SCIENCE POLICY FOR TRANSDISCIPLINARY RESEARCH

K. Kastenhofer
Institute of Technology Assessment (ITA), Vienna, Austria

I. Omann
Sustainable Europe Research Institute (SERI), Vienna, Austria

S. Stagl
Science and Technology Policy Research (SPRU), University of Sussex, UK

K. Steininger
Department of Economics and Wegener Center for Climate and Global Change, University of Graz, Austria

Keywords: education, interdisciplinarity, post-normal science, research career, science and society, science policy, sustainable development, transdisciplinary research

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Summary

Sustainable development represents a challenge not only to science but also to science policy since it relates to an enormously wide range of societal goals. Thus, research for sustainable development—in addition to monodisciplinary approaches—ultimately has to address and integrate these various goals. In order to do so, transdisciplinary research crosses disciplinary boundaries and involves the publics concerned, national governments and individual stakeholders. While it has become evident that it is necessary to address sustainability problems jointly by a number of disciplines and

actors, it has not yet been fully acknowledged that transdisciplinary research needs new approaches and offers new opportunities and challenges. New demands as well as potential problems of such transdisciplinary science also set new requirements for science policy. Despite increased recent endeavors, particularly in some European countries, to support transdisciplinary research through suitable policy measures, knowledge on how to support this type of research is still in its experimental phase.

In summary, the conclusions drawn in this article are the following: First, for fostering transdisciplinary research four prerequisites have to be met. These are (1) the possibility of a societal, extra-scientific definition of the research area, (2) the existence of a societal demand for a problem solution, (3) the possibility of a pooling of funding, and (4) the willingness to cooperate between institutions, science and society. Given these four basic requirements, it is the task of science policy to take account of the characteristics of transdisciplinary research by meeting the demands stated in this article in particular with respect to evaluation criteria, project management, funding level, and resource structure. Although tertiary education for transdisciplinary competences can be influenced only indirectly by science policy, in assigning an adequate time horizon for transdisciplinary research programs, science policy can allow for complete career steps to be accomplished under the criteria of transdisciplinarity, and, equally important, allow for a socialization of researchers in this field so that they may develop the additional social and communicative competences and trans-scientific skills which are necessary for transdisciplinary research. Trans-scientific capacity building, competence development and quality assurance beyond the individual research projects and programmes are important corollary activities.

1. Introduction

Transdisciplinary research has strongly developed as a response to the demands of sustainable development. The term was coined throughout the first international conference on interdisciplinarity in 1970 in France (see *Unity of Knowledge and Transdisciplinarity: Contexts of Definition, Theory and the New Discourse of Problem Solving*) by the French developmental psychologist Jean Piaget and further elaborated by the Austrian astrophysicist Erich Jantsch. Sustainable development relates to a range of societal goals. Research for sustainable development ('sustainability research') thus ultimately has to address and coordinate these goals as far as possible. For several reasons monodisciplinary research encounters limits in achieving this task. First, problems of sustainable development extend across many scale levels of time and space as well as across various qualitative dimensions (ecological, cultural, economical, political, etc.). Second, the interrelations between society and nature are characterized by significant uncertainties, irreducible complexity and subjective valuations and thus allow for a plurality of legitimate perspectives. Third, the scientific approaches and normative attitudes involved in problem-solving strategies are not only divers, but eventually incompatible. Research that tries to address this type of problem situation is usually called transdisciplinary research. Such research does not merely respond to demands from its scientific community but also addresses the tensions with and within the public, political and economic domains. To support such a novel type of research presents a challenge not only to researchers but also to science governance. Questions

of how to promote this type of research with respect to the special character of transdisciplinary research are analyzed in this article.

