

The Taxonomy of Interdisciplinarity

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Taxonomies classify entities according to similarities and differences, whether they are animal species, artistic genres, or medical symptoms. Since the late nineteenth and twentieth centuries, taxonomies of knowledge in the Western intellectual tradition have been dominated by a system of disciplinarity that demarcates domains of specialized inquiry. Over the course of the last century, though, this system was supplemented and challenged by an increasing number of interdisciplinary activities. Proliferation gave rise, in turn, to new taxonomies differentiating motivations for interdisciplinary teaching and research, degrees of integration and scope, modes of interaction, and organizational structures. The first major typology was created for the first international conference on interdisciplinarity, held in France in 1970 and co-sponsored by the Organization for Economic Cooperation and Development (OECD) (*Interdisciplinarity* 1972). It introduced a set of terms that differentiated forms of disciplinary interaction. Other labels soon followed, producing a sometimes confusing array of jargon. However, the three most widely used terms in the OECD typology – “multidisciplinary,” “interdisciplinary,” and “transdisciplinary” -- constitute a core vocabulary for understanding both the genus of *Interdisciplinarity* and individual species within the general classification. This chapter distinguishes *Multidisciplinarity* and *Interdisciplinarity (ID)* then describes species of *Methodological ID* and *Theoretical ID*, *Bridge Building* and *Restructuring*, *Instrumental ID* and

Critical ID. The chapter closes by examining major trendlines in the current heightened momentum for *Transdisciplinarity*.

- Table 1 is a graphic overview of key descriptors and terms in the chapter. For a comprehensive examination of the nature and problematics of classification, with attention to both disciplinarity and interdisciplinarity, see Szostak 2004. On changing codifications of interdisciplinarity, see also Klein 1990, 1996, and 2005.

---→ Table 1 about here

Multidisciplinary Juxtaposition and Alignment

Most definitions, Lisa Lattuca found in a comparative study of taxonomies, treat integration of disciplines as the “litmus test” of interdisciplinarity. In fields that prioritize critique of knowledge over synthesizing existing disciplinary components, the premise is disputed, along with the view that disciplinary grounding is the necessary basis for interdisciplinary work. Nonetheless, integration is the most common benchmark and, combined with degrees of disciplinary interaction, provides a comparative framework for understanding differences in types of interdisciplinary work (2001, pp.78, 109). In the OECD classification, *Multidisciplinarity* was defined as an approach that juxtaposes disciplines. Juxtaposition fosters wider knowledge, information, and methods. Yet, disciplines remain separate, disciplinary elements retain their original identity, and the existing structure of knowledge is not questioned. This tendency is

evident in conferences, publications, and research projects that present different views of the same topic or problem in serial order. Similarly, many so-called “interdisciplinary”

Table 1: Typologies of Interdisciplinarity

Multidisciplinarity	Interdisciplinarity	Transdisciplinarity
<ul style="list-style-type: none"> • juxtaposing • sequencing • coordinating 	<ul style="list-style-type: none"> • integrating • interacting • linking • focusing • blending 	<ul style="list-style-type: none"> • transcending • transgressing • transforming
• complementing		• hybridizing
<ul style="list-style-type: none"> • Encyclopedic ID • Indiscriminate ID • Pseudo ID 		<ul style="list-style-type: none"> Systematic Integration Transsector Interaction
<p style="text-align: center;"><u>Partial Integration</u> ←-----→</p> <ul style="list-style-type: none"> Contextualizing ID Auxiliary ID Composite ID 	<ul style="list-style-type: none"> Supplementary ID Generalizing ID 	<p style="text-align: center;">-----→ <u>Full Integration</u></p> <ul style="list-style-type: none"> Conceptual ID Structural ID/Unifying ID Integrative ID
<p style="text-align: center;"><u>Degrees of Collaboration</u></p> <p style="text-align: center;">Shared ID ←-----→ Cooperative ID</p>		

