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METHODS FOR TRANSDISCIPLINARY RESEARCH

A Primer for Practice

campus

Methods for Transdisciplinary Research

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A Primer for Practice

Preface by Julie Thompson Klein
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Campus Verlag
Frankfurt/New York

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Bibliographic Information published by the Deutsche Nationalbibliothek.
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie;
detailed bibliographic data are available on the Internet at <http://dnb.d-nb.de>.
ISBN 978-3-593-39647-7

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Cover illustration: © Marco Birn/www.fotolia.de

Cover design: Campus Verlag GmbH, Frankfurt-on-Main

Typeset: Harry Kleespies and Edith Steuerwald, Frankfurt-on-Main

Printing office and bookbinder: Beltz Druckpartner, Hemsbach

Printed on acid free paper.

Printed in Germany

This book is also available as an e-book.

For further information:

www.campus.de

www.press.uchicago.edu

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Preface to the English edition

The English edition of *Transdisciplinary Research Methods* appears at a propitious time in the history of interdisciplinarity, for two reasons. The first is the growing prominence of transdisciplinary research (TDR) for solving “real-world” problems. The second is heightened focus on integration methods for the process of TDR. This book benchmarks the importance of the Frankfurt-based German Institute for Social-Ecological Research (ISOE) and the German-language literature in both the discourse and the praxis of TDR.

The scope is wide, broadening and deepening understanding of integration in its communicative, social and organizational, and cognitive-epistemic dynamics. The book also illuminates multiple types of integration, while eschewing shortsighted assertion of a universal method for subject-specific and situation-specific contextualization. Appropriate choice of method is realized, in the authors’ words, in “concrete occasions” and “constellations of disciplines and stakeholder views” that limit and order the need for integration. Yet, informed choice is crucial. *Transdisciplinary Research Methods* builds capacity for informed choice at every turn in its unique structure.

Chapter II’s “decontextualized essence” presents a compendium of individual methods decoupled from their problem fields and research settings. It is paired deliberately with Chapter III’s “contextualized practicality” of methods and integration histories from particular projects. Moving between the nomothetic and the idiographic simultaneously advances general understanding and appreciation of contextualized needs. Chapter IV synthesizes knowledge of supportive aspects of managing integration in TDR processes and networks. Textual and graphic “Further instructions for use” in Chapter V then guide readers through integration methods in the early chapters. A phase-centered method matrix situates TDR in accordance with the ISOE model, and the book’s rich repertoire of methods-

instruments-tools-strategies is situated in terms of process-related functions.

All integration methods, the authors assert, have one overriding characteristic in common: serving the goal of helping to solve integration tasks in problem-oriented TDR. Mindful of the complexity of tasks, the authors describe their volume as a “beginning step” in building a canon of methods and a community of transdisciplinary thinkers. Their foundational step synthesizes lessons from key projects and tested methods that include hypothesis and model building, integrative assessment procedures, boundary objects and concepts, heuristics, research questions, artifacts and products, mutual learning, and stakeholder participation. It would be harder to accomplish TDR without such standardized pathways. Yet, the authors do more. Methods often need to be adapted and new interdisciplinary methods and integrative epistemic objects created. The continuous process of making adjustments refigures transdisciplinary research process from mere transfer and translation to the generative complexities of iteration, revision, reconnection, reconciliation, and recursiveness. As selected terms are generalized, their “interdisciplinary connectivity” transports once singular meanings into “transdisciplinary usage.” Only through the feedback between discourse and practice provided by this book can we fully understand and conduct transdisciplinary research. The prospects are greatly enhanced by its availability to a large international audience.

May 2012,

Julie Thompson Klein

(Professor of Humanities in the English Department and Faculty Fellow for Interdisciplinary Development in the Division of Research, Wayne State University)

Foreword to the English edition

The German edition of this book, published in 2010, was the result of several years of research on methods, quality standards and evaluation procedures in transdisciplinary research. Based on our experiences in the field of transdisciplinary social-ecological research we aimed at laying a foundation for codified, continuously growing knowledge and scholarly quality standards on how to methodically use the transdisciplinary research approach. Feedback on the publication of the methods book confirmed that we had identified an existing demand. In addition, a development has started which, at that time, we did not pay any particular attention to: our transdisciplinary research process model, along with the methods collection, is now used for the teaching of students at all levels. These teachings encompass on how to conceptualize and implement transdisciplinarity to solve societal problems that cannot be addressed by means of a single discipline.