2. Transdisciplinarity

2.1. Definitions of transdisciplinarity

In the literature numerous definitions of transdisciplinarity are given. Frequently, inter- and transdisciplinarity are either not distinguished or used interchangeably. This leads to differing focuses or even to a contradictory use of the term (see *Methodology of Transdisciplinary Research*). Following a broad understanding, transdisciplinary research answers to a practical societal problem situation (see *Unity of Knowledge and Transdisciplinarity: Contexts of Definition, Theory and the New Discourse of Problem Solving*). Monodisciplinary specialists as well as scientists oriented towards a wider integration of disciplines, theoreticians as well as practitioners, politicians as well as the general public or individual stakeholders who are confronted with such applied research are not only part of transdisciplinary research processes but also contribute to its implicit definition and shape the way it is realized. Following the aim to encompass a broad perspective, the list of attributed qualities has become rather long and difficult to summarize when no single demand or specific level of discussion is specified. As this article is meant to address transdisciplinary research *in general*, no specific theme has been selected, but the article occasionally refers to questions of "sustainability" or "environmental problems" as specifying examples, thus trading off precision against universal validity.

However, some detail concerning the definition of transdisciplinarity is presented. In sections 2.1.1-2.1.3 three complementary traditions of defining transdisciplinarity are compared. The first one stems from philosophy of science and discusses the special attributes of transdisciplinary concepts as *epistemic units* of our knowledge system. The second one originates in science studies and draws on a *wider definition* of science as a social system engaged in the production of knowledge. The third approach is derived from concrete experience with research projects, their achievements and shortcomings in meeting their predefined goals, and is primarily concerned with the *actual process* of transdisciplinary research performed by scientists in cooperation with practitioners and the public concerned. Each approach is making important contributions to the advancement of transdisciplinary science, although exchange between these approaches has so far been rather limited. This is unfortunate because transdisciplinary research, which is meant to go beyond strict disciplinary borders, needs to explain, to clarify and legitimate itself to a *broader public with multiple backgrounds*. Pluralism of self-definition and different contexts of self-clarification may help to reach this diverse public in a fruitful way, but lively exchange between the different approaches is necessary to promote critical self-esteem, common goals and quality assurance for transdisciplinary research in the future.

2.1.1. Transdisciplinary Concepts in the Philosophy of Science

Science can be represented as a hierarchically ordered system consisting of broader

fields (such as the natural sciences, humanities and arts), of singular disciplines and of further differentiated subdisciplines. This hierarchical representation is mirrored in the traditional university structures and the division of universities in faculties, institutes or departments, and research groups.

From this point of view, *transdisciplinary concepts* can either be described as working on a supra-disciplinary level, thus on a hierarchical level above the disciplinary science system and its further sub-disciplinary differentiation (see Figure 1). Or they can be described as shifting the hierarchical structure according to their supra-disciplinary aims and thus contradicting current hierarchical patterns of scientific organisation. In this latter case, the units of science are regrouped following the specific logic imported by a certain transdisciplinary concept.

