INTERDISZIPLINÄRE FORSCHUNGSSTELLE | WISSENSCHAFT · DEMOKRATIE VERFAHRENSGESTALTUNG

Working Papers Series

No. 1 PREPRINT

Werner Kogge

Building Interdisciplinarity

How the analysis of underlying structures and core questions of disciplines can open up ways for a non-hierarchical, modular, and combinatorial approach to cooperative research

FREIE UNIVERSITÄT BERLIN

Zitationsangabe für diesen Beitrag:

Kogge, Werner. Building Interdisciplinarity. How the analysis of underlying structures and core questions of disciplines can open up ways for a non-hierarchical, modular and combinatorial approach to cooperative research. Working Paper No. 1 der Schriftenreihe der *Interdisziplinären Forschungsstelle Wissenschaft – Demokratie – Verfahrensgestaltung*. Berlin 2024.

doi: http://dx.doi.org/10.17169/refubium-43960

Interdisziplinäre Forschungsstelle Wissenschaft – Demokratie – Verfahrensgestaltung

Freie Universität Berlin
Habelschwerdter Allee 45
14195 Berlin
Webseite: https://forschungsstelle-verfahrensgestaltung.de
Email: werner.kogge@fu-berlin.de

INTERDISZIPLINÄRE FORSCHUNGSSTELLE | WISSENSCHAFT · DEMOKRATIE VERFAHRENSGESTALTUNG

FREIE UNIVERSITÄT BERLIN

Werner Kogge

Building Interdisciplinarity

How the analysis of underlying structures and core questions of disciplines can open up ways for a non-hierarchical, modular, and combinatorial approach to cooperative research[1]

Interdisciplinarity is seen as research's answer to complex problems and as a recipe against the parcelling of science. The importance of interdisciplinarity is reflected in a growing number of interdisciplinary research agendas, handbooks and introductions to interdisciplinary studies. But the question of how interdisciplinary research can actually be realised widely evokes perplexity. Here we present an approach that conceptualises interdisciplinary research in a new way. By assuming not disciplines but different types of research as basic elements of interdisciplinary cooperation, a programme of type-based modular combinatorial interdisciplinarity can be developed. Such a form of interdisciplinary research does not aim at integration on a common basis, but at a complementarity of differences. In the combinatoriality of different research modules lies the opportunity for a much more conscious research planning. The recognition of different forms of research can help to make research programmes more circumspect and sustainable.

Water scarcity, migration, pandemics, climate change, racism, democracy, artificial intelligence, cancer, adaptive materials, limited resources – these are major topics that challenge the sciences and raise the following question: Doesn't the reaction to complex problems require research that is equally complex? Interdisciplinarity appears to be the order of the day.

The same conclusion can be drawn from a different perspective: Are the 100–500 subjects that study program portals now list (depending on the resolution) separate worlds with no connection to each other? And if sciences were split up in this way, wouldn't the view of reality itself disintegrate? Here too: interdisciplinary cooperation promises a way out.

This issue is not new. Interdisciplinarity has been a hyped topic for decades. It is no surprise that trans- and interdisciplinary research already started becoming an established field several years ago. A *Handbook of Transdisciplinary Research* was published in 2008, followed in 2010 by the *Oxford-Handbook of Interdisciplinarity*.[2] Surveys on interdisciplinary and transdisciplinary research methodology were published,[3] as well as a *Philosophy of Interdisciplinarity*.[4] The first *Introduction to Interdisciplinary Studies* appeared in 2013[5] and *Nature* dedicated a Special Issue to interdisciplinarity in 2015, dealing with "Team Science" and the problem of "How to catalyse collaboration."[6]

That problem is not easy to resolve. Researchers and research organizations in different countries continue to report on difficulties posed by interdisciplinary collaboration.[7] How can scientists cooperate if they come from different disciplines? It is not enough to form a team and put it to work. The point of interdisciplinarity is to produce more than just a juxtaposition of various disciplines.