With the English translation we now try to link this positive feedback from the German speaking community with the growing international discourse on transdisciplinarity. This discourse mirrors the increasing awareness in the scientific community that the transdisciplinary approach is most useful, maybe even inevitable, when it comes to investigating societal problems. The transdisciplinary research approach and its scholarly foundations therefore are of ever-growing importance, as can be seen in sustainability sciences in particular. Thus, the backbone of widely acknowledged concepts and methods is required to make transdisciplinary research processes a success, on both their epistemic paths: for a transformation to a better state in the societal problem field and for innovative (e.g. methodological) developments in the sciences (cf. Jahn 2008; Mobjörk 2010). Furthermore, the implementation of transdisciplinary curricula that combine disciplinary rigor with parallel seminars devoted to complex real-life problems that transcend disciplinary boundaries (<http://curriculumreform.org>) has been started and shared across a considerable number of disciplines and countries

(e.g., McGregor/Volckmann 2011; Elkana/Kloepper 2012; Klein 2010). Science studies take up the subject of transdisciplinarity, of case studies, and their idiographic and nomothetic aspects (Krohn 2010; Frodeman et al. 2010; Hirsch Hadorn et al. 2010; Repko et al. 2011).

Thus, the number of publications referring to transdisciplinarity has increased exponentially over the past years as recently shown by Jahn et al. (2012). And one can observe the growing diversity of societal (problem) fields making use of the transdisciplinary research approach (e.g., Kirst et al. 2011; Doucet/Janssens 2011; Leavy 2011; Cutler 2011; Tröndle/Warmer 2011). This makes us confident that the methods and instruments described in this book will help bring about a reflective, integrative, and method-driven approach to transdisciplinary research in an ever growing community.

Acknowledgements

With our very specialized German publication, its often complicated sentence structures, covering so many different fields of research and aspects of philosophy of science and transdisciplinarity, we pushed Ronald C. Faust and Monika Miller into a truly difficult job taking many months. Therefore, we wish to express our deep respect to well-read Ronald C. Faust for his knowledgeable translation and to Monika Miller for her insistent, detailed and attentive editing. Without them we would have been lost completely.

Many thanks of course, to Julie Thompson Klein for encouraging us to publish this book in English and for her supportive preface.

Last but not least, we appreciate the professional and helpful support of Edith Steuerwald and Harry Kleespies who managed the typesetting for both editions.

This English edition was made possible through the generous funding from the German Federal Ministry of Education and Research (in the context of the project tdPrax2, FKZ 01UT1004) and the ISOE—Institute for Social-Ecological Research, Frankfurt am Main.

Matthias Bergmann (for the authors)

ISOE—Institute for Social-Ecological Research, Frankfurt am Main, May 2012

Introduction to the 2010 German edition

A book on scientific methods for transdisciplinary research? That certainly sounds like ivory tower thinking and, some might say, a contradiction. For isn't the transdisciplinary approach to research one that takes real-world problems—that is, those arising out of the center of society—as the object of its studies? Can one really develop scientific methods that go beyond the production of individual case studies for such an approach, bound as it is so tightly to specific societal contexts? Yes, it is possible to come up with good—that is both understandable and rigorous—descriptions of such methods, though it is not an easy task. But despite the difficulties we have made the attempt.

The book that has resulted is not a theoretical rulebook and it is not lacking in practical relevance. To the contrary: this book rose from the need of researchers for support in their actual research work, support in the form of a document that collects in one place successfully developed and tested methods for the integration of knowledge in such a way that these methods can be used successfully in many different kinds of transdisciplinary research projects. At the same time, this book marks the completion of a particular project, *tdPrax*¹, itself part of a series of research projects carried out at the ISOE—Institute for Social-Ecological Research since 2001. The aim of the meta-project was to analyze and investigate the scientific concept of transdisciplinary research, its quality criteria, and its methods.

According to Mittelstraß (2005), transdisciplinarity is a “principle of research and science” but not a method. That is, no doubt, an appropriate formulation, as far as it goes. Now let us try, however, to look behind the

¹ tdPrax: Strengthening Transdisciplinary Research Practice—Synopsis and Guide to Concepts, Methods and Quality Management. tdPrax was funded as part of the funding program “Social-Ecological Research” initiated by the German Federal Ministry of Education and Research (BMBF) (FKZ 07IF518).

narrow idea of a principle by drawing on the experience of more than two decades of research and scientific practice. Then we shall see that this *principle*, remarkably, bears traces of the turmoil currently convulsing the sciences. Carried out at the interface of society and science, transdisciplinary research explores and finds solutions for societal problems, by making these problems, and the societal actors involved, a central reference point of research and by further developing the scientific research tools it has employed.

