



Philosophical Framework for Inter- and Transdisciplinarity: Facilitating and Deepening Critical Reflectivity

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Abstract: Contrary to today’s hype, interdisciplinarity—and its cognate transdisciplinarity—was once a synonym of a critical-reflexive attitude towards knowledge production and the technoscientific progress, including the mindset, power and authority of science. The role of the entire academic system in causing the environmental crisis and the non-sustainable state of our life-world came under scrutiny. This article aims to strengthen a critical-reflexive approach to the discourse on, and practice of, inter- and transdisciplinarity, as part of the program of a “Philosophy of Interdisciplinarity” (Schmidt, 2022). Referring to well-established distinctions in philosophy, this article argues in favor of a plurality of four different types of interdisciplinarity: interdisciplinarity with regard to (a) objects (ontology), (b) knowledge/theories (epistemology), (c) methods/practices (methodology), and further, (d) problem perception/reflection and/or solving. The philosophical framework of the four different types will be illustrated by case studies: nanoresearch, complex systems theory, biomimicry/bionics, and technology assessment/sustainability research/social ecological research. For strengthening a critical-reflexive approach, this article further distinguishes between two modes of problem-oriented interdisciplinarity. One mode can be termed the critical-reflexive mode whereas the second is primarily an instrumentalist, strategic or solutionist account. The other three types of interdisciplinarity—object-, theory- and method-oriented—share an instrumentalist view. The article concludes by underlining the flaws of instrumentalism and the prospects of critical-reflexive elements in interdisciplinary projects.

Keywords: philosophy of interdisciplinarity, against instrumentalism and solutionism, critical theory, critical reflexivity, critical-reflexive problem-oriented interdisciplinarity

Strong pull

Specialization and separation, in particular disciplinarization, differentiation and the division of labor, were the traditional success strategies of modern sciences.¹ “It is not an improvement of the sciences but a deformation if their boundaries are allowed to run into one another” (Kant, 2000, p. B viii/106).² More than 200 years ago, Immanuel Kant was reluctant to cross the boundaries of scientific disciplines, as we call them today. He warned against what would later be known as interdisciplinarity.

Today, Kant’s point of view is no longer mainstream. In the mid-20th century, the cyberneticist Norbert Wiener (1961) argued “the most fruitful areas for the growth of the sciences were those which had been neglected as a no-man’s land between *the* various established fields [= disciplines]” (p. 2). In the 1970s, the notion of “interdisciplinarity” was made popular, although the word “interdisciplinarity” was already being used in the 1920s in the United States. It was coined by the *Organisation for Economic Cooperation and Development* (OECD) and its *Center for Educational Research and Innovation* (CERI) for a broader audience, in particular by the physicist Erich Jantsch (1970, 1972). It quickly experienced an impressive career and became popular. Today, interdisciplinarity is *en vogue* in science and politics, economics and society, as well as in higher education—fuelling the rhetoric of knowledge politics in our late-modern knowledge societies (Schmidt, 2007; Schmidt, 2022). It is increasingly being used as a synonym for application-oriented research and the commercialization of the university in neoliberal times. Most researchers, politicians and economists regard interdisciplinarity as a positive element and value in itself that merits and compels support. The *National Academy of Sciences* (2005), for instance, has declared “facilitating interdisciplinary research” as one of its chief goals.

Interdisciplinarity is attributed to a plethora of research, innovation and higher education programs. A highly esteemed initiative of the *National Science Foundation* regards the development of “converging technologies”—namely nanotechnology, biotechnology, information technology and cognitive science (NBIC)—as being necessarily interdisciplinary (Roco & Bainbridge, 2002). Interdisciplinarity serves as a fashionable label for innovation programs, for economics, for business and management studies, for military research or for programmatic strategies of institutions of higher education. Even basic research programs seem to be interdisciplinary. For example, physical

1 This analysis also holds for the development of global economy and modern capitalism.

2 From *Critique of Pure Reason*, second preface. In German: “Es ist nicht Vermehrung, sondern Verunstaltung der Wissenschaften, wenn man ihre Grenzen ineinander laufen läßt.” A common translation is: “We do not enlarge but disfigure the sciences when we . . . allow them to run into one another.” I think my translation is more appropriate.

cosmology has become established as an interdisciplinary effort at the intersections of physics, mathematics, chemistry, geology and computer science. And last, but not least, nearly everything in the booming field of AI claims to be interdisciplinary, including the so called “digital humanities.”

Interdisciplinarity is seen as a kind of a panacea capable of curing the pathologies of academic and entrepreneurial knowledge production (Frodeman, 2014). The appeal of the term is enormous. It seems that no one is willing or able to resist its pull. Who can ignore the hype? Who would not subscribe to interdisciplinarity? Who wants to stand on the sidelines while neoliberal incentives facilitate new research perspectives? Who would renounce the label that symbolizes creativity, signals innovation and promises added value?³

Enabling a deeper reflection . . .

Although the *rhetoric* for interdisciplinarity and the *reality* of the disciplinary academic system differ—and, therefore, we have been experiencing a “paradoxical discourse” for more than four decades (Weingart, 2000)—the intensified hype is more than remarkable. In the hype, there are not many critical voices, as Robert Frodeman (2014) observes. Today, interdisciplinarity is neither the source, the medium, the facilitator nor the object of critique. The inflationary usage seems to have turned interdisciplinarity into a tame and toothless notion.

However, this is not the whole story. Rhetorical mainstreaming obscures the fact that interdisciplinarity entails political dimensions (Schmidt, 2007): Interdisciplinarity is a core label of the late-modern science policy discourse on the present and future of scientific knowledge production. This political dimension—including ideology, interests and power relations—is often not recognized; the political economy is overlooked. Interdisciplinarity seems to be largely depoliticized. This depoliticization is decisively triggered by a focus on methods, in other words, by the “magic of methodism” (Frodeman, 2014, p. 49): Interdisciplinary prioritize a discourse around methods, means and management procedures.⁴ Interdisciplinarity is seen mainly as a methodological and organizational challenge. Manuals, recipes, toolboxes and guidelines on how to conduct interdisciplinarity research have been developed (National Academies of Science, 2005; Newell, 2001; Newell, 2013; Repko & Szostak, 2017; Pohl & Hirsch Hadorn, 2007; Keestra et al., 2022). There is a lot of talk about integration methods; interdisciplinarity is often conjoined with integration. In order to foster procedures of integration, several new fields—such as *Science of Team Science* (SciTS) and *Integration and Implementation Sciences* (i2S)—have

³ Note that the overall approach in this article follows Schmidt (2022).

⁴ This observation has also been made by Maasen (2010, p. 249).

been established.⁵ This is a perfect *instrumentalist* viewpoint that depoliticizes knowledge production:⁶ Interdisciplinarity is solely seen as a smart *instrument* to overcome the deficits in disciplinary knowledge production. The instrumentalism of interdisciplinarity stands in the cultural tradition of the optimistic Baconian program of modern sciences and the ideals of science- and technology-driven modernization. Interdisciplinarity appears as a symbol for innovation, progress and advancement within the sciences and for society at large. As such, it is intertwined with a high valuation of scientific knowledge, in line with *concepts of modernization*. That even interdisciplinary knowledge can be inherently ambivalent, though, does not seem to be included in this depoliticized framing.