- Narrow versus Broad or Wide ID
- Methodological versus Theoretical ID
- Bridge building versus Restructuring
- Instrumental versus Critical ID
- Endogenous versus Exogenous ID

curricula are actually a “multidisciplinary mélange” of disciplinary courses (Messer Davidow 2000, p.158), including programs of general education and particular interdisciplinary fields that ask students to take a selection of department-based courses. The keywords in Rebecca Crawford Burns’ typology of integrative education provide everyday images of multidisciplinary juxtaposition. When disciplines and school subjects are aligned in parallel fashion, they are in a *Sequencing* mode and, when intentionally aligned, in a *Coordinating* mode (1999, pp.8-9). In either case, however, integration and interaction are lacking. Several technical terms shed further light on the nature of *Multidisciplinarity* in both education and research.

Encyclopedic, Indiscriminate, and Pseudo Forms

Multidisciplinarity is encyclopedic in character. In a six-part typology, Margaret Boden defined *Encyclopaedic Interdisciplinarity (ID)* as a “false” or at best a “weak” form. It is an expansive enterprise typically lacking inter-communication, embodied in joint degrees, the journals *Science* and *Nature*, and co-located information on the World Wide Web (1999, pp.14-15). Comparably, in the OECD conference Heinz Heckhausen defined *Indiscriminate ID* as an encyclopedic form, citing the *studium generale* of German education, vocational training that prepares workers to handle a variety of problems with “enlightened common sense,” and exposure to multiple disciplines in professional education. A second form, *Pseudo ID*, is embodied in the erroneous proposition that sharing analytical tools such as mathematical models of computer simulation constitutes “intrinsic” interdisciplinarity (in *Interdisciplinarity* 1972,

p.87). A number of disciplines have also been described as “inherently interdisciplinary” because of their broad scope. Philosophy, literary studies, and religious studies were early examples, followed by anthropology, geography and many interdisciplinary fields. A wide compass alone, however, does not constitute *Interdisciplinarity*.

Contextualizing, Informed, and Composite Relationships

The loose and restricted relationship of disciplines in *Multidisciplinarity* is illustrated by the familiar practice of applying knowledge from one discipline in order to contextualize another. For instance, a scholar might use the discipline of history to inform readers about a particular movement in philosophy or use philosophy to provide an epistemological context for interpreting a particular event. In *Contextualizing ID*, Boden stipulates, other disciplines are taken into account without active cooperation. She cites the engineering profession’s effort to include social contexts of practice, and the Academy of Finland Integrative Research (AFIR) team adds the example of a research proposal for an extensive reference book on Scandinavian history. Authors from multiple disciplines were to be involved, but their chapters would be arrayed in encyclopedic sequence (Boden, 1999, pp.15-16; Bruun *et al.* 2005, pp.112-13).

The label *Composite ID* names another familiar practice – applying complementary skills to address complex problems or to achieve a shared goal. Heckhausen cited major societal problems such as war, hunger, delinquency, and pollution. He deemed peace research and city planning “interdisciplinarity in the making,” because they simulate exploring interdependencies among a “jigsaw puzzle-like composition” of adjacent fields. He also noted the Apollo space project (in *Interdisciplinarity* 1972, p.88). In *Composite ID*, the AFIR team found, production of

knowledge retains a strong disciplinary thrust. However, results are integrated within a common framework. In the biosciences, for instance, technical knowledge from many fields and expensive instruments are often shared. A research proposal for a forest technology project included a large array of approaches in the forest sciences. The approaches were dissimilar but did not cause conceptual barriers because of their historical co-existence within forestry (Bruun *et al.* 2005, p.114).

Interdisciplinary Integration, Interaction, and Collaboration

When integration and interaction become proactive, the line between *Multidisciplinarity* and *Interdisciplinarity* is crossed. Integrated designs, Burns indicates, restructure existing approaches through explicit *Focusing* and *Blending* (1999, pp.11-12). Lattuca adds the image of *Linking* issues and questions that are not specific to individual disciplines. In education, for example, courses achieve a more holistic understanding of a cross-cutting question or problem, such as historical and legal perspectives on public education or biological and psychological aspects of human communication (2001, p.81-83) Purposes differ, however. A course on the environment is not the same motivation as building the infrastructure of a new interdiscipline such as clinical and translational science or borrowing the concept of imagery from art history in a political science research project on visual symbols in election campaigns. Scope varies as well. William Newell depicts a spectrum moving from *Partial* to *Full Integration* (1998, p.533), and the focus may be narrow or wide. *Narrow ID* occurs between disciplines with compatible methods, paradigms, and epistemologies, such as history and literature and the AFIR example of

forest sciences. Fewer disciplines are typically involved as well, simplifying communication.