CONCEPTUALIZING INTERDISCIPLINARITY

To make differences clear, interdisciplinarity researchers have coined special terms: collaboration versus cooperation,[8] interdisciplinarity instead of mere multidisciplinarity.[9] The purpose of interdisciplinarity is to create added value. Alan Repko, author of Introduction to Interdisciplinary Studies, put it succinctly: "Interdisciplinarity is the study of a complex issue, problem, or question from the perspective of two or more disciplines by drawing on their insights and integrating them. The interdisciplinary process is used to construct a more comprehensive understanding of the problem."[10] How can such integration work? Respect between different disciplines is often lacking, as is recognition that the research conducted by others has just as much scientific value as one's own. [11] But the problems lie much deeper. Disciplines develop their own languages, which makes it difficult to find a common language. This pitfall is not easy to avoid. As researchers attempt to explain something as precisely and comprehensively as possible, they delve ever-deeper into a language and manner of thinking that is understandable only within their own discipline. However, the difficulties in translating terminologies often go even further: it regularly turns out that there are initially invisible differences in the preliminary assumptions, in the entire theoretical framework, in the methods and in the question of what can be regarded as the object of research and what can be regarded as a scientific result.

INTEGRATION, BUT HOW?

Scientific collaboration requires more than just good will. The practice of science is research and if interdisciplinarity is to be more than just an aspiration, then it must affect the form of research itself.

It has become increasingly clear in the discourse on interdisciplinarity that true interdisciplinarity requires not only a social framework, but also a scientific one. What medium would be appropriate for this? Research on interdisciplinarity discusses a number of options: Is it a common *problem*, a common *theory*, a common *object* or a common *method* that brings together different perspectives of research in different disciplines?[12] However, all four of these dimensions are to some extent problematic. Focusing on shared problems helps with team-building, but says nothing about working methods and solutions; common objects are not easy to determine in the sciences, since the objects depend on the hypotheses posed, which in turn depend on theories. The remaining options are methodology and theory, a sort of meta-methodology and meta-theory. Precisely here there is a twentieth-century example that represents the largest and perhaps only comprehensively implemented research program of methodological and theoretical interdisciplinarity: From the 1950s until into the 1990s, the theories of control, self-organization, and emergence formed a theoretical umbrella that in methodological terms covered the field of mathematical and IT instruments. Cybernetics, system theory, complexity theory, chaos theory, modeling, and fuzzy logic are the names of sections and stages of this research program. However, integration into a theory and methodology that translates phenomena into mathematical models make up a very specific type of science that is unsuitable for many research objects and foreign to many disciplines. We are dealing here less with a guide to interdisciplinary cooperation than with a translation into a specific research program.

What can a form of research integration look like that is not based on a particular program and view of science? An integration that takes into account all forms of knowledge generation without any prejudices (to the extent that they have developed standards for scientific quality and procedures of correctability)?

One answer to this question might lie in the notion that cooperative research is based not on common ground but on the complementarity of differences. That is the idea behind a form of integration that can be referred to as a *type-based modular combinatorial interdisciplinarity* (TMC-ID). This model is based on two pillars: (1) the assumption that the disciplinary levels represent only the surface, and that integrated research must begin at a deeper level, that of *research types*; and (2) the assumption that different types of research are *equivalent* and can be combined as independent modules. Such combinatorics could be a step on the path to integrating research from various perspectives. This is because the combination of approaches takes place here as a conscious and explicit process of research planning at the level of the very structures that actually constitute the research types. This is not technocratic planning. A proactive combination in fact sets scientific creativity free. It is like a good football team: Different types of players are available for different tasks and teamwork works as well as processes are cleverly organised and the balance is right.

FROM SCIENCES TO RESEARCH TYPES

One science – hundreds of disciplines? If there really was only one kind of science, then the problem of interdisciplinarity would not even exist. Or are there just as many kinds of science as there are disciplines? Evidently not: Many disciplines that differ in name have very similar research methodologies; and very different research approaches can also be juxtaposed within a single discipline. Below the disciplinary level there are various kinds, cultures or types of research.

The discovery of research types can be traced back to nineteenth-century history, philosophy, and philology. Johann Gustav Droysen, Wilhelm Dilthey, and Wilhelm Windelband coined the concepts of history [Geschichtswissenschaften] and humanities [*Geisteswissenschaften*] as independent forms of science. Best known was Windelband's distinction between nomothethic and ideographic science as two methodologically different scientific practices. According to Windelband, the difference was one of direction: while in the natural sciences "the individual given object" is only relevant as a "type, as a special case of a generic concept [...] for insight into a lawful generality", historical science considers "an entity of the past in its entire individual form".[13] Like his predecessor Droysen, Windelband viewed the difference between the two types of science not as an ontological difference but as a difference in the perceptions and approaches. A scientific phenomenon, such as the origin of life,[14] can either be described as a historical event – one then attempts to reconstruct the process as it actually took place, as detailed and comprehensive as possible – or as universal laws, which means formulating the conditions under which life would always arise in the same way. It is a question of the epistemic interest, the perspective, the internal orientation and structure. So it comes to the thought that there are differences in the sciences as different modes of research.