Of course, given the disciplinary silos of the academic system, the questions of *how* to practice interdisciplinarity and *how* to conduct interdisciplinary projects is obviously pressing. However, there remains an uneasiness with the dominance of methods and the instrumentalist take. There is hardly any cultural critique to be found of the sciences, scientific knowledge, research institutions or science policy programs. The general crisis of scientific knowledge, in particular the role of the sciences in causing the climate and biodiversity crisis and other environmental problems, is not recognized. Political dimensions such as power relations, institutional settings, positivist governance regimes, economic pressures, cultural habits of the sciences, the framing of nature and of human-nature relations, as well as the overall transformation of knowledge production towards an engineering or technoscience approach are often not considered. The political role and function of interdisciplinarity in our knowledge society in neoliberal times are seldomly noticed or reflected upon.⁷ And even the obviously instrumental means-ends relations are not identified or scrutinized—including the fact that means tend to become ends.

5 The means and methods centrism which is also obviously present in the common parlance of “joint problem solving” (Klein et al., 2001) is often not recognized. Related to the “methodism” is the implicit “solutionism” (Morozov, 2013): Interdisciplinarity should provide “solutions to societal pressing problems.” Instrumentalists advocate a solutionism, namely that solutions exist and, furthermore, that these solutions ensure an ultimate elimination of the problem. In this view, society resembles a mechanical arrangement which seems to be a kind of a machinery; interdisciplinarity appears as a mechanical tool to fix the things.

6 This view in particular is advocated by the social sciences engaged in interdisciplinary practice. The social sciences appear to be both competent and in charge here; they seem to be the facilitator of interdisciplinarity.

7 This critique was also formulated—in the one or another way—by Robert Frodeman (2014) and Sabine Maasen (2010). In this context, the notion “neoliberal,” which is often used in political philosophy as well as in economics, does not refer primarily to the ideal of a minimum or a minimization of state regulations (as in the classic concept by Adam Smith or in the modern version of Milton Friedman and colleagues) but to an evaluation-based money-oriented governance regime that is considered the fundament for the institutional setting and the governance strategy of the university. Incentives for faculty members and other actors (scientists, researchers, lectures, staff and others) play a central role; mostly they are money oriented. The quality of research, of grants,

Originally, a critical and political attitude towards knowledge production and technoscientific progress was a cornerstone of interdisciplinarity. It appeared as a critical environmentalist concept (Frodeman, 2014; Schmidt, 2022). The focus was on pressing environmental problems, the challenges of global change and the side effects of technological advancement. The role of science and of the entire academic system in causing the non-sustainable state of our life-world came under scrutiny. The mindset of modernity, including the power and authority of science to dominate our way of framing and conceptualizing nature and human-nature relations, was questioned. Occasionally, interdisciplinarity was deemed a fundamental challenge to the academic and research system within late-modern knowledge societies. In the 1970s and 1980s, such a critique was articulated by Jantsch (1970; 1972), Mittelstraß (1987), Weingart (1987) and others, as well as by feminists (Fox Keller, 1985; Harding, 1986) and environmentalists (Næss, 1973; Norton, 1991). Ten years ago, Frodeman (2014) renewed this critique from a new angle, and later, Schmidt (2022) further underpinned the critical-reflexive perspective.

According to Jantsch (1972), inter- and transdisciplinarity are the key notions for “renew[ing] the education and innovation system” (p. 116). For Jantsch, there is an obvious need for renewal. He observes “degrading side-effects of technology on the systems of human life,” particularly on the “natural environment” (p. 101). Moreover, “there does not seem to be any alternative if a rational, one might even say, an ecological approach to science and technology is mandatory, as indeed it has to be considered in the present situation” (p. 120). What is strongly required, Jantsch states, is a different way of shaping and designing the “joint systems of society and technology” (p. 119). In this vein, Jantsch argues for a new agenda and a different orientation of science and society—an orientation that, today, can be found under the umbrella term “sustainable development” (WCED, 1987). In the 1980s, interdisciplinarity was a

medium of self-reflection of [scientific] knowledge . . . [It is] a reflection on the boundaries of science and ethics, in particular on the inherent, but implicit, normative elements of the sciences. The most important role of interdisciplinarity is to reveal these [value dimension], in order to make people aware of them and free them from the authority of (seemingly) natural law. (Weingart, 1987, p. 165)⁸

Weingart (2000) observes an instrumentalist or solutionist concept of interdisciplinarity which he calls “strategic or opportunistic interdisciplinarity” (p. 39).

of publications, of service, of teaching or of all other activities are assumed to be measurable. In this sense, neoliberalism is based on a positivist view of the social sphere of the practice of the actors of the science, research and higher education system.

8 This is my translation.

The lack of a broader perspective in the discourse is not the only deficit. In many interdisciplinary projects or research programs, the focus on methods allows for the exclusion and neglect of ends and purposes, objectives and goals, as already mentioned: *For what* and *why* are we practicing interdisciplinarity? The common reference to (so called) “wicked” or “complex” problems that require interdisciplinary collaboration for problem-solving does not seem to be a satisfying answer. What is missing is the reference to, reflection on, and (possible) revision of overarching ends, goals, objectives, purposes and values of a certain interdisciplinary project. Such a critical perspective could be easily added. Issues need to be addressed, such as: Who has the authority and the power to define what a problem is? What are the political interests, the power relations and the intended societal relevance?⁹

In general, these are wider and deeper (*why* and *for what*) questions. What is strongly needed in the public and scientific discourse of interdisciplinarity, as well as in every interdisciplinary project, is a sensitivity for values, normativity, ethical and political dimensions: not only the values as normative aspects *within* the methodology of interdisciplinary knowledge production itself, but the values *ex ante*—the objectives and goals of the entire interdisciplinary program or project, and their assessment and justification. In the latter sense, ethical elements are indispensable, in addition to the political dimension.¹⁰ Seen from this angle, interdisciplinarity was originally linked to the idea of a political and ethical orientation and reflection of the dynamics of the sciences and research processes.¹¹ This is in line with Machiel Keestra

9 For instance, there are objectives of an interdisciplinarity project such as gaining military superiority—as in the NBIC-convergence scenario of the Roco-Bainbridge report (Roco & Bainbridge, 2003). Other goals concern the reduction of greenhouse gases and the transformation of the transportation system.

10 In addition, there might be a third point that gives substance to my reluctance to engage in the dominant discourse on instruments, means and methods, recipes and procedures. Insofar as interdisciplinary practices and projects are diverse and heterogeneous, there seems to be fundamental arguments that question whether there can be common methods or unifying instruments. Paul Feyerabend (1975), for instance, scrutinized in his seminal work *Against Method* whether even in disciplinary sciences, such as physics, there are core methods: What holds for disciplines would also hold for inter- or transdisciplinary projects. And, Wolf Krohn (2010) argued that interdisciplinary practice is somewhat similar to ideographic and hermeneutic approaches that address singular and unique objects; it is in sharp contrast to nomothetic traditions that govern the natural sciences and engineering. So, any inter- or transdisciplinary toolbox, such as the one of the Swiss Academies of Sciences and Arts, developed by td-net and Christian Pohl, (implicitly or explicitly) advocate a certain view of what a good and successful inter- or transdisciplinary project is—or has to be. This could be seen in contrast to the diversity of inter- and transdisciplinary practice, although toolboxes can be of functional help.