Broad or *Wide ID* is more complex. It occurs between disciplines with little or no compatibility, such as sciences and humanities. They have different paradigms or methods and more disciplines and social sectors may be involved (Kelly 1996, van Dusseldorp and Wigboldus 1994, p.96).

Many believe that interdisciplinarity is synonymous with collaboration. It is not. However, heightened interest in teamwork to solve complex intellectual and social problems has reinforced the connection, especially in team teaching and research management (Davis 1995, Amey and Brown 2004, Derry *et al.* 2005). Here too, degrees of integration and interaction differ. In *Shared ID*, Boden designates, different aspects of a complex problem are tackled by different groups. They possess complementary skills, communicate results, and monitor overall progress. Yet, daily cooperation does not necessarily occur. In contrast, *Cooperative ID* requires teamwork, exemplified by the collaboration of physicists, chemists, engineers and mathematicians in the Manhattan Project to build an atomic bomb and in research on public policy issues such as energy and law and order (1999, pp.17-19). In a four-level typology, Simon and Goode sketched the range of interactions that occurs in both research and teaching. The least degree is the reductive role of supplying background or contextual information to other disciplines. Elaboration or explanation of findings is the next level, but is still limited. At higher levels of interaction, joint definition of variables or categories occurs and, the greatest degree, fundamental questions are refined by integrating all participants' approaches into the research design (1989, pp.220-21). Differing degrees of integration and interaction are further evident in the *Methodological* versus *Theoretical ID*.

Methodological ID

Methodological and *Theoretical ID* are often differentiated in taxonomies. The typical motivation in *Methodological ID* is to improve the quality of results. The typical activity is borrowing a method or concept from another discipline in order to test a hypothesis, to answer a research question, or to help develop a theory (Bruun *et al.* 2005, p.84). Here, as well, degrees of integration and interaction differ. If a borrowing does not result in a significant change in practice, Heckhausen stipulated, the relationship of disciplines is *Auxiliary*. If the borrowing becomes more sophisticated and an enduring dependence develops, the relationship becomes *Supplementary*, exemplified by incorporation of psychological testing in pedagogy and neurophysiological measures in psychology (in *Interdisciplinarity* 1972, pp.87-89). When new laws become the basis for an original discipline, such as electromagnetics or cybernetics, a new *Structural* relationship emerges (Boisot in *Interdisciplinarity* 1972, pp.94-95). Some methodologies have also formed the foundation for recognized specialties such as statistics, oral history, and econometrics (Becher 1989, p.49).

The history of interdisciplinary approaches in social sciences yields an extended illustration. In a six-part taxonomy, Raymond Miller identified two kinds of *Methodological ID*. The first, *Shared Components*, includes research methods that are shared across disciplines, such as statistical inference. The second, *Cross-Cutting Organizing Principles*, are focal concepts or fundamental social processes used to organize ideas and findings across disciplines, such as “role” and “exchange” (1982, pp.15-19). New engineering and technological methods that were developed during World War II stimulated post-war borrowings of cybernetics, systems theory,

information theory, game theory, and new conceptual tools of communication theory and decision theory. In addition, the roster of shared methods includes techniques of surveying, interviewing, sampling, polling, case studies, cross-cultural analysis, and ethnography. In the latter decades of the twentieth century, a “third methodological movement” also emerged, marked by new borrowings that combine quantitative and qualitative traditions (Mahan 1970; Smelser 2004, p.60; Tashakkori and Teddlie 2003).