We may apply the somewhat over-used slogan of the “excellence and usefulness” of research to the transdisciplinary approach. For transdisciplinary research means the pursuit of a certain epistemological principle, according to which two paths for acquiring knowledge are to be followed simultaneously—a path committed to the exploration of new options for solving societal problems (*the practical path*); and a path committed to the development of interdisciplinary approaches and methods (*the scientific research path*), without whose help following the practical path would be hardly possible or not possible at all. Instead, however, of using the two fashionable terms we could just simply say that transdisciplinary research delivers high quality solutions for practice actors facing societal problems (and is in that sense “useful”) and provides discipline-related and/or interdisciplinary scientists with the means to improve their methods (thus, resulting in “excellence”). By linking these two epistemic paths transdisciplinarity thus offers science the possibility of new developments in the production of knowledge.

Transdisciplinary research is a new mode of the production of knowledge. For, if hybrid societal problems are translated into scientific issues during the transdisciplinary research process, then a new complex structure involving different scientific fields and disciplines is created. And this complex web of researchers and specialized knowledge has to be involved as a whole in the research process. At the same time, researchers with their potential knowledge must be linked to practice actors involved in the research process, who are working on strategies to be used to solve societal problems, bringing with them their own potential knowledge. This latter link is achieved by means of an integration process carried out continuously throughout the research endeavor. The research methods that have been developed during this process—to a certain extent inevitably—over the course of years of transdisciplinary research have been modified as needed in the face of the hybrid nature of the issues dealt with, and suc-

cessfully applied to these, proving themselves important for *both* paths to knowledge. The new methods developed have served to integrate knowledge generated throughout the research process. In this sense, transdisciplinarity is, then, not a method; rather, it is a way of doing science, a mode producing knowledge that requires research methods developed and adapted to its own specific approach. Identifying, describing and ordering these methods, moreover, is a reasonable and critical task—the task, in fact, of this book.

This book is based on research work during which concrete transdisciplinary research projects were analyzed. A screening of numerous completed transdisciplinary projects was undertaken, a screening that looked at the methods of knowledge integration employed during each project. The final selection of the projects whose methods were included in our account was guided by two thoughts: that they represent the broadest spectrum possible of transdisciplinary research in terms of their problem dimension (that is, whether focused more on societal issues or scientific ones); and in terms of their main research goal (divided into the categories “understanding—concept development—implementation/solution development”).

The context dependence of transdisciplinary research, however, leads to fundamental problems when attempting to describe and order methods of knowledge integration. The methods of a transdisciplinary knowledge integration are normally described as relating to a specific societal problem and in the context of the specific constellation of a given research team, one composed of various disciplines, scientific fields and societal experts—that is, as case-related. If, then, one wants to apply these methods to any other transdisciplinary problem and discipline, these methods must be decoupled from their original contexts—that is, decontextualized—and described in general terms.

In this book we have tried to find descriptions of methods and instruments of knowledge integration that provide maximum usefulness across many different transdisciplinary research contexts. To this end we chose an analytical description of the methods, one which focuses on their tasks and functions within the processes of integrated knowledge production. However, we also wanted to not lose sight of the importance of the context in which the problems and actors were situated. Therefore we describe the methods selected also in the context of their research projects. In this way, both individual integration methods for research processes in general and context-related overall integration strategies are made visible.

We wish to make a contribution with this book to broadening the knowledge base available to both those who wish to work following the transdisciplinary principle and those interested in transdisciplinarity and knowledge integration for other reasons. We believe it is important, given the particular epistemological opportunities mentioned above—for both society and science—to document and therefore make available the theoretical, conceptual and methodological basis of this principle of science. To this end, this book is not intended as a self-contained canon; rather it should be regarded as a foundation to be built upon and enriched. For transdisciplinary research, because of its diverse references to the social world, is open to a wide variety of concepts, methods and criteria.

Thus, though a collection of research methods remains distant from practice, it still may have an indirect effect on social reality. That, at any rate, is our hope.