11 Interdisciplinarians should recognize the dangers and threats of scientific knowledge for the future of society; the inherent ambivalence of scientific knowledge was apparent. Such a critical take could enrich the recent discourse on interdisciplinarity as well as the practice of interdisciplinary research.

and colleagues who have encouraged interdisciplinarians to reflect on their “normative assumptions” since they “inevitably play a role in science,” and in particular, in interdisciplinary research approaches.

More generally, normative assumptions underlie ideas about what science is and what it can accomplish, whether it is acceptable to derive ethical claims from facts of nature, how to define societal welfare in financial terms only, or whether we should develop medical knowledge (for example of contagious diseases) that might also be used in warfare—to give a few examples. (Keestra et al., 2022, p. 39–40)

To summarize: The instrumentalist, strategic or solutionist understanding of interdisciplinarity, based on methods and tools, is not sufficient. What is needed is a *critical-reflexive* kind of interdisciplinarity or, at least, critical-reflexive elements within every interdisciplinary project. As we can learn from Jantsch (1972), Mittelstraß (1987), Weingart (1987), Maasen (2010) and Frode-man (2014), a wider discourse on, and broader practice of, interdisciplinarity could encompass some key things: First, a politicization of interdisciplinarity. This implies a cultural critique of scientific knowledge and its ambivalent role in society at large, in particular a critique of the modern sciences, the Baconian optimism and the crisis of modern knowledge production (Schmidt, 2022). Second, a concrete critique, namely a reflection on, and revision of, ends, goals and objectives of a certain interdisciplinarity project. In the following, I will focus on the second type of critique and lay the foundation for such a critique. It should be noted, however, that the first type is much more comprehensive as it goes beyond means-ends relations and rationalities, and it recognizes scientific knowledge in general, while the second type accepts means-ends rationalities and focuses on goals and ends.¹²

A major reference point for philosophical critique is Kant. Since Kant, critique in the broadest sense has meant questioning, scrutinizing and differentiating what seems to be given, in order to enable an argumentative discourse and communicative action. In this traditional philosophical sense of critique, providing differentiation is a central task for what I call the “philosophy of interdisciplinarity” (Schmidt, 2022). This view is shared by the critical thinking of the critical theorists of the Frankfurt School, the transcendental pragmatists and some (neo-)materialist thinkers.

On this basis, acknowledging the political and ethical dimension would imply posing questions such as: What do we mean when referring to “inter-disciplinarity”? Which type of interdisciplinarity do we want to facilitate and foster—and which do we not? What are the guiding intentions, the driving interests, the underlying values and the power dimensions of a specific interdisciplinary project? In this sense, critique means to assess the agendas and

¹² A third type, which scrutinizes the possibility of a methodological arch and a common denominator, is not pursued here since an empirical approach would be necessary.

objectives of research projects.¹³ Such a broader *critical-reflexive* perspective could and should be pursued and strengthened—both in the discourse on interdisciplinarity and in every interdisciplinary project. This recommendation of mine is part of a program I developed called the “philosophy of interdisciplinarity” (Schmidt, 2008b; Schmidt, 2022).

Opening the Door for Critique: Boundary Dialectics

To enable critique, the starting point and first task of the *philosophy of interdisciplinarity* is to scrutinize the very notion of interdisciplinarity. Differentiation can help us to not fall into the trap of common parlance which relates interdisciplinarity to “wicked problems,” “joint problem solving across science and society” and “integration” (Klein et al., 2001).

Analytically, interdisciplinarity is based, in one way or another, on disciplinarity. The term itself is a derivative of disciplinarity. Although the latter is not much simpler to define than the former, shifting the focus onto disciplinarity can prompt a fresh way of thinking about the field of interdisciplinarity. Interdisciplinarity urges us to rethink disciplinarity, particularly with regard to the institutional constitution of the academic system, to the authority and power of disciplinary gatekeepers, and to the criteria of what counts as scientific knowledge and objectivity (see also Frodeman, 2014; Weingart, 1987, 2000).

What are disciplines? In fact, the philosophy and sociology of science—in line with the science and technology studies (STS)—have shown that disciplines cannot be adequately grasped as coherent structures rooted in given domains of objects, certain theoretical entities or distinguished methods. Although these aspects may indeed play a role, disciplines need to be seen as historically constituted institutional structures that are, to a greater or lesser extent, created by the social and cultural sphere—which is itself influenced by societal trends, historical contexts, economic interests, political decisions, authorities and “power games” (Habermas, 1987). This historical contingency

¹³ Such a philosophical approach could contribute to a fundament for critical engagement with interdisciplinarity and it could enrich and facilitate the interdisciplinary practice. This article follows a normative program. It provides differentiations to advocate for a certain type of interdisciplinarity, namely, a certain kind of problem-oriented interdisciplinarity that can be seen as critical-reflexive. However, the distinction between the instrumentalist view and the critical-reflexive approach is not absolute; we find a kind of dialectic relationship, which is not disjunctive or antagonistic in the sense that it requires us to subscribe to either one or the other understanding. Rather, the instrumentalist position can be taken as a necessary first step towards a critical-reflexive type of interdisciplinarity. In short, the latter complements the former. Not only is the critical-reflexive understanding based on instrumentalist considerations but, moreover, it can be regarded as instrumentalist on a higher or deeper level—since it aims to achieve a much bigger impact on a sustainable development of science, technology, and society.

of disciplines is inescapable and is inherited with the notion of interdisciplinarity. Given the contingency of disciplinarity, and thus of interdisciplinarity, we can still identify two assumptions that constitute the semantic core components of interdisciplinarity.

First, whenever one speaks of interdisciplinarity, a *boundary premise* is present. Boundaries—which are central to any kind of differentiation, demarcation, separation, segregation or fragmentation—are seen as existing between disciplines as well as between the academic system and society. Not only do boundaries contribute to the delineation of disciplines, they are also seen as barriers and obstacles to knowledge production; boundaries appear as synonyms for limits and limitations.

Second, the *transgression, synthesis or integration premise* assumes that options are available to overcome those boundaries. Interdisciplinarity aims to facilitate the transfer, circulation, synthesis, integration or unification of disciplinary perspectives. It is typically linked to the ideal of bridging disciplines and integrating the splintered fragments of disciplinary knowledge.

Considering these two complementary premises of “interdisciplinarity” results in what could be called a *boundary paradox*: the conservation *and* elimination of boundaries simultaneously. The elimination of disciplinary boundaries would naturally render conservation impossible—and interdisciplinarity would dissolve. In fact, the elimination of interdisciplinarity pursuant to the elimination of boundaries has been, and still is, a frequently occurring phenomenon in the academic system: The historical institutionalization of computer science and informatics during the 1960s and early 1970s provides a prominent example of the gravitational pull of the normalization or mainstreaming process by which interdisciplinarity is eliminated by the creation of a new discipline. A newly institutionalized “interdiscipline” rapidly turns into a new discipline with a new regional ontology. This disciplinary gravitational pull is always a threat to interdisciplinary efforts.