Relations with humanities changed as well. In 1980, Clifford Geertz identified a broad shift within intellectual life in general and social sciences in particular. The model of physical sciences and a laws-and-instances explanation was being supplanted by a case-and-interpretation model and symbolic form analogies borrowed from humanities. Social scientists were increasingly representing society as a game, drama, or text, rather than a machine or quasi-organism. They were also borrowing methods of speech-act analysis, discourse models, and cognitive aesthetics, crossing the traditional boundary of explanation and interpretation. Conventional rubrics remain, but they are often jerry-built to accommodate a situation Geertz dubbed increasingly “fluid, plural, uncentered, and ineradicably untidy.” Postpositivist, poststructural, constructivist, interpretive, and critical paradigms also stimulated new interactions in the interdisciplinary study of culture. Mieke Bal (2002) highlights the analytical and the theoretical force of concepts, including image, *mise en scène*, framing, performance, tradition, intention, and critical intimacy. Concepts exhibit both specificity and intersubjectivity. They do not mean the same thing to everyone, but they foster common discussion as they travel across disciplines, individuals, academic communities, and historical periods. In the process of travel, Bal emphasizes, their meaning and use change, stimulating productive propagation and prompting a new articulation with a new ordering of phenomena within the cultural field.

Theoretical Interdisciplinarity

Theoretical ID connotes a more comprehensive general view and epistemological form. The outcomes include conceptual frameworks for analysis of particular problems, integration of propositions across disciplines, and new syntheses based on continuities between models and analogies. Individual projects also exhibit theoretical imperatives. One research proposal the AFIR team examined sought to develop a model of mechanisms that mediate mental stress experiences into physiological reactions and eventually coronary heart disease. Previous studies emphasized correlation of single stress factors or separate personal traits associated with the disease. In contrast, the project aimed to develop an interdisciplinary theory based on integration of psychological and medical elements and testing the conceptual tool of inherited ‘temperament’ (Bruun *et al.* 2005, p.86).

For Boden, the highest levels of the genus *Interdisciplinarity* are *Generalising ID* and *Integrated ID*. In *Generalizing ID*, a single theoretical perspective is applied to a wide range of disciplines, such as cybernetics or complexity theory. In *Integrated ID*, which Boden pronounces “the only true interdisciplinarity,” the concepts and insights of one discipline contribute to the problems and theories of another, manifested in computational neuroscience and the philosophy of cognitive science. Individuals may find their original disciplinary methods and theoretical concepts modified as a result of cooperation, fostering new conceptual categories and methodological unification (1999, pp.19-22). Comparably, Lattuca judges *Conceptual ID* to be “[t]rue or full” form of *Interdisciplinarity*. The core issues and questions lack a compelling disciplinary basis, and a critique of disciplinary understanding is often implied (2001, p.117).

Talk of “true” or “full” interdisciplinarity leads to a further distinction that between motivations of *Bridge Building* and *Restructuring*.

Bridge Building versus Restructuring

The Nuffield Foundation in London identified two basic metaphors of interdisciplinarity - bridge building and restructuring. Bridge building occurs between complete and firm disciplines. Restructuring detaches parts of several disciplines to form a new coherent whole. The Foundation also noted a third possibility that occurs when a new overarching concept or theory subsumes theories and concepts of several existing disciplines, akin to the notion of *Transdisciplinarity* (*Interdisciplinarity* 1975, pp.42-45). The difference between *Bridge Building* and *Restructuring* is illustrated by Landau, Proshansky, and Ittelson’s classification of two phases in the history of interdisciplinary approaches in social sciences. The first phase, dating from the close of World War I to the 1930s, was embodied in the founding of the Social Science Research Council and the University of Chicago school of social science. The interactionist framework at Chicago fostered integration, and members of the Chicago school were active in efforts to construct a unified philosophy of natural and social sciences. The impacts were widely felt, and on occasion disciplinary “spillage” led to the formation of hybrid disciplines such as social psychology and political sociology. However, traditional categories of knowledge and academic structures remained intact.