THREE TRADITIONS OF RESEARCH

It is thus no coincidence that anyone interested in the types of research still draws upon Windelband.[15] There are simply few alternatives. And yet they are needed, since the differentiation between natural sciences, which seek laws, and the humanities, which focus on the unique, is far too general and fails to consider far too much. It was certainly helpful that nineteenth-century philosophers looked at the practice types that prevailed in the sciences. However, they considered only one difference: that of explaining and understanding.

Starting from here and moving forward means delving deep into this history. What kind of tradition is behind the concept of explaining? It is a tradition that ultimately traces back to Aristotle's idea of *episteme*, which in the transition from the Late Middle Ages to the Early Modern Age became a concept of mathematized *scientia*. What is at the core of understanding? Unraveling a puzzling matter from the context, that is, from the mutual relationship between part and whole, as was already practiced in the interpretation of legal and religious texts in Ancient Rome. And what about a very different group of activities: observing, describing, collecting and categorizing data? Here as well there is a venerable tradition, namely, that of *Naturalis Historia*, natural history, which shaped its own image of science. Three traditions and three basic concepts of science: the *Episteme-*

Scientia tradition, the *Interpretatio-Hermeneutic* tradition, and the *Naturalis Historia* tradition.

***Episteme-Scientia* Tradition**	***Interpretatio-Hermeneutic* Tradition**	***Naturalis Historia* Tradition**
prove, explain, demonstrate, derive, reduce, operationalize, model	*understand, interpret, contextualize, puzzle-solve, reconstruct, reconceptualize, redescribe, trace, expose, deconstruct*	*observe, discover, describe, collect, measure, document, categorize, typify, compare, classify, correlate*
experiment, vary		

TYPES OF RESEARCH TODAY

Througout history, these three traditions each became established as a coherent understanding of research. They also continued to develop and differentiate. Looked at more closely, three different branches can be distinguished in each of the three traditions, making a total of nine types of research. In addition to the image of science as a logical form of proof, the *Episteme-Scientia* tradition also developed a mathematized and an experimental form, which gave rise to mathematical modeling and experimental laboratory research as typical forms. The *Interpretatio-Hermeneutic* tradition exhibits as different basic patterns the paradigm of adequation, the research form of reconstruction, and the science type of criticism. And in the *Naturalis Historia* – natural history – tradition, we find the object-identification type of data collection and description, the classification-based ordering type, and the correlating type, statistics.

***Episteme-Scientia* Tradition**			***Interpretatio-Hermeneutic* Tradition**			***Naturalis Historiae* Tradition**		
Paradigm								
of logical **proof**	of **experimentation**	of mathematical construction and **modeling**	of **reconstruction**	of adaptation/ **adequation** of concepts	of **criticism** (reflection on conditions)	of object identification and **description**	of creating order/ **taxonomy** (typification, classification)	of **statistics** (gathering and correlating data)

Today these nine types of research each appear individually as independent forms that are usually perceived as examples of *science in general.* Let us look at each of them in detail (the order has been changed for presentation purposes):

(1) Object identification research approach: Collecting data is a basic form of research. How is data gathered? By observing, counting, measuring, datumizing, locating, and describing elements in question. The simplest form consists of questions such as: How often does *x* appear? Where does *x* appear? When does *x* appear? Instruments can be used to track temperature, mass, electrical conductivity, and age of an element. Recording systems such as time lines, maps, tables, and diagrams serve the gathering of data. It can generally be said that data is captured by noting elements in recording systems.

(2) Taxonomic classification research approach: Whereas the element x itself is not in question in the object-capturing variant of research, when for example a planet is located or a chronology of rulers is compiled, in the taxonomic approach the question arises as to the determination of 'x': What type, what species, what epoch, what genre can *x* be classified in? The basic practice of this research approach is comparison: What properties exist in one sample and which in the other? What types can be distinguished? What types are more general and which are more specific? How is the classification system structured in general? Results here are usually presented in the form of classification diagrams, comparative discussion, and synoptic taxonomies.