Acknowledgements

For the dynamic and constructive support over several years given to our research on the methods included in this book, we thank Ingrid Balzer, Karolina Begusch-Pfefferkorn, Paul Bergweiler, Hans-Liudger Dienel, Gertrude Hirsch Hadorn, Gerd Michelsen, Monika Wächter and Gabriele Wendorf. We also wish to thank Marie Céline Loibl, Florian Keil, Uwe Schneidewind and Michael Stauffacher for their valuable input. And last but not least, we want to express our gratitude to all those whose research we have used in gathering the methods found here and who have willingly answered our questions concerning our descriptions of their integration strategies. Finally, our thanks to Edith Steuerwald and Harry Kleespies for their usual tireless and insightful work on layout and typesetting.

Frankfurt am Main, January 2010
Matthias Bergmann (for the authors)

Structure of the book and how to use it

The logical structure of each chapter of the book, as well as that of the book as a whole, is motivated by one central purpose: to support researchers as directly as possible in carrying out their transdisciplinary research. To this end we have made the following assumptions, based on our own experience carrying out transdisciplinary research.

When describing the integration methods and instruments collected and analyzed in this book we have kept two things in mind with the hope of making the book as useful as possible for dealing with integration issues. First, the methods are described in such a manner that they can be used by different transdisciplinary research projects dealing with different problem fields and drawing on different constellations of scientific fields; that is, they have a context-independent, general value. Second, it is equally important not to lose sight of the context-dependence of transdisciplinary research because what one can learn from the individual examples—that is, from the application of the methods in specific research projects with their individual problem contexts and the constellation of scientific fields—can be of great benefit for research practice as well (cf. Krohn 2008).

In addition, the first way of describing the methods—as context independent—fulfills the purpose of giving, from an epistemological point of view, a structured overview of useful integration methods. Here a position within the philosophy of science is being assumed, one which takes a stand on which specific approaches to the generation of knowledge are appropriate to transdisciplinary research.

Therefore, we have chosen to give the readers of this book, in the central Chapters II and III, first the decontextualized, then the contextualized descriptions of the integration methods and integration strategies.

In *Chapter II*, the integration instruments and methods that we have identified in concrete transdisciplinary model projects are detached from their projects and described independently of both their concrete research

contexts and the given constellation of scientific fields. At the end of the description of each of these integration methods the reader will find a reference to the specific research project from which this method either originated or which project used it in an exemplary way.

In *Chapter III*, there follows a description of those research projects whose integration methods were evaluated. To be sure, the research project is not described here in its entirety; instead, the description concentrates on the “integration history” of each project, so that the reader will, with a focus on a description of the integration tasks involved, be able to understand these tasks, and, also, the research design and the research process. By describing the integration instruments contextually one can highlight the integrative processes of particular importance for the transdisciplinary research process. Following up on the abstract description of the methods presented in Chapter II the reader is in a position in Chapter III to see the concrete ways in which the methods are used. The description of each project and its respective research strategy also makes it possible to recognize whether the integration method in question “works well” by itself or whether it promises more success for an integrative research project when used in conjunction with other methods. At the end of each project description there is a “fact sheet” that provides further information, for example, concerning project-related literature. The publications most important for the project are listed first.

How to use the method collection and examples

Since the individual chapters of this book serve different purposes and readers' interests may differ, we offer here a brief guide through the book.

Chapter I—Essential for understanding the concept of transdisciplinarity and the basis for the subsequent chapters

In this chapter the authors lay out their understanding of transdisciplinary research. This provides the groundwork for the discussions in the subsequent chapters of many of the issues involved in integrative research. The model of a reflexive transdisciplinary research process—the *ISOE model*²—is presented and a working definition of transdisciplinarity is given. We think to read this chapter is essential, since otherwise the reader will lack the basic information needed to understand subsequent chapters.

Key Chapters II (decontextualized methods) and III (methods in project context)

Depending on the reader's interest, there are various ways of using these two chapters.

Read straight through: The two chapters may simply be read in their entirety. The chapters give the reader an overview of a unique collection of integration methods brought together here for the first time, and a look at both their epistemological and pragmatic aspects. This approach will probably be useful for the more theoretically interested reader, as well as for researchers who wish to gain an overview of the integration options in order to expand the knowledge base of their research activities.