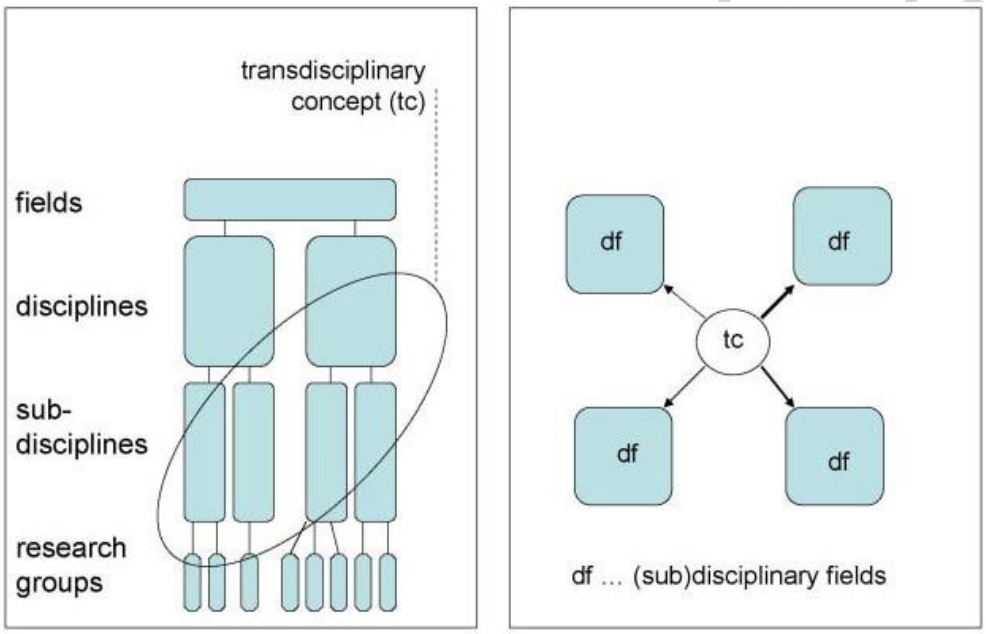

Figure1: Hierarchical Levels of Science

In any case, transdisciplinary concepts do not represent a mere transfer of concepts from their discipline of origin to a multitude of new contexts. They are situated on a *supra-disciplinary level* from the very beginning of their formulation, and therefore refer to contexts of relevance beyond disciplinary boundaries.

Against this conceptual background, two different types of transdisciplinary concepts can be discerned: models and tools generated by formal disciplines like mathematics and logic on the one hand, and conceptual systems like those of “structuralism” or the “general systems theory” on the other hand (see *Methodology of Transdisciplinary Research*, see *Systems Analysis and Modelling in Transdisciplinary Research*). Their introduction not only resulted in a blurring of disciplinary boundaries, but also in a regrouping of the involved disciplines, a reformulation of the relationship between these disciplines and a shift in the perception of the object world in general.

2.1.2. Transdisciplinary Research as 'Post-normal Science'

Despite the appealing clarity of the above definition of transdisciplinary concepts, it should be added that transdisciplinary *research* encompasses far more than the mere use of a specific type of theoretical entity. Especially from a pragmatic point of view, research may be conceptualised as methodological action and as scientific *activity*, situated in any of the following: in laboratories, in the field, in offices or in discussion groups.

The type of research activity that is considered suitable for answering a research question obviously depends on the underlying problem situation. As Funtowicz and Ravetz have pointed out, environmental problems often lack neat and simple solutions: the facts are uncertain, values are in dispute, the stakes are high, and the decisions are urgent. The research itself, including crucial decisions about which aspects should be ignored and which others should be taken into account, becomes part of the societal decision making process. This requires opening the research activities to broader categories of both, facts considered and actors involved, than those traditionally thought of. Applicability and social robustness rather than the goal of achieving abstract truths or de-contextualised knowledge become the guiding principles of research. To capture this type of research Kuhn's 'normal science' is contrasted to 'Post-Normal Science'. While puzzle-solving by experts within a paradigm (Kuhn) still takes place in basic research, Post-Normal Science has emerged as an issue-oriented iterative process involving knowledge of researchers as well as of practitioners. In this sense, 'Post-Normal Science' explains why participation of different actors is necessary. It helps ensure that the given societal goals can be pursued effectively with the help of transdisciplinary projects.

In this manner, science can be seen as one subsystem out of many within society, allowing for the integration of actions, participants and factual knowledge. These components and their relation towards each other are not necessarily fixed and constant. Moreover, this type of science does not supply us with the one and only truth, but with one or more possible means for interpreting social situations.

These aspects indicate that problem-oriented (or mission-oriented) environmental research has many characteristics of a new type of knowledge production. This type of knowledge is produced in the context of an application, in a transdisciplinary way, by people with heterogeneous skills and experiences, oriented towards social robustness, and with extended quality control (see section 2.2). It has been labelled as 'Mode 2 science' and has been discussed in detail by Michael Gibbons and colleagues (see bibliography). Inhowfar the knowledge production per se has changed or merely our perception of it, has been a matter of debate until today in the field of science studies.

2.1.3. Definitions of Transdisciplinary Research

Monodisciplinary, multidisciplinary, interdisciplinary and—most recently formulated—transdisciplinary research mark a development from high scientific specialization to maximum re-integration of different scientific domains as well as of scientific, political

and social systems in order to address given societal problem situations.

Monodisciplinary research works with hypotheses as means of answering to research questions that stem from within a single scientific field. We have to be aware, that such a monodisciplinary 'problem formulation' differs from socially perceived 'problem situations' in fundamental ways.