(3) Classical statistics in its basic form also operates within the framework of the taxonomic research paradigm. In the statistical version, however, it not only classifies events, but also records their frequency. With this it opens up its own field of research – that of frequency distribution. Different event frequencies can be compared with respect to other ordering aspects: What is the frequency of *x* with respect to a particular time, a particular area, or a particular segment of the population? Statistical knowledge is largely tabular and diagrammatic knowledge.

(4) Reconstructing research approach: The basic question here is: What did a whole look like if only relicts, signs, traces, or fragments are available? The research form here resembles the investigation of a criminal case: a course of events, an incident, a context needs to be reconstructed as a coherent whole. The defining practice here is trying out combinations in the sense of: How do *x* and *y* fit together? How would the whole be affected if *x* is viewed as *a*, and *y* is viewed as *b*? And if the whole looks a certain way, is it possible that the element *z* in turn would be viewed as *c*? This kind of puzzle-solving in a part-whole setting is an element common to historical reconstruction with text interpretation and some forms of experimental research. In each case, an attempt is made to develop a 'theory' of an overall context from the singular and to interpret the behavior and quality of elements as integral components of an (assumed or hypothetical) overall context.

(5) Reconstructive, explanatory research approach: If there are not signs, traces, or relicts from which to interpret a previous context, but instead a complete phenomenon (such as the start of a revolution, a surprising behavior of a chemical substance, an astronomical anomaly, a

disease), then the research focuses on the conditions under which the occurrence of *x* can be explained: What must be assumed as a given for the (surprising, questionable) phenomenon *x* to occur? Because such a combination of conditions can be extremely complex, the research here also has a strongly heuristic and experimental character. Different means are used to test the explanatory approaches and create a model, which bring together possible sets of conditions and simulate possible processes. Such reconstructions can take place in the laboratory or as representations of real-world conditions (as is usually the case in astronomy and the historical sciences).

(6) The research approach of <u>interpretive adequation</u>: Whereas explanatory reconstruction focuses on conditional factors, research in the paradigm of adequacy gains its value by trying to do justice to phenomena in their wealth of aspects as comprehensively as possible. And it attemps to do so by adapting the representation. The main question here is: How must terms, concepts, and formulations of relationships be modified in order to bring out an object's phenomenality without neglecting any characteristic aspects?

(7) The research approach of <u>critique</u>: There is no scientific research that starts from scratch. There are always preexisting concepts, views, and representations. Research is contingent on preconditions, which are specified by history, environment, and disciplinary patterns of thought and action. Clarifying and reflecting on such conditions represents at least one central element of conscientious research. This is the basic notion of critical research. Such a practice can be described as that of revealing, detecting, uncovering, and exposing. Hidden, unnoticed, neglected, or repressed influencing factors are detected and brought forward. Epistemic critique, ideology critique, and deconstruction denote approaches in this type of research.

(8) <u>Reductive, apodictic research approach</u>: If one assumes that the structure of conditions, from which an overall context is explained, can be completely detached from the respective phenomena and represented as a universal and regular set of rules in a formal language, then a different form of the basic question arises: How can a phenomenal context be trace back and reduced to a universal formalism? The scientific practice here is primarily aimed at building up a formal, logical, or mathematical language such that it depicts the features in question. This is often referred to as *mapping*.

(9) The <u>approach of experimental laboratory sciences</u>: In this research approach, formalisms that belong to symbolic systems are not used as research goals, to which phenomenal contexts can be traced back (reduction), but instead as *instruments* of research. The formalism is not simply confirmed in the laboratory, but is used to structure experimental systems focused on discovering and describing as yet unknown qualities, determinants, and interdependencies in the subject area. The key practice is setting up experimental systems that are as stable as possible, so that individual factors can be controlled and varied. In securing results, this never involves merely indicating a rule formalism ("explanation"), but always describing the experimental system, the technical experimental setup, and the idealized conditions under which the contexts can be observed.

AN OBJECTION: ARE THESE TYPES OF RESEARCH OR STATIONS IN THE RESEARCH PROCESS?