Search for an integration method: Secondly the reader might be interested in a specific method of coping with an integration task for a concrete research project. In this case we recommend looking through Chapter II first for a suitable integration instrument. The methods and instruments found there are grouped according to their integrative function within a research process. Given this structure, it would be useful to first become clear about which of the methods and instruments described would most closely match the integration needs of the reader. To that end, the chapter is divided into six sections, II.A–II.G, comprising a specific epistemic hierarchy

2 According to ISOE—Institute for Social-Ecological Research, where the model was developed.

(for more on this hierarchy, see the introduction to Chapter II). This will facilitate in many cases the identification of the appropriate method for integrative knowledge production. Here it is important to remember that to cope with an integration task more than one method may be required. To decide if this is the case, it would be helpful, after identifying a possibly suitable integration method, to read one of the illustrative examples to see what the purpose was for which the method was developed or successfully applied. To help here, the reader will find at the end of each description of a method in Chapter II—under the heading *Source*—a reference to the project in which the method was successfully used or first developed, and where to find in Chapter III a description of the method in its original research context. Looking there, readers may discover that in the project, from which the method they are interested in was derived, an ensemble of methods was employed to successfully shape an integrative research process.

Following the procedure just described—searching Chapter II for an appropriate method, then checking its original context of use in Chapter III—leads to a productive use of the combined resources—general analysis of the methods and practical assistance for the research process—provided by the book as a whole.

Overall grasp of the concept of integration: It is also possible to reverse the order. The reader then begins, first by looking at the integration concepts as contextually described in their respective projects in Chapter III, and only then turns, with the help of the cross-references (indicated by, \rightarrow *compare*), to Chapter II where the individual methods are described in isolation from their original problem and discipline context.

It is important in any case to be aware that across the entire research process there will often be a need to review the integration strategy being used again and again, and to adjust it if necessary. The reason for this is a principle whose application in transdisciplinary research is in general advisable, namely, the principle of recursiveness. Every step of a transdisciplinary research process may be subjected to an iteration. For example, conceptual work and theory building during research in sub-projects require, given a heterogeneous composition of scientific fields, a continuous process of making adjustments, reconciling differences and revising hitherto accepted knowledge claims, since agreement during the process of knowledge integration is something that must always be achieved anew. Bringing

research results to fruition³ in particular involves a recursive process whenever the results are not acceptable to the actors dealing with a given societal problem, and modifications will be needed so that the problem transformation or solution can actually take place.

Chapters IV and V—Further assistance

There are numerous publications which do not deal with the scientific methods of (knowledge-)integration in the strict sense yet nonetheless work with the idea of integration in their own way. They describe practices for the management or cooperation of transdisciplinary research associations which are particularly well suited for supporting the integration strategies used in research. In *Chapter IV* short descriptions of such publications help the reader to quickly locate the appropriate management practice for their integration plan. In *Chapter V* further help finding suitable integration methods is given. There, overviews of the different integration methods are provided, and organized according to different order principles.

³ “In-Wert-Setzung” in German

Chapter I: The integrative approach in transdisciplinary research

“It is important to emphasize that strong contextualization not only shapes research agendas and priorities, but also influences research topics and methods. It enters into the process of knowledge production and therefore leaves visible traces in the science itself.”

(Nowotny et al. 2001: 131–132)

Integration as scientific principle

Integrative research is a trend standing in opposition to the progressive differentiation of science. Since the middle of the 19th century there has been a continual splitting of science into specialized disciplines, each investigating ever more precisely particular aspects of reality. Two important points must be noted here. First, because of this development, the number of nodal points on the map of knowledge has increased immensely; in other words, for individual aspects of many problems there are, increasingly, individualized disciplinary jurisdictions. And second, the depth of focus of knowledge in the various fields has also increased enormously. This means that problems once described and explained only phenomenologically can now be described and explained scientifically at various levels—from the classical descriptions and explanations of physical, chemical and biological theories and models, to the fine structures and complex fields of nano-science and quantum physics. Accordingly, the depth of technical intervention in the design of solutions to the original phenomenological problems has also increased. This twofold increase in, on the one hand, the number of scientifically manageable problems (the nodal points on the map of knowledge, constituting a horizontal dimension) and, on the other, the granulation of knowledge (the depth of focus and intervention, constituting vertical dimension) raises the problem of integration. For the casual observer this might seem to be primarily a problem of knowledge management: how can the knowledge produced by an ever larger number of specialized disciplines be brought together to form a coherent and consistent set of scientific problem descriptions, analyses and solutions? As we shall see, however, the problem is more complex than this.