From a philosophical perspective, we should underscore that boundaries are indispensable, and also constitutive, for any research activity labelled “interdisciplinary.”¹⁴ Instead of a “boundary paradox,” a more appropriate term to describe the tension between conservation and elimination might be “boundary dialectic.” Locating the notion of interdisciplinarity within dialectic thinking—which comes close to Hegel’s *Aufhebung*—highlights that interdisciplinarity always holds a hidden critical potential. Interdisciplinarity is both dependent on disciplinarity *and* a challenge to disciplinarity. A critical-reflexive approach, as set forth throughout this article, is intrinsically bound to the recognition of, and reflection on, boundaries. Hence, any concept of interdisciplinarity requires a reference to boundaries and, more specifically,

¹⁴ Descriptively, the elimination of interdisciplinarity through the formation of a new discipline might be of interest to research fields such as the science studies or the history of the sciences.

it requires a boundary-based dialectic concept of (a) separation and differentiation and (b) transcendence and integration. Employing dialectic thinking enables us to reject prominent interpretations that associate interdisciplinarity solely with synthesis, fusion, or integration. Typically, integrationists follow the traditional pull of disciplinarity and disciplinarization, namely “disciplining of interdisciplinarity”; they aim to establish a new discipline, a “discipline of interdisciplinarity,” as Gabriele Bammer (2013) calls for. In contrast to these one-sided and self-contradictory approaches, interdisciplinarity requires dialectic thinking.

Interestingly, boundaries are an old and ongoing philosophical topic, which touches on fundamental questions about the entities and the structure of the world, the condition of the possibility of scientific knowledge, and ways to acquire that knowledge. Well-known philosophical positions embrace monistic or dualistic concepts (ontologies and epistemologies) interlaced with topics such as (non-)reductionism. Over the last 40 years, philosophers and social scientists have extensively examined boundaries but with only the very occasional reference to interdisciplinarity. Interdisciplinary themselves, on the other hand, rarely consider boundaries and borders explicitly. The large overlap of the two fields holds huge potential for cross-fertilization and mutual learning. The discourse on interdisciplinarity could, for instance, undoubtedly derive benefit from the line of thought of Ulrich Beck and Christoph Lau (2004), who seek to establish a “boundary politics in the age of boundary dissolution and border elimination” (p. 15).

In summary, the key point is that reflecting on boundaries, that is, recognizing, setting, maintaining as well as transcending and transgressing boundaries—in short, *boundary work* (Gieryn, 1983)—can be considered central to the reflection on interdisciplinarity. Since any adequate definition of “interdisciplinarity” refers to boundaries, a *philosophy of interdisciplinarity* needs to explicitly address boundaries and provide a conceptual framework encompassing both (a) separation or differentiation and (b) transgression, transcendence or integration. Hence, any concept or theory of interdisciplinarity must fulfil this twofold dialectic requirement.

Basis for Critique: Types of Interdisciplinarity

In the following, I develop a framework of various dimensions or non-disjunctive types of interdisciplinarity which refer to boundaries and fulfill the dialectic requirement elaborated above: the separation or border premise as well as the transgression or integration premise.

While the *semantic core* of interdisciplinarity consists of boundaries, as argued above, the *various types* will show that interdisciplinarity is a multifaceted phenomenon. In other words, from a philosophical viewpoint, the

extension of the term must be characterized by a plurality: a plurality of types unified in a semantic core of boundaries. Such a framework is not an end in itself but will be used to analyze and assess interdisciplinary research programs and projects. The leading question of this paper is: Which type of interdisciplinarity can be seen as critical-reflexive and which not? And what could this mean? By employing distinctions that are well established in the tradition of philosophy—such as those between ontology (objects), epistemology (knowledge, concepts, theories), methodology (methods, approaches, heuristics), as well as one more central aspect, namely problems—four types of interdisciplinarity can be identified.¹⁵

First, *an object-oriented or ontological type of interdisciplinarity* can be defined in terms of objects, entities or structures of reality such as the human brain, the evolution of the earth, the ozone hole, the cosmos, nanoparticles, nuclear power plants, personal computers, skyscrapers, water supply systems or military infrastructures. When it comes to this kind of interdisciplinarity, the basic assumption is that the historical, functional differentiation of the academic world into institutionalized disciplines is not contingent. Rather, the differentiation mirrors and represents aspects of the nature of the things and entities themselves. Interdisciplinary objects are deemed to be located within or built into the deep structure of reality. Edmund Husserl, Nicolai Hartmann, Alfred North Whitehead and others argue for a structural layered understanding of reality, according to which interdisciplinary objects were to be seen located at the boundaries between different micro-, meso-, macro- and other cosms, that is, on, at or in the border zones between the disciplines.

When advocating for the position of object-oriented interdisciplinarity, one must presuppose an ontological realism or at least a real-constructivism concerning objects, interlaced with a layered concept of reality, and, based on this, an ontological non-reductionism. Old and ongoing philosophic issues about ontological monism, dualism and pluralism emerge in this debate. Interdisciplinarity according to this view is not primarily concerned with knowledge, methods or research goals, but above all with a reality that is assumed to be independent of humans. A minimal realist view is involved. More recent versions of this position do not assume the timeless, somewhat Platonic existence of objects. New interdisciplinary objects are constructed and created through the massive spread of technologies or are cognitively constructed by the sciences themselves. Examples include the hole in the ozone layer, nano systems, high-frequency trading on the stock exchange or virtual objects in computer science. The massive spread of human-constructed objects, sometimes labelled “human-created nature,” also supports the observation that we

¹⁵ There may be other types of interdisciplinarity. However, in order to classify and clarify the dominant types, these four types seem to be sufficient.

are witnessing an epochal break with regard to ontology, as Martin Carrier (2011, p. 51) argues.

Second, *the knowledge and theory-oriented type of interdisciplinarity* refers to epistemological aspects as the central criterion. The underlying motive for this kind of interdisciplinarity is interlaced with the traditional epistemic value of truth, explanation and intersubjective justified belief. The focus lies on knowledge, propositions, theories, models and concepts—and not primarily on objects or methods. The crucial questions in this case are the following: How can we demarcate interdisciplinary knowledge from disciplinary knowledge or from non-scientific knowledge? How should we specify interdisciplinary theories, models, laws, descriptions and explanations? Do these provide a specific conceptual understanding of the objects under consideration? Interdisciplinary theories or concepts can be applied to describe very different disciplinary objects. According to this understanding, an interdisciplinary theory highlights structural similarities between properties of different objects from various disciplines. Systems theory is one of the most prominent examples of an interdisciplinary theory, as is cybernetics and, to a certain extent, some variants of the theory of evolution. Furthermore, strong arguments have been put forward over the last fifty years claiming that, on a deeper level, we are witnessing the emergence of novel interdisciplinary theories—specifically self-organization theories—which provide an evolutionary, dynamic, self-organizing understanding of the entire world.

As elaborated above, the basic requirement is that an interdisciplinary theory is not reducible to a disciplinary one; that is, interdisciplinary theories do not fit into disciplinary frameworks. An epistemological non-reductionism of interdisciplinarity with regard to disciplinary theories is essential to this view. Theory-oriented interdisciplinarity questions the ideal of the covering-law model and the feasibility of grand unification based on the subsumption of all phenomena under a disciplinary law.