Multidisciplinary (sometimes also called pluridisciplinary) research is motivated by wider questions, and tries to bring together knowledge from different disciplines. A research topic is not only studied in one discipline, but—separately—in several disciplines at the same time. The understanding of the topic is not only improved by an adequate multidisciplinary approach, the individual disciplinary insights gained also lead to contributions to the single disciplines.

Nevertheless, monodisciplinary and multidisciplinary approaches proved unsatisfactory for several reasons: (a) too much abstraction from important factors in the problem definition takes place (problem of de-contextualisation); (b) multi-faceted complex problems are captured only fragmentarily by adding up monodisciplinary knowledge (problem of contingency); (c) the methodology and terminology used within one discipline may be incompatible with the methodology and terminology used within another discipline (problem of incommensurability). This has led to a call for new approaches capable of tackling the wider questions, which have been subsumed under the labels ‘interdiscipliplinarity’ and transdisciplinarity’.

Interdisciplinarity is defined in various ways. In addition to crossing disciplinary boundaries in one or the other way, some or all of the following requirements have to be met:

- joint definition and elaboration of the research;
- adoption of findings from other disciplines;
- fundamental familiarity with tools of co-workers;
- joint elaboration of the central concepts;
- integration and joint presentation of findings.

A *transdisciplinary* approach takes the integration of disciplines a stage further. It begins with the identification of a societally relevant problem and aims at contributing to its solution. For some authors this problem-orientation alone is sufficient to characterize transdisciplinarity. Increasingly, however, the cooperation between scientists, practitioners and the publics concerned is emphasized. In this sense, transdisciplinarity is to be understood as being complementary to monodisciplinary and interdisciplinary research. Transdisciplinarity is nourished by and draws upon monodisciplinary expertise. By confronting the different disciplines in turn, new concepts and logical structures are generated which subsume and extend even the interdisciplinary approaches. A call for transparency and public participation accounts for the political agency of transdisciplinary research. Transdisciplinary research is therefore often conducted in a participatory way, i.e. researchers are working with the parties and users involved in a problem situation (see *Actor Participation and*

Knowledge Dissemination in Transdisciplinary Research).

Uncertain, ambiguous and case-specific knowledge as well as (occasional) blurring of the boundary between science and societal agency are constitutive for transdisciplinary research. This need not lead to the dissolution of existing science (following the complementary approach), but to additional expertise for and new modes of science and research. Moreover, the very mode of combining disciplinary, interdisciplinary and transdisciplinary research and different kinds of relating expertise is currently being further discussed and elaborated (cf. the framework presented by Collins and Evans 2007 or the risk governance approach published by Renn in 2005).

In the following pages the term 'transdisciplinarity' will be used in the sense of 'transdisciplinary research' as defined above.

2.2. Transdisciplinarity and the Changing (Self-)Perception of Science

Modes of defining transdisciplinary science are not, as indicated in the previous sections, independent of modes of defining science *in general*. Even while the necessary attributes of transdisciplinarity are being formulated, the underlying picture of science itself is shifting. This section gives a very brief overview of this interdependency, although it should be noted that this topic is presently controversial.

The calls for "a new production of knowledge" by means of transdisciplinarity are not only cause but also effect of a new picture and self-perception of science and scientists. Accordingly, definitions of transdisciplinary concepts and research not only differ from definitions of monodisciplinary concepts and research in that they simply encompass a *broader* field of interest, but also because they often adopt a 'modern' or even 'post-modern' point of view as opposed to 'traditional' *(self-)definitions of science*. Here, a change in the general perception of science and the rise of a new mode of science can be seen as interwoven. If, for instance, science is re-interpreted as a discursive process, or a particular cultural structure, the general definition of science changes. Mono-, multi-, pluri-, inter- and transdisciplinary science are *all* seen in a different light. In contrast, when closer attention to the participatory character of science is required, *trans*disciplinary science alone is of concern. The latter demand is due to specific tasks that a certain new type of research should fulfill, the former derives from newly formulated requirements that science in general should provide for, e.g. social robustness.