It would be a mistake, then, to view integrative research only as a backlash against differentiation and specialization. To be sure, integrative research, by its very name, suggests the bringing together of different fields

of knowledge and ways of working; but it may well also result in new specializations, institutionally strengthened by new journals, associations and congresses, as well as new educational training programs. More generally, it can be argued that, while integration is a development trend fed by specialization and differentiation, it also contributes to these. Specialization, to be sure, as a progressive branching of knowledge, increases the potential for integrative research at the same time. But integration can also mean a new form of specialization driven by the expectation that the merging of specialized forms of knowledge can produce gains in knowledge that would be impossible without an explicitly integrated approach.

The impetus for integrative tendencies within scientific research is often (though not always) external to science. A societal problem, the solution to which requires a scientific contribution, is rarely susceptible to specialized handling. The specialized knowledge of an individual scientific field can usually deal only with certain aspects of the problem. This suggests a key task for researchers—bringing together these disparate aspects of the problem. However, this will not happen by itself; it requires, among other things, reaching understanding across different theoretical languages. Coordination of different bodies of knowledge, identification of gaps in knowledge and understanding how to handle these gaps, as well as methods for constructing an overall picture of the problems identified and their partial solutions—all of these are also required and are therefore genuine scientific tasks facing transdisciplinary research.

Considering the two opposing tendencies—scientific differentiation on the one hand, and the demand for integrated solutions to societal problems on the other—it might be supposed that integrative research is distant to current scientific issues and more of a research service useful in contexts of application. This may, in fact, sometimes be the case, and such research service can be important enough in itself. But the claim that an integrative orientation is more or less incompatible with the real motives of scientific research is not tenable in light of the history of science. An early prominent counterexample to such a claim—it dates back to the 17th century—is Newton's integration of engineering mechanics and astronomy. The unification of the pressure and impact effects found in machines with the majestic movement of the planets as described by the theory of gravity demonstrates the fundamental importance of integrative research for the internal dynamic of scientific theory. Making connections across the border areas of the individual disciplinary fields has always belonged to the

highlights of theory development, and is all the more fascinating the more heterogeneous the knowledge assets to be integrated are. Some of the great scientific revolutions, in Thomas Kuhn's sense, are just such integrations of scientific traditions that had previously existed independently of one another. And in our time, in the philosophy of science we find concepts such as "unified science" (Vienna Circle) or the hopes for a "grand unified theory" (GUT) or a "theory of everything" (TOE) in physics, which all bear witness to the hope of bringing all of the knowledge of the specialized disciplines into one integrated knowledge base. In addition to these grand visions there are many lines of research aiming at the unification of specialized areas—in part, dependent on external impulses, in part, independent of these. From the foregoing it is clear that the unification of fields of knowledge is something that takes place all the time within science itself. And a modern metaphor that captures the interplay between branching and joining together found in such integration is the network. What we see more and more today is the growth of cognitive networks of specialized scientific knowledge, resulting both from the further branching out of specialized knowledge bases and from the joining together—and thus the morphing into new forms—of existing specialized knowledge bases.

The argument that integrative research also results in the creation of new specializations is neutral regarding the question of whether the impetus for such integration is internal or external. In this book, therefore, integrative research is viewed as a general scientific issue to be dealt with scientific means. To be sure, aspects of the management and organization of knowledge always play a role as well. However, attention is paid first of all to the cognitive problems associated with integration tasks. But since this book is based on various transdisciplinary research projects one also needs to keep in mind that the research questions at issue come from contexts in which social-ecological problems are in the forefront. As a result it is often necessary to consider the interests, perceptions, knowledge bases and goals of the non-scientific actors involved—and, where possible, to bring these into the research process itself. The collection of instruments and methods brought together here is especially sensitive to this need for integration services that are required in addition to the inner-scientific forms of integration.

The need for integration within research practice can be distinguished according to three dimensions—a communicative, a social or a cognitive dimension. It may also be distinguished according to the type of knowl-

edge base and procedures to be integrated. For example, the integration of the work and results of natural and social sciences requires a different approach than one aimed at integration within the natural sciences alone. Based on these different sources of integration we have constructed an integration typology, to be presented shortly. In addition, and equally important, needs for integration vary according to the manner in which one wants to integrate knowledge from different disciplines. Here one might need to simply integrate forms of knowledge produced by different disciplines additively or—much more challenging—there may be a need to develop a new, common theory. There are, of course, gradations between these two poles.