An objection might be raised against this presentation of research types: Are these really independent types of research? Or are they merely *stations* in the process of scientific research?

One could thus arrive at a picture according to which the types of research are not truly separate and autonomous research units, but instead different *steps* or stations in a unified research process. A research flowchart could look like this:

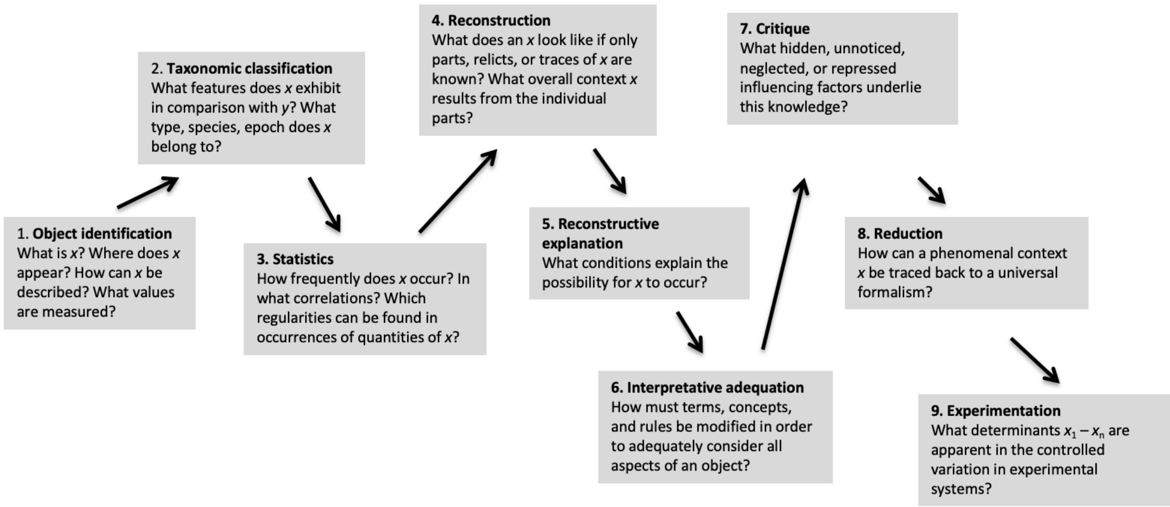

Fig. 1

However, if we examine the language of this flow chart and its internal pictorial logic, then the suggestion with which such a scheme is always associated becomes clear: The actions seem here to progress from initial, elementary steps to highly complex and subtle, reflected activities. It is as if we are starting out with hard labor in the boiler room of research and continually climb up to the cleaner activities in the white-coat upper floors. When these "higher" actions are then expressed in artificial and sophisticated languages such as "higher" mathematics or post-structuralist philosophy, then this process seems to progress from primitive preliminary work to elaborate knowledge.

However, this suggestive picture is based on certain prejudices about what comprises the essence of scientific knowledge. This is precisely the source of all the struggles for status and interpretative sovereignity that run through the histories of the sciences.

The fact that the directions can be changed makes it clear that the combination of research types is by no means a linear advancement scheme, but rather a modular system in which the research processes can be combined in various ways. There are research projects in which conditions are reconstructed (5) in order to achieve a taxonomy (2); laboratory tests (6) are conducted in order to identify phenomena chronologically, geographically, etc. (1). Prerequisites for research programs are questioned (7), which can lead to a new description of the object (1).

These remarks suffice in indicating that every type of research can determine the cognitive goal of a concrete research program. The motive of each type can make up the goal of the research, so that arrive at a picture of combinability, an *egalitarian modularity.*

When we talk about egalitarian modularity here, what do we mean?

It means that typical scientific practice-motive complexes can be understood as *modules*, that is, as independent functional units that are integrated into a research project. However, this modular structure is rarely perceived as such. In project descriptions it disappears under headings such as 'preliminary work' and 'research program'. What if it wasn't? What would it look like?

If research projects were to be designed so that the modular structure was explicit, this would have a number of effects:

(1) The intrinsic value of each of the research steps would become visible, that is, each element would be considered as an individual type of research, which can promote the diligence of planning, of securing the results, etc.

(2) It would become apparent that certain modular units, for example a critical reflection or a taxonomic classification, are missing in a project, although they might be necessary for the overall issue.