Consequently, transdisciplinary science as a rather new phenomenon faces challenges and opportunities resulting from the present redefinition of science on the one hand, and from its transdisciplinary character on the other hand. Some authors have taken an extreme position and have called for a combination of these two points, aiming for transdisciplinarity as the *only* legitimate way of practicing science, because transdisciplinarity alone is (in principle) able to fulfill both demands at the same time. It may combine a 'new production of knowledge' and answering to societal problem situations. The evaluation of science would then be reduced to an evaluation of its transdisciplinary character.

Others still stress the importance of monodisciplinary experts and basic research, as being of complementary importance to processes of mission-oriented integration and adaptation. This debate is broadly paralleled by the question, whether our education system should primarily focus on the education of generalists or specialists or both.

In any case, whether transdisciplinarity is seen as a complementary or a substitutive mode of scientific research, defined as a 'missing link' between traditional science and societal problem solving, or as a totally new mode of science, its realization not only brings about answers to old problems, but also new weaknesses, which need special consideration.

Two points raised by (post-)modern science theory illustrate the relevance of these distinctions for science policy:

- Science in general plays a threefold role for sustainable development: science may itself cause sustainability deficits (e.g. via its technological application), science is used to identify and explain sustainability deficits (via its theoretical background and aggregated pool of knowledge) and science is applied to prevent or to solve sustainability deficits (via both). Science policy has to be aware of this plural interrelation. General financial support of science need not automatically result in an improvement of a society's degree of sustainability.
- There are mutual interdependencies between transdisciplinary science and society due to the deficiency and lack of scientific systems knowledge and due to the conflicting values and preferences involved. But while science can content itself with reporting uncertainties and describing conflicts, science policy has to make decisions and bear responsibility, that science itself cannot make or bear.

Both points serve to show that considerations of a truly political character play an important part in our scientific system, and that we have to choose between taking these into account in a conscious, transparent and democratic way or leaving the necessary decisions to individual stakeholders and chance.

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Biographical Sketches

Karen Kastenhofer graduated in biology/ecology in 2000 at the University of Vienna. In 2005, she completed a doctoral thesis on the epistemic enculturation of biology students. In 2005-2007 she joined the research project 'Nichtwissenskulturen' at the University of Augsburg. Since February 2007 she is a research member at the Institute of Technology Assessment (Austrian Academy of Sciences, Vienna) in the field 'governance of technological knowledge'. Her research focuses on social and cultural studies of the life sciences and on scientific and societal ways of dealing with risk, uncertainty and controversial opinions in the context of biotechnology.

Ines Omann, received her masters degree in Economics and Environmental Systems Sciences at the University of Graz and the School of Economics and Management in Lund (Sweden) and her PhD in Ecological Economics in 2004 at the University of Graz and Leeds. After her graduation 1997 she worked as a research fellow, at the Joanneum Research in Graz, Dept. of Technology and Regional Policy, and at the Wuppertal Institute for Climate, Environment and Energy. From 1999 to 2001 she was an Assistant Professor at the Department of Economics, University of Graz. Since then she is teaching environmental sciences and sustainability in Graz and at the University of Applied Life Sciences in Vienna. Since 2004 she is a senior researcher and team leader at the Sustainable Europe Research Institute in Vienna. Her main research interests are in the fields of sustainability science, integrated assessment, quality of life research.

Sigrid Stagl is a senior research fellow at Science and Technology Policy Research (SPRU), University of Sussex. Her research interests lie in (1) the analysis of human behaviour and behaviour change (e.g. by use of agent-based modelling), and (2) environmental valuation / sustainability appraisal (e.g. by use of participatory multicriteria appraisal). She was awarded the first PhD in Ecological Economics worldwide and co-authored (with M Common) a book on Ecological Economics (2005, Cambridge University Press). She is currently Vice-President of the European Society for Ecological Economics.

Karl Steininger received his education in Economics and Computer Science at the University of Vienna and UC Berkeley. In research he specialized in environmental, and ecological economics, and in international trade. Since 1999 he is professor at the Department of Economics and since 2004 deputy chair of the Wegener Center for Climate and Global Change, both at the University of Graz, Austria. Further he is a member of the Austrian National Global Change Committee. He is lecturer at the Vienna based University of Life Sciences. Previously he held positions in the World Bank (Environment Department) and at the University of Triest, Italy (Guest Professor).