Many transdisciplinary research projects are characterized not only by the fact that many specialized disciplines are involved, but also by the fact that solutions to very specific constellations of problems are expected. This means that to begin with one is dealing with concrete, often singular, cases. These concrete cases must then, in a second step, be generalized through a process of criticism of, and theoretical reflection on the case-specific results. For example, one must work out a general model of lake district or neighborhood restoration, or a model of sustainable nomadic pastoralism, by critically reflecting on concrete case results. Now, every lake and every pasture landscape exists in a specific constellation. The same is true of transportation regions, settlement areas and socio-cultural traditions. The specificity, or even singularity, of problem constellations means that concrete groups of societal actors, with their own interests, perceptions and evaluations, often come into play. Researchers are therefore forced to negotiate project targets and procedures that meet the specific needs of a given constellation. Even when stakeholder groups are not currently involved in a transdisciplinary project, the expectation that the project will provide solutions to concrete problems continually presents difficulties, with which scientists are not necessarily familiar.

In the past, scientists did not consider the various constellations of concrete societal problems found in the real-world, with all of their specificity, as belonging to science; rather, this was a matter for industrial development departments or administrative planning staffs. Science, it was believed, had to abstract from specific conditions and focus on typical and generalizable properties that can be captured in laws and theories. In recent decades, however, the relationship between science and society has changed in this respect. Specific, complex problems can now be examined

so precisely with respect to many of their aspects that a piecemeal approach yielding solutions to individual cases is not beyond the capacity of science, at least not in principle. While in the past the statement that every patient, every city and every lake is different marked a boundary between science and real-world, today it represents a challenge for the relevant sciences. In response the networks of knowledge have become more finely meshed. Specific, individual solutions to specific problem constellations are feasible—not everywhere, but in an increasing number of situations. However, success can be achieved only if the kinds of methods and instruments dealt with in this book are available to support the necessary integration work. These methods and instruments, in turn, can only be useful to the extent researchers have a common understanding of the problem under investigation, its different aspects, and of how the integration of the work of sub-projects is to be achieved. Thus, there is a need for sorting out the necessary conditions for such an understanding.

Often one can divide a project into sub-projects without much difficulty, with the partial solutions provided by the sub-projects being then adjusted only at the “seams.” Such an organic division of labor is always justified where there are no strong interactions between the sub-projects or modules. However, if the development of partial solutions in one module depends heavily on those developed in other modules then this organic approach quickly reaches its limits. In such cases, it may also often be the case that those responsible for project management fall prey to the illusion that the division of labor agreed to is progressing well along various tracks, when in fact none of the results are integrable. In an open-ended research process, moreover, the conditions upon which one could build a stable division of labor can rarely be formulated clearly and reliably; rather, these are subject to change throughout the research process.

For all these reasons, then, it is necessary that, both before a division of labor is decided upon and while a given one is in place, prior and parallel work be carried out on a modeling of the overall problem. On the one hand, this joint work on the overall problem is a matter of reaching an understanding concerning the use of concepts, individually, and in relation to one another; on the other hand, the work methods employed need to be methodically coordinated, that is project phases and modules need to be identified. In addition, the partial solutions produced by the different modules must then be integrated. The computer has come to exercise an extremely important influence on the theory and technology of modeling.

Transdisciplinary research can draw three benefits from this. First, the concept of a model is no longer exclusively a theoretical concept, but increasingly oriented towards the real-world complexity of problem constellations and, thus, towards interdisciplinarity. Second, models often refer to processes. They take loops and recursions into account, making possible a continuous review of a given process of modeling as it is being implemented. Third, the possibility of producing quantitative solutions (e.g., for scenarios) has increased dramatically. In this way, the particular needs of individual projects can be satisfied.

Transdisciplinarity—Construction as reaction

Scientific differentiation, then, has over the centuries, but especially in recent decades, resulted in more and more hybrid disciplines, with the interdisciplinary tasks these call forth leading—as noted above—to numerous specialized scientific fields. Scientific disciplines, scientific fields and subject areas, however, are all in a sense constructs shaped by the interactions of scientists with research objects, interactions that also determine the process of theory and model building. Research tasks and their related problems, to the extent to which they have not been formulated with respect to the interests of one scientific subject area, are, moreover, often resistant to being located within the boundaries of one discipline or scientific field.

