdisciplinary research (Bergmann et al., 2005, 28-34)

Possible answers: Yes; Yes, but…; No; Inapplicable

Actors and Competences
1. Do the disciplinary composition and the competence in the team permit the treatment of the essential aspects of the problem or of the study?
2. Is the competence of the practice partner appropriate to the everyday life problem and its solution (relevant knowledge, role in the projects, possibilities for implementing results)?
Problem formulation, focus, goals, and criteria of success
3. Does the project take up an everyday life problem, and how is this problem relevant
4. Is the everyday life problem adequately translated into scientific questions? Is the current state of knowledge taken into consideration and can the research question be regarded as innovative in relation to this state of knowledge
5. Is a common research object formulated that covers the whole research team, and can it serve in the research process as a basis for knowledge integration
6. Has the project team formulated plausible criteria for success of the project?
7. Is a distinction made between goals of scientific knowledge and goals of practice? Are reasons given for the focus?
8. In the research project, is flexibility ensured by permitting research with as few normative goals as possible (the desired goal situation in the realm of practice; not anticipating results)?
9. Do the methods envisioned, the interfaces of transdisciplinary collaboration, the form of integration in practice, and the form of results and products in the project fit the solution strategy sought for the project goal?
10. Does the structuring of the project (work steps, connection between modules, integration steps, etc.) correspond to sensible processes of generating and integrating knowledge in research process and to the requirements of the participating actors?
11. Have means and opportunities for the specific tasks of coordinating, integrating, and organizing a transdisciplinary research project been planned?
Work planning and project management
12. Did the research team plan the work jointly?
13. Are the kind of project management and decision-making structures described, and do they seem to promise success under the conditions of the project?
14. Are suitable methods used or have they been developed to conjoin contributions of knowledge from participating scientific fields and practice?
15. Are there regular reflection on the cooperation in the team and on the implementation plans for knowledge integration? If applicable, are conclusions drawn from this?
16. Are the planned procedures of self-reflection and quality assurance used (“revision points”) and, if applicable, are adjustments made (procedure, structure, products)?
Results
17. Have the scientific goals been achieved? Do scientific innovations (methodical/conceptual) come about
18. Can the results make a contribution to solving the everyday life problem
19. Are the criteria of success set by the research team being fulfilled?
20. Do Publications and other products (For example, changes in actors strategies, organisational reforms, social network structures, guides, ranging., artefacts) represent an appropriate yield from the project?
21. Are the methods and procedures of transdisciplinary knowledge integration and collaboration presented and their success/problem reflected
22. Are the publications and products tailored to the needs of and actively conveyed to the target groups?
23. Are the elucidations on whether and how research results that are context-related or worked out on the basis of a model case can be generalized
24. What additional use for the research result does the transdisciplinary approach have in comparison with other research approaches?

Appendix A5
Guiding questions for ex-post self evaluation of transdisciplinary research for sustainable development (Späth, 2008, 225)

Normativity
What are the values and objectives of the relevant stakeholders? How are they empirically investigated?
In what way does the project relate to sustainable development?
What objectives and normative orientations have been adopted?
What is the role of the project with regard to the broader discourse on sustainable development?
Integration
What links or contexts are considered by the project that disciplinary science would ignore? What is the comprehensive problem definition?
What forms and sources of knowledge (theories, experiences, etc.) does the project integrate? How is this conceptualised?
What social differences are bridged by the research process? By what procedures?
How is the processing of subtasks coordinated? How are partial results integrated? How does the project secure a balance between focusing on specifics and keeping the whole picture in mind?
Participation
What functions do scientists and stakeholders fulfil for the project flow? What different roles do they play in the project?
According to which criteria have they been selected for participation?
By what procedures are they integrated into the workflow?
How are practitioners', or stakeholders', perspectives integrated into the project results? How meaningful are the project results for their day-to-day practice?
What constellations of interests and power are found in the field of enquiry? How does the project deal with them?

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