(3) Reasons why and how which modules are linked become explicit and thus can be reflected upon and negotiated.

Overall, such a modular perspective would lead to research projects being designed more conscientiously. In other words, the design of research projects would then go much deeper, all the way to the level of the structures in which their practices are rooted and motivated.

The structure of research projects composed of independent modules implies a completely new activity in research design: Planning here also means elementary combinatorics. This concerns the selection of modular elements – which ones are important? – and their configuration. Whether or not certain modules are included in a research project is a recurring question and must always be justified. Not every research project needs to be expanded to integrate all of the modular elements. However, going through the list of modules and determining what role each one might or might not play in the project at hand can lead to a more profound and more thoroughly reflected research plan. This includes questions such as what research approaches should be used to supplement or complement each other and how different research approaches are geared to dovetail with each other.

A modular structure in research planning also implies a newly oriented program of interdisciplinarity. When certain modules are viewed as meaningful and thus included in the research planning, it is possible to ask specifically which disciplines the necessary competencies can be found in. The interdisciplinary integration – in contrast to earlier practices – is not carried out by means of external assignment or strategies of a more or less implicit reduction to specific object classes, theories, or methods. *Modular interdisciplinarity is radically nonreductive.* Although integration into an overarching key question remains, the question itself can be exchanged. This also means that the same research program agenda can be run through multiple times with different orientations. This can lead to extraordinarily interesting results and would also make it possible to increase the effectiveness of research programs.

TURNING THE GAZE

What does not seem possible in the logic of these considerations is a research grammar without a goal. Such anarchic research may seem attractive as an idea, but it contradicts the basic assumption that research as a practice works in motivations. What, how and for what purpose something is investigated is deeply rooted in the historically evolved types of research. Motivation means orientation. And just as it is always possible to go in different directions one after the other and to head for different goals, but not at the same time, the modular structure means the possibility of an alternative goal, but not the dissolution into an 'anything goes' at any time.

We are dealing here with the phenomenal structure of aspect change. Something can be looked at in one way and in another, but not at the same time. The gaze can be directed in one way and then again in the other. In each case, something becomes visible that disappears in the other way of looking. Both ways of looking view the whole, neither is reductive, neither sets certain elements as ultimate units or certain structures as 'the true form'.

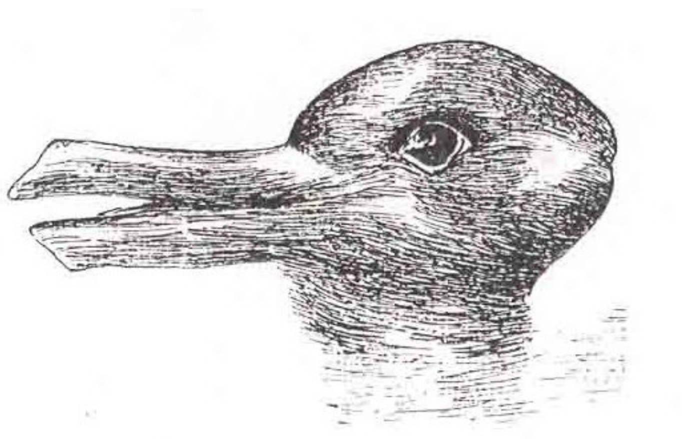

Fig. 2

The analogy to visual aspect change goes one step further: aspect change cannot be learned technically - there is no method for this - but it can be practiced. Thus, a modular form of interdisciplinarity also trains a certain ability at the deep-structural level of scientific types: the ability to change the direction of view here means the competence to be able to approach research in different modes. In this way, it can be achieved that research planning can be more creative and free and at the same time structurally deeper.

Even in this modular picture of scientific cooperation, tensions between the different views of science do not disappear completely. The dispute over questions such as whether there is a formally comprehensible world order behind all phenomena or whether each individual event represents its own order that can only be reconstructed or described; the dispute over whether we can see through all the conditionalities of our knowledge to reality or whether we only perceive as much as we reflect in its conditionalities; such conflicts will not simply disappear. But even such conflicts appear in a different light when different types of research are recognized as equal, and when cooperation means making the different types strong - strong as independent modules in integrated research.