This rough sketch of the development and new ordering of the sciences also applies, and especially so, to problems coming from outside of science yet requiring scientific knowledge in a form appropriate to societal needs. If science responds to societal problems and their related research tasks with a transdisciplinary approach to research, this is not simply a matter of “a fashionable ritual [...] but rather a consequence which is induced by the problems themselves” (Mittelstraß 2005: 19). Transdisciplinarity, that is, is a response to changing epistemic demands on science and research, an attempt to deal with hybrid problems in a scientifically controlled and reflective manner—in short, a *principle* of science and research.

Transdisciplinary research, moreover, promises two innovative effects. To begin with, its original, and primary goal is to initiate and promote forms of societal development that will provide solutions for problematic situations. These real-world problems, which are the starting point for research, can, however, not be processed normally by single disciplines.

Since a number of scientific fields, often in cooperation with practice partners from the problem areas, must therefore work together to develop strategies for action that can prove effective within societal processes, this leads of necessity to new problems for scientific methodology. For often transdisciplinary research cannot rely on the already existing methods of specialized scientific fields. Rather—and here we see transdisciplinary research’s second innovation path—new interdisciplinary methods and instruments aimed at ensuring cognitive integration must be developed in order to enable the first effect.

The quote at the head of this chapter speaks of the visible traces left in science by a highly contextualized approach to research. It is above all the parallel production of knowledge along the two innovation paths just mentioned that demands a very particular form of scientific work and thus places special demands on scientists. The special requirements placed on transdisciplinary science mean that the knowledge cores produced in several different disciplines must be integrated, which further means that they must be made connectible, resulting in a meaningful whole in respect of the task. “A central epistemic attribute of transdisciplinary research, therefore, is the development of methods for integrating knowledge across disciplinary boundaries [...]. By providing such integration transdisciplinary research assumes a leading role in the development of the knowledge-based society.” (Krohn 2008: 46) Thus the “traces” that a transdisciplinary approach leaves within science as a whole are attributed great significance. Another point is pertinent here: integration processes leave “traces” within the new scientific fields and disciplinary constructions as well, for there may be changes in their methodological and theoretical orientation.

The task of integration is not only aimed at recognized disciplinary knowledge, for it is a matter of “distinguishing and linking disciplinary knowledge bases, as well as scientific knowledge and knowledge drawn from daily practice” (Jahn 2008: 32). Two points are important in this respect. To begin with, the differences among the various disciplinary approaches involved, as well as in the terms and concepts and theoretical frameworks being used, must be recognized and acknowledged; only then is a meaningful integration possible. And secondly, integration must also be ensured between science and forms of practical knowledge drawn from the societal problem area under consideration—a particularly unusual task for scientists. Thus integration tasks may also be motivated by knowledge lying outside science. This means forms of knowledge that differ in their

modes of acquisition and confirmation must be dealt with together. This in turn means that the integration aimed at cannot be limited to inspecting and merging these different knowledge bases; it is also a matter of “moving towards a common development of method and theory” (ibid.).

Thus new methodological tasks arise from the need for scientific fields and disciplines to work together to conduct research and find solutions for societal problems. Consequently, it is a matter of creating procedures and instruments that can bring together knowledge bases and modes of research from different fields and disciplines. These procedures are, as described above, a response on the part of scientists to new societal demands. At the same time, these procedures and instruments have become methods; they have been developed and used in a conscious, controlled and reflective process, which can be described and thus repeated.

Methods in transdisciplinary research and their contextuality

Following the logic of transdisciplinary research, the methods and instruments of integrative linking are developed and used for the particular research task tightly bound up with the specific societal context. As a result they are at first associated narrowly with a specific constellation of the involved scientific fields. This means in addition that the procedures used to achieve integration are not, as a rule, described outside of their context, as is the usual practice in scientific discipline-oriented methods, but are described instead within the context of solving problem-specific tasks and within a specific disciplinary constellation. Indeed, the integrative methods and instruments in problem-oriented research are, as a rule, only recognized in their context. Thus, for example, an integrative scientific method or model, developed for research on the sustainable development of water supply systems, will only be seen as such by experts in this particular societal problem area and from the corresponding scientific disciplines involved. However, this specific integrative method and model could well be suitable for research on similar social-ecological supply networks (in the broadest sense), or even for problems related to other network-organized supply systems such as, for example, problems related to sustainable forms of mobility.

Such a straightforward transfer from one problem area to another, however, often fails because the individual problem-specific discourse is