Third, as noted before, the mainstream approach to interdisciplinarity recognizes interdisciplinarity from a methodological angle and primarily regards it as a challenge to scientific methodology. Interdisciplinarity appears as a method. In other words, *a method-oriented type of interdisciplinarity* can be identified. Methodology generally refers to knowledge production, the research process, rule-based actions of scientists, procedures of inquiry, and the languages used therein. In methodology, the main issue is how, and by which rules and procedures, we obtain knowledge and insight. This procedural understanding of the sciences—science as research—is sometimes called *context of discovery* or the *research form* of science to distinguish it from the context of justification, which refers to knowledge, theories or propositions. Rough, classical categorizations distinguish between empirical and hermeneutic, nomothetic and ideographic methods as well as, more generally, between the methods of the natural sciences and those of the humanities or between

explanation and understanding. With respect to interdisciplinarity, some of the central questions include: Do interdisciplinary methods and actions exist? Is there a specific context of discovery that is prevalent in interdisciplinary projects? Which validity, evidence and quality criteria can be applied to the results of interdisciplinary projects? Do they differ from those found in disciplinary projects?

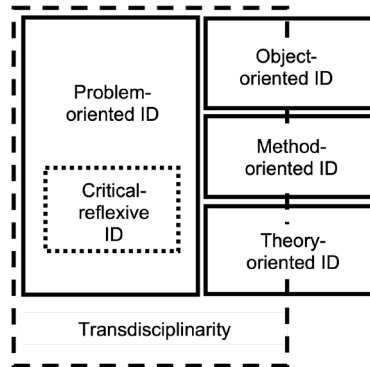
Interdisciplinary methods appear to be irreducible to disciplinary ones. Outstanding prospects are ascribed to those interdisciplinary methods that facilitate the transfer of knowledge between disciplines and also to those that combine descriptive, normative and abductive methods of reasoning beyond disciplinary havens. In addition, some scholars see interdisciplinarity (and its cognate transdisciplinarity) as a method to bridge the gap between the academic system and society—in other words, methods are interdisciplinary when they enable, facilitate and foster knowledge production between the academy and society in one way or another. Most recently, AI methods used in the natural, engineering and social sciences as well as in the humanities appear as a form of method-oriented interdisciplinarity.

Towards a More Critical Take: Problem-Orientation Interdisciplinarity

The list above, in particular the three types, is not fully satisfactory. These types overlook the starting points and underlying motives—in particular societal problems, issues and goals—of many interdisciplinary research projects and activities. To overcome this deficit, we need to consider a fourth perspective that opens up a more fundamental level of reflection. Such a take on interdisciplinarity is quite common in some areas of interdisciplinary practice, for example in sustainability research. Interdisciplinarity is seen in connection with tackling wicked societal problems that are deemed beyond the scope of a specific discipline and are even located outside the academic domain. This type of interdisciplinarity is often described as problem-oriented, purpose-driven, issue-focused or—with a slightly different meaning—as transdisciplinary. It is important to point out, see Figure 1, that transdisciplinarity should not be restricted to cases where stakeholders or lay people are involved in the process of knowledge production (Gethmann et al., 2015; Jaeger & Scheringer, 2018; Mittelstraß, 2018; Schmidt, 2022).

Compared with the three other types of interdisciplinarity, *problem-oriented interdisciplinarity* regards science and research from a more comprehensive and inclusive perspective. Its focus is on societal problems and ethical-relevant issues. However, as we will point out later, not all modes of problem-oriented interdisciplinarity deal explicitly with problems, ends, goals, objectives, values and normative elements; some modes assume that problems

Figure 1. Landscape of Definitions



Note. We can distinguish four types or dimensions of interdisciplinarity (ID): object-oriented ID, method-oriented ID, theory-oriented ID and problem-oriented ID. The last focuses on societally or ethically relevant (extra-scientific) problems. Some problem-oriented interdisciplinary projects are also critically reflexive: The latter category is a subset of problem-oriented ID. In addition to a mere means-centered instrumentalist approach, critical-reflexive (problem-oriented) ID also involves reflection on and, if deemed necessary, the revision of the problems, goals, purposes or values of research agendas. Of greatest interest is the overall relation of ID to transdisciplinarity (TD) insofar as TD is a very popular notion. The latter should not be restricted to or defined by only referring to the involvement of (extra-scientific) lay people or stakeholders (see this Chapter 2). Since TD addresses trans-epistemic, extra-scientific or real-world issues (e.g., mode 2, trans-science, post-normal science, technoscience and the like), TD and ID (in particular: TD and problem-oriented ID) need to be distinguished. Some disciplinary issues are transdisciplinary but *not* interdisciplinary and, more specifically, *not* problem-oriented interdisciplinary (e.g., the design and construction of a bridge). In fact, many engineering challenges are to be considered disciplinary *and* transdisciplinary. Conversely, certain interdisciplinary objects (object-oriented ID) cannot be considered transdisciplinary, such as the cosmos (in particular, the cosmic evolution of the universe) or the human brain and its (self-)consciousness. Since problem-oriented ID always refers to real-world or trans-scientific, societally/ethically relevant problems, problem-oriented ID is effectively a subset of transdisciplinarity. In addition, some interdisciplinary objects cannot be classified as problem-oriented, such as (techno-)objects on the nanoscale that extend across the borders between physics, chemistry, biology, informatics, material engineering and others. Nano-scale projects are very technically centered and therefore cannot be regarded as being problem-oriented, although they are clearly transdisciplinary since they are associated with extra-scientific or trans-epistemic goals. Therefore, the notion of problem-oriented transdisciplinarity makes sense. The point to recall is that projects may be disciplinary *and* transdisciplinary (e.g., bridge construction) or interdisciplinary *and* non-transdisciplinary (e.g., cosmic evolution). Transdisciplinarity is not the counterpart to (and not a disjunctive form of) disciplinarity. (This figure and note can also be found in Schmidt, 2022, p. 30; reprinted by permission.)

and ends are given. The reflection on and (possibly) the revision of goals, ends, objectives and values, seem beyond the scope of their professional inclinations and even expertise as scientists. This differentiation regarding how problems, goals and values are dealt with (namely, in an explicit or implicit manner) is of central importance for understanding the critical-reflexive mode

of problem-oriented interdisciplinarity. Here is the crucial point to characterize critical-reflexive interdisciplinarity and to distinguish it from the common, namely instrumentalist and solutionist view of interdisciplinarity. Before we go in more details, let us clarify the notion of “problem.”