---

[1] The present text is an independent, completely revised presentation of considerations that were previously developed in a German-language book publication (Werner Kogge: Einführung in die Wissenschaften, Wissenschaftstypen, Deutungskämpfe, Interdisziplinäre Kooperation, Bielefeld (Transcript) 2022). Some of the graphics have been adopted, the captions translated.

[2] Gertrude Hirsch Hadorn, Holger Hoffmann-Riem, Susette Biber-Klemm, Walter Grossenbacher-Mansuy, Dominique Joye, Christian Pohl, Urs Wiesmann, and Elisabeth Zemp, *Handbook of Transdisciplinary Research* (Dordrecht: Springer, 2); Robert Frodeman, Julie Thompson Klein, Carl Mitcham, and J. Brott Holbrook, eds., *The Oxford Handbook of Interdisciplinarity* (Oxford and New York: Oxford University Press, 2010).

[3] Matthias Bergmann, Thomas Jahn, Tobias Knobloch, Wolfgang Krohn, Christian Pohl, and Engelbert Schramm, *Methoden transdisziplinärer Forschung: Ein Überblick mit Anwendungsbeispielen* (Frankfurt/M: Campus, 2010); Gert Dressel, Wilhelm Berger, Katharina Heimerl, and Verena Winiwarter, eds., *Interdisziplinär und transdisziplinär forschen* (Bielefeld: Transcript, 2014).

[4] Jan C. Schmidt, “Towards a philosophy of interdisciplinarity: An attempt to provide a classification and clarification,” *Poiesis and Praxis* 5(1) (2008): 53–69; Henrik Thorén, and Johannes Persson, “Philosophy of Interdisciplinarity: Problem-Feeding, Conceptual Drift, and Methodological Migration,” in *3rd Biennial Conference of the Society for Philosophy of Science in Practice* (Exeter 2011).

[5] Allen F. Repko, with Rick Szotak and Michelle Phillips Buchberger, *Introduction to Interdisciplinary Studies* (Thousand Oaks, CA: Sage, 2014).

[6] Heidi Ledford, “Team Science,” *Nature* 525 (17 September 2015): 308–311; Rebekah R. Brown, Ana Deletic, and Tony H.F. Wong, “How to catalyse collaboration,” *Nature* 525 (17 September 2015): 315–317.

[7] See also Rico Defila, Antonietta Di Giulio, and Michael Scheuermann, *Management von Forschungsverbünden – Möglichkeiten der Professionalisierung und Unterstützung*, DFG Standpunkte (Weinheim: Wiley-VCH, 2008); for additional literature on the problem of interdisciplinary cooperation, see p. 17.

[8] See also Margaret A. Boden, “What is interdisciplinarity?” in *Interdisciplinarity and the organization of knowledge in Europe*, ed. R. Cunningham (Luxembourg: Office for Official Publications of the European Communities, 1999), 13–24; Paul Rabinow, and Gaymon Bennett, “Human Practices: Interfacing Three Modes of Collaboration,” in *The Prospect of Protocells: Social and Ethical Implications of Recreating Life*, ed. Mark A. Bedau and Carol E. Cleland (Cambridge, MA: MIT Press, 2008).

[9] Julie Thompson Klein, "A taxonomy of interdisciplinarity," in *The Oxford Handbook of Interdisciplinarity*, ed. Robert Frodeman et al. (2010), 15–30, here: 17f.
[10] Repko 2014, 35; emphasis in original.
[11] Brown, Deletic, and Wong 2015.
[12] See also Boden, 1999; H. Bruun, J. I. Hukkinen, K. I. Huutoniemi, and J. Thompson Klein, "Promoting Interdisciplinary Research: The Case of the Academy of Finland," in *Publications of the Academy of Finland* (2005), no. 8; Jan C. Schmidt, "What is a problem? On problem-oriented interdisciplinarity," *Poiesis and Praxis* 7(4) (2011): 249–274.
[13] Wilhelm Windelband [Rectorial Address, Strasbourg, 1894], "History and Natural Science," trans. Guy Oakes, *History and Theory* 19(2) (Feb. 1980): 169–185, here: 178.
[14] Windelband cites the "evolutionary history" of life as an example; Windelband, "History and Natural Science," 176.
[15] See for example Wolfgang Krohn, "Learning from Case Studies," in *Handbook of Transdisciplinary Research*, ed. Gertrude Hirsch Hadorn et al. (2008), 369–383, here: 371.

List of figures