The second phase, dating from the close of World War II, was embodied in “integrated” social science courses, a growing tendency for interdisciplinary programs to become “integrated”

departments, and the concept of behavioral science. The traditional categories that anchored the disciplines were questioned and lines between them began to blur, paving the way toward a new theoretical coherence and alternative divisions of labor. The behavioral science movement sought an alternative method of organizing social inquiry, rather than tacking imported methods and concepts onto traditional categories. The field of area studies is another prominent case. In contrast to earlier “interdisciplinary” borrowing, it was a new “integrative” conceptual category with greater analytic power, stimulating a degree of theoretical convergence also potential in the concepts of role, status, exchange, information, communication, and decision-making (Landau, Proshansky, and Ittelson 1962, pp.8, 12-17).

Interdisciplinary Fields and Hybrid Specializations

The formation of new interdisciplinary domains is a major instance of restructuring. Miller identified four pertinent categories in his typology. *Topics* are associated with problem areas. “Crime,” for instance, is a social concern that appears in multiple social science disciplines and in criminal justice and criminology. “Area,” “labor,” “urban,” and “environment” also led to new academic programs, and study of the “aged” produced the field of gerontology. *Life Experience* became prominent in the late 1960s and 1970s with the emergence of ethnic studies and women’s studies. *Hybrids* are “interstitial crossdisciplines” such as social psychology, economic anthropology, political sociology, biogeography, culture and personality, and economic history. *Professional Preparation* also led to new fields with a vocational focus, such as social work and nursing and, Neil Smelser adds, fields of application to problem areas such as

organization and management studies, media studies and commercial applications, and planning and public policy (Miller 1982, pp.11-15, 19; Smelser 2004, p.61).

The growth of interdisciplinary fields is having an impact on conventional taxonomies. When a committee affiliated with the National Research Council proposed an updated taxonomy of Research-Doctorate Programs in the United States, it recommended an increase in the number of recognized fields from 41 to 57, including emerging fields such as global area studies; feminist, gender, and sexuality studies; and nanoscience, bioinformatics, and computational biology. Acknowledging the changing character of disciplines, the committee also recommended that “Biology” be renamed “Life Sciences” and include agricultural sciences, while urging that subfields be listed in many domains to acknowledge their expansion. Mathematics and physical sciences, they added, should be merged into a single major group with engineering and, more broadly, the Committee called attention to the problem of naming in all fields. Despite general agreement that interdisciplinary research is widespread, doctoral programs often retain traditional names (Ostriker and Kuh 2003).

Ursula Hübenhal’s keyword for the formal intersection of topics and objects is *Intermeshing*, in contrast to *Complementing* interests among disciplines that remain apart (1994, p.63). Heckhausen called the higher level of formality *Unifying ID*, an outcome that occurred when biology reached the subject matter level of physics, forming biophysics (in *Interdisciplinarity* 1972, pp.88-89). Within the field of science, technology, and society studies, Susan Cozzens also noted a specialized interdisciplinary bridge formed by alliances of economists of scientific research and technological development with historians and sociologists of technology interested in technological innovations (2001, p.57). Observing a historical increase in hybrids, Dogan and Pahre identified two stages in the process. The first stage is

specialization, and the second is continuous reintegration of fragments of specialties across disciplines. There are two types of hybrids. The first kind becomes institutionalized as a subfield of a discipline or a permanent cross-disciplinary program. The second kind remains informal. Hybrids often form in the gaps between subfields. Child development, for example, incorporates developmental psychology, language acquisition, and socialization (1990, pp.63, 66, 72,

One of the myths of interdisciplinarity is that the “‘inter-discipline’ of today is the ‘discipline’ of tomorrow” (*Interdisciplinarity* 1972, p.9). Their trajectories vary greatly, however. Some fields remain embryonic, while others develop epistemological strength anchored by shared thematic principles, unifying core concepts, and a new community of knowers with a common interlanguage. Economic and social capital are powerful determinants in the political economy of *Interdisciplinarity*. The growth of area studies was enabled by significant amounts of funding from the Ford Foundation. Molecular biology also enjoyed a level of funding lacking in social psychology, and the same discrepancy is evident today in the differing status of biomedicine and cultural studies. Labels are not absolute states of being, either. Richard