In general, the problem dimension, notably the will to know, precedes both the “context of discovery” (the methods) and the “context of justification” (the theories or the body of knowledge). Despite the obvious significance of the points of departure of research projects, philosophers have, surprisingly, only rarely acknowledged this broader and more appropriate view of the sciences.¹⁶ Their reluctance might stem from a fear that problems, because of their being obviously value-laden, cannot be separated from the social and societal dimensions of research activity. Outside the mainstream of the traditional philosophy of science, thought-provoking approaches have been pursued under the label of the new field of social epistemology (Fuller, 2002) and by some newer streams in the philosophy of science. However, scholars in these fields have not done an in-depth examination of problems, goals and agenda-setting procedures.¹⁷ The structure and elements of problems have barely been clarified or understood.¹⁸

What kinds of problems are meant in problem-oriented interdisciplinarity? (a) At first sight, one might assume that they are merely epistemic in nature. Indeed, there are also challenging problems that emerge through intra-scientific progress and require an interdisciplinary effort within the sciences. For instance, problems in the field of physical cosmology need collaboration among physics, chemistry, geology and computer science. Tackling these problems is of interest to the sciences and serves their truth-seeking but does not have wide-ranging relevance for society at large. (b) In addition, interdisciplinary problems can emerge within the economic or business field. Finding solutions to these trans-scientific or extra-epistemic problems is guided by the objective of economic utility and is often motivated by the growth imperative of shareholder value. The same holds true for technical problems and their solutions that are based on ideals of improving technical functionality or efficiency.

Although both kinds of interdisciplinary problems (a and b) clearly pose challenges to scientific collaborations, they are usually not what interdisciplinarians have in mind when they speak of problem-oriented, issue-initiated or purpose-driven interdisciplinarity. Against these two kinds of problems,

16 Indeed, Popper sees science as a “problem-solving enterprise” in a quasi-(bio-)evolutionary way. However, for Popper problems are regarded from a disciplinary angle, for example, they are framed necessarily from the conceptual backgrounds of a specific discipline.

17 The same is true for innovative fields in the social sciences where scholars have addressed so-called “wicked problems” (Rittel & Webber, 1973).

18 Exceptions include Nickles (1981).

we now can advance an adequate understanding of the specific problems of problem-oriented interdisciplinarity. To do so, we need to consider the overall relation of interdisciplinarity to transdisciplinarity, in particular to transdisciplinary problems.

Firstly, problem-oriented interdisciplinarity is always transdisciplinary, which excludes mere academic and intra-scientific problems (against a). Although the proponents of problem-oriented interdisciplinarity do not deny the existence of an intra-academic kind of problems, they emphasize the transdisciplinary nature of the problems of problem-oriented interdisciplinarity. This is why they often refer to interdisciplinarity as transdisciplinarity. The term transdisciplinarity underlines the extra-scientific orientation of knowledge production and the trans-academic character of the problems: Science produces knowledge in and for society.

Secondly, when interdisciplinarians describe their approach as transdisciplinary, they are not denying that traditional disciplines such as certain business or engineering/technical sciences can be seen as endeavors that transcend the boundaries of academic system. Their problems are trans-academic and, in this sense, are clearly transdisciplinary. However, problem-oriented interdisciplinarity is more specific than transdisciplinarity. The former is a genuine subset of transdisciplinarity (against b). The problems of problem-oriented interdisciplinarity are generally linked to societal and ethical motives. They are primarily ones that represent challenges to society at large, such as climate change, the loss of biodiversity, the limits of energy resources, new wars, the threat posed by atomic weapons, nuclear waste from power plants, the danger to human health caused by environmental pollution and the global injustice surrounding the worldwide distribution of wealth. All problems that hinder us from pursuing the goals of sustainable development represent the kind of issues addressed by problem-oriented interdisciplinarity. Transdisciplinary problems are therefore much broader in scope and less specific than the problems of problem-oriented interdisciplinarity (see Figure 1).

However, this is not yet enough differentiation to characterize and promote a more critical-reflexive view of interdisciplinarity. We need to distinguish between two modes of problem-oriented interdisciplinarity. *One mode* involves the reflection on and, if deemed necessary, the revision of the problems, ends and goals of research agendas—which includes the leading values and an argumentative justification of the relevance of the specific problems addressed. This approach concurs, for instance, with the transcendentalist-pragmatist thinking of Jürgen Habermas (1971), who reflects upon normative elements and guiding interests of scientists and their research agendas. A *second mode*, contrary to this first mode, accepts problems as being simply given. The former can be termed the *critical-reflexive* kind of problem-oriented interdisciplinarity whereas the latter is primarily an *instrumentalist, solutionist* or *strategic*

account.¹⁹ The other three types of interdisciplinarity discussed above—object-, theory- and method-oriented—share the instrumentalist view.

Case Studies

The framework of the four types of interdisciplinarity can be further illustrated by some popular examples of research programs that are labeled “interdisciplinary.”

First, let us consider interdisciplinary objects and the ontological type of interdisciplinarity. Nano research is a very prominent field that claims to be interdisciplinary, as presented by the U.S. National Science Foundation in an influential report (Roco & Bainbridge, 2002). In 1959, the physicist Richard Feynman stressed the presence of “white and unconquered domains” on the “disciplinary map of sciences.” There seems to be “plenty of room at the bottom” (Feynman, 2003). According to Feynman, nano-objects are located between the microscale of quantum physics and the mesoscale of chemistry and biology. Some of them are designed, constructed and created by researchers; others existed or came into existence independently before the emergence of nano research but have now been discovered or brought under control. Nano-objects are interdisciplinary in nature insofar as they lie on, or between, boundaries of scientific disciplines, whereas the boundaries themselves are thought to mirror the deep ontological structure of reality. Interdisciplinary nano-objects seem to be the unifying core and umbrella notion encompassing the heterogeneous fields of nano research and nanotechnology, which include electron-beam and ion-beam fabrication, molecular-beam epitaxy, nano-imprint lithography, projection electron microscopy, atom-by-atom manipulation, quantum-effect electronics, semiconductor technology, spintronics and micro-electromechanical systems. In these examples, interdisciplinary objects are an essential part of reality on an ontological level: Nano-objects, constructed and created as part of a joint effort of the disciplinary fields of physics, chemistry, biology and the engineering sciences, are today regarded as technoscientific objects.

Similarly, the objects with which neuroscience is concerned are located on various boundaries between the disciplines, that is, between the natural sciences, social sciences and the humanities. Interdisciplinary neuroscientific objects are much more complex than nanotechnological objects. Furthermore, socio-technical objects, such as the water supply system, the internet or the hole in the ozone layer, are further examples of interdisciplinary objects that are characteristic for object-oriented interdisciplinarity.

¹⁹ I refer here to the general argument provided in Schmidt (2022).

Second, let us turn our attention to epistemological dimensions of interdisciplinarity, which refer to knowledge, theories, models and concepts. This kind of interdisciplinarity can be called theory- or concept-oriented interdisciplinarity. Systems theory and complex systems are examples of interdisciplinary theories and interdisciplinary knowledge. Cognitive integration and a theoretical synthesis of knowledge—which avoid the trap of reductionism—are goals that have been partly attained in this area. Other interdisciplinary concepts, very similar to and interlaced with complex systems theory, include self-organization theories, dissipative structures, synergetics, chaos theory, nonlinear dynamics, fractal geometry and catastrophe theory (Mainzer, 1996; Schmidt, 2008a; 2019). Most of these concepts were established in the late 1960s and early 1970s, although some foundational work dates back to the late 19th century. Hermann Haken (1980), for instance, regards his research field of synergetics as an “interdisciplinary theory of general interactions.” Erich Jantsch (1980) views “self-organization theories” and general “concepts of evolution” as “unifying approaches” with multiple “implications to the sciences and the humanities.” Edward O. Wilson (1998) anticipates a new “consilience” entailing a “unity of knowledge,” for instance, through research programs in socio-biology. Klaus Mainzer (2005) identifies within complex systems theory “the basic principles of a common systems science in the 21st century, overcoming traditional boundaries between natural, cognitive and social sciences, mathematics, humanities and philosophy” (p. v). On closer scrutiny, however, this type of theory-oriented interdisciplinarity, which could also be characterized as meta-disciplinary or non-disciplinary, is not as novel as it might appear. It is also found in works from the 1950s. At that time, the physicist and philosopher Carl Friedrich von Weizsäcker (1974) coined the term “structural sciences.” As Weizsäcker writes, structural sciences “study their objects regardless of disciplinary origin and in abstraction from disciplinary allocation” (p. 23). Weizsäcker had in mind concepts such as information theory or cybernetics.

Today, structural sciences have been extended and enriched by complex systems theory, which investigates nonlinear, unstable and chaotic behavior in dynamic systems and describes processes as they evolve over time, such as pattern formation, self-organization, critical behavior, bifurcations, phase transitions, structure-breaking and catastrophes. Complex systems theory addresses old questions concerning the emergence of new phenomena as well as of novel properties, patterns, entities and qualities. One important lesson provided by this interdisciplinary concept for all sciences is the fundamental role of instabilities in nature, technology, and even in social processes.

Third, a common take on interdisciplinarity is the methodological one. Bionics or biomimicry could be regarded as prominent examples of an interdisciplinary method. These fields claim to provide a method of transfer between two disciplines: from biology to the engineering sciences and probably (though

this is usually not acknowledged) vice versa. It is maintained that the central idea of bionics is to “learn from nature” so as to “inspire technological innovations” and “optimize artifacts and technical processes” (Benyus, 2002). Nature is seen as active, creative and productive. As such, it serves as a source of inspiration for inventions that can be used for the design and construction of new technical systems. The proponents of bionics are convinced that nature “reaches its goals efficiently and economically, with a minimum of available energy and resources. The experience available in nature can be applied to conduct engineering research and technological development” (Hill, 1998, p. 17). Here, interdisciplinarity in the methodological sense is based on a kind of “translation” or “transfer” between nature and technology—more specifically between certain framings, representations, perceptions, understandings or models used in biology and in the engineering sciences. “Learning from nature” therefore means learning from *models* of nature: Nature is not simply given but is constituted or constructed, as Immanuel Kant argued. The models of nature built in the field of bionics are based on the perspective of the engineering sciences. For example, a robot may be a technical model of an ant and therefore mimic the ant, but at the same time the ant is modelled by the bionics researcher from a technological perspective. Construction and reconstruction—in this case the engineering sciences, on the one hand, and biology, on the other—merge, at least to some degree, since the goal of bionics is not only to produce knowledge but also to create technological artefacts. Bionics can be seen as a paradigm of a technoscience based on an interdisciplinary method of transfer across the border or trading zone between biology and engineering (Galison, 1996; Gorman, 2010).

There are further examples of interdisciplinary methodologies besides bionics. Econophysics, which methodologically organizes a knowledge transfer between physics and finance/economics, is another paradigm of the methodological type of interdisciplinarity that is very similar to bionics. Further examples entail transdisciplinary methods employed in problem-oriented interdisciplinary projects aimed at organizing and managing the knowledge transfer and production between the extra-scientific and academic participants (Pohl & Hirsch Hadorn, 2007; Bergmann et al., 2012).

Fourth, the most far-reaching type of interdisciplinarity, often referred to as transdisciplinarity, is problem-oriented interdisciplinarity—even though not all transdisciplinary projects can be considered problem-oriented, as elaborated above. In general, interdisciplinary problems can be intra-scientific ones emerging from the curiosity-driven domain of truth-seeking within the sciences, such as problems regarding the origin of life on earth or dealing with the characteristics of consciousness of the human brain. However, these are not the kind of problems that scholars specifically mean when they use the expression “problem orientation.” So, we need to look beyond the curiosity-driven academic field and beyond an economic perspective on interdisciplinarity.

Technology assessment, sustainability science and social ecology are paradigms of problem-oriented interdisciplinary approaches.²⁰ Research in these fields starts from the perception of pressing interdisciplinary problems that are seen as being societally and ethically relevant.²¹

Here, a central distinction concerns the way in which problem-oriented projects deal with ends, goals, objectives and values. The *instrumentalist, strategic or solutionist* mode of problem-oriented interdisciplinarity accepts given goals and problems. It does not see it as a part of the scientific endeavor to deal with them explicitly. The reflection on and revision of goals seem beyond the scope of their professional expertise as scientists. But some projects in technology assessment, sustainability science, and social ecology in particular, reflect on goals and the value dimension in an explicit manner, for instance, in technology assessment of human enhancement, which occasionally considers the fundamental ideals of a capitalist society. These projects can be regarded as critical-reflexive problem-oriented interdisciplinary projects.

Philosophical Schools and Background Convictions

The four types of interdisciplinarity sketched above can be regarded as ideal types, which, admittedly, do not occur exclusively in particular interdisciplinary practices or programs—they are by no means disjunctive in the sense that a research practice or program can be subsumed under (only) one type or another. For example, a specific research program claiming to be interdisciplinary can be both problem- and method-oriented. Nonetheless, one type of interdisciplinarity will typically dominate whereas the other types are seen as derivatives that are related in one way or another to the principal type. Moreover, the question of which types of interdisciplinarity will take precedence over which is undeniably open to discussion and subject to justification. A method-oriented interdisciplinary research program, for instance, can be seen as resulting from a certain problem orientation or vice

20 Problem-oriented interdisciplinarity as a specific type of interdisciplinarity has its own history. We may recall that Jantsch, at an OECD conference in the early 1970s, called for “inter- and transdisciplinarity” not only in an academic context but also for societal and ethical purposes. Jantsch accused the university and academic systems of failing to address the pressing real-world problems such as warfare (involving atomic, chemical and biological weapons); environmental problems such as global warming and the loss of biodiversity; waste production, disposal and contamination; dwindling natural resources; water and food quality problems; and anthropological problems related to the ambivalence of biomedical progress.

21 These fields aim to gain system, target and transformation knowledge (Pohl & Hirsch Hadorn, 2007)—accompanied by consideration of the possible societal impacts of new and emerging technologies (e.g., side effects, risks and potentials)—in order to address prospective problems as early as possible.

versa. In light of the foregoing considerations, we can provide additional arguments to confirm the existence and prevalence of the four types of interdisciplinarity. Most interestingly, one's philosophical background conviction is what—consciously or unconsciously—predetermines which of the four types one considers relevant and which of the types one sees as inferences, derivations or mere consequences. We can inquire into the philosophical background and various implicit philosophies influencing the discourse on interdisciplinarity.

One, with their primary focus on objects, things and artefacts, *realists* and (to some extent) *empiricists*, *new experimentalists* and *real-constructivists* assume the existence of given or constructed objects which can be cognitively perceived from an objective angle. In this object-centered account, interdisciplinary research—like any research activity—is seen to begin directly on the ontological level. The need for interdisciplinarity stems from the essential structure of the objects located beyond or across disciplinary boundaries. Considering these interdisciplinary objects, one must select or develop adequate methods. Furthermore, interdisciplinary knowledge—for realists, empiricists and others—originates in, or results from, the interdisciplinary objects themselves. To summarize, a realist or empiricist position is central to the ability to defend object-oriented interdisciplinarity. Those who deny the plausibility, soundness or justification of the object-oriented view of interdisciplinarity are at the same time attacking central assumptions of positions such as realism, empiricism and new experimentalism.

Two, rationalists tend to frame interdisciplinarity by referring primarily to knowledge, theories, models, concepts, theoretical entities or even mathematical structures. According to such a rationalist perspective, interdisciplinarity becomes necessary because of the increasing fragmentation of knowledge and the lack of unity: Interdisciplinarity is regarded as an attempt to counteract this development. Its goal is to contribute to a broader view of things by bridging, synthesizing, integrating or unifying various knowledge fragments from different disciplines and subdisciplines. The guiding ideal is to provide a coherent picture of the whole of reality or at least of those things that are regarded as a central part of reality. In contrast to the belief underpinning object-oriented interdisciplinarity, the different academic disciplines are *not* assumed to mirror different natures of the objects, but rather are (pre-)defined by a specific kind or corpus of concepts, knowledge, theories or models. The theory-oriented type of interdisciplinarity certainly seems the most ambitious given that it requires a process of cognitive integration or even unification. According to this understanding of interdisciplinarity, theories or concepts have first priority and precede the selection of methods, the framing of objects and the definition/constitution of problems. Object-, method- and problem-oriented interdisciplinarity are therefore seen as derivatives of theory-oriented interdisciplinarity.

Three, many interdisciplinarians—notably methodological constructivists, scholars from science and technology studies, and some pragmatists—tend to reflect on methods, rules of knowledge production, practical procedures or heuristics. They regard science as a method-based action (i.e., as a research activity). Accordingly, interdisciplinarity is defined by methods: Interdisciplinary methods are considered non-reducible to disciplinary ones. Interdisciplinarity from this perspective challenges researchers to set up new procedures, to create a vocabulary that overlaps disciplines, to establish novel validity or evidence criteria, and, in addition, to organize collaboration among the disciplines, and to institutionalize interdisciplinary research processes. The recent predominance of disciplinary cultures—and, more specifically, of disciplinary orientations, validity criteria, heuristics, habits, vocabularies and languages—poses major obstacles to interdisciplinarity. The primacy of methods means that interdisciplinary problems, objects and knowledge are mere derivations or consequences of the respective methods.

Four, a different approach to interdisciplinarity is taken by pragmatists, critical theorists and others such as political philosophers and many ethicists insofar as they refer to problems, goals, purposes and interests. As they see it, the need for interdisciplinarity is due to the emergence of pressing problems that do not fit into the disciplinary differentiation of academia. Holders of these viewpoints evaluate interdisciplinarity by its ability to pragmatically define or address problems. Typically, the problems in question have societal and ethical relevance. The advocates of problem-oriented interdisciplinarity see the framing, construction or reconstruction of objects as a mere consequence of the perception or constitution of problems. The methods, and also the ensuing knowledge, are regarded as derivations. In particular, a critical-reflexive position as a subfield of this approach is advocated by some scholars of this group.

To summarize, philosophical schools of thought serve as lenses through which one views both the disciplinary and interdisciplinary landscape. They determine what meaning and significance one is willing to attach to interdisciplinarity—and which order of priority, hierarchy or chain of inference of the different types of interdisciplinarity one is willing to subscribe to. Given the relevance and prevalence of the four positions on interdisciplinarity, eliminating the plurality of understandings and their reduction to a single meaning—beyond the twofold, dialectic reference to boundaries—is not feasible. The plurality of notions of interdisciplinarity mirrors the plurality of the different intellectual traditions and schools of thought in philosophy. Therefore, the debate on interdisciplinarity is, in a broader sense, not only political, but also philosophical in nature.

Prospects: Politicization of Interdisciplinarity and the Future of Our Knowledge Society

Today, interdisciplinarity is neither the source nor the object of critique. Its inflationary use and mainstreaming have rendered interdisciplinarity a tame and toothless notion. The aim of this article was to expand the recent discourse on interdisciplinarity and to encourage interdisciplinarians to adopt a more critical-reflexive approach in their projects and research programs.

This article did not advance an overall cultural critique of the sciences and of the research and higher education system that was associated with interdisciplinarity in the 1970s (first type of critique).²² It focused on another kind of critique that is concerned with research agendas, policy programs and practical projects, namely a reflection on and revision of ends, goals, objectives and related values and normative dimensions of a certain interdisciplinarity project (second type of critique). My plea for a critical-reflexive mode of problem-oriented interdisciplinarity initially started—in the tradition of Kant—by providing differentiation. According to Kant, differentiation is a normative enterprise that advances the condition of the possibility of critique. By referring to established positions in philosophy, different types of interdisciplinarity can be distinguished: the object-oriented type, the theory-oriented type, the method-oriented type and the problem-oriented type, the last of which can be regarded as a subset of what is known as transdisciplinarity. On a more general note, transdisciplinarity opens science to society; “transdisciplinary disciplines” is not a contradiction and is certainly not an oxymoron. More specifically, the problem-oriented type of interdisciplinarity, as part of transdisciplinarity, takes ethical, societal and political aspects into consideration. A central, further differentiation concerns the way in which problem-oriented projects deal with ends, goals, objectives and values. The instrumentalist, strategic or solutionist mode of problem-oriented interdisciplinarity accepts given goals and problems. It does not see it as a part of their scientific endeavor to deal with them explicitly. The reflection on, and revision of, goals seems to be beyond the scope of their professional expertise as scientists. But some problem-oriented projects include reflections on goals and ends, and explicitly on value and the normative dimension. These are *critical-reflexive* problem-oriented interdisciplinary projects.

Above all, the semantic core of interdisciplinarity is tightly connected to boundaries, more specifically, there is a dialectic relationship between setting boundaries and simultaneously transcending and overcoming them. The acknowledgement of this relationship gives substance to a twofold requirement that is intertwined with both non-reductionism and integration: Interdisciplinary objects, theories, methods and problems are deemed irreducible to

22 This should be done soon.

disciplinary ones. Ontological, epistemological and methodological boundaries, as well as the boundaries of the academic system, are seen as obstacles or barriers to various kinds of reductionism. On the other hand, crossing boundaries is an indispensable aspect of interdisciplinarity. In fact, the bridging of boundaries or the transfer of knowledge across boundaries can be viewed as a kind of integration or, even more so, as synthesis.

This article has specified a critical-reflexive type of interdisciplinarity and argued for a normative, political and ethical take on interdisciplinarity. Interdisciplinarity should go beyond instrumentalism, beyond the “magic of methodism” (Frodeman, 2014, p. 49) and the ongoing depoliticization. Interdisciplinarity needs to be deeper and broader than just an instrumentalist and strategic concept. Methods are necessary, but not sufficient. The consideration of a more comprehensive perspective such as this could enhance the critical reflexivity of any interdisciplinary project.

Biographical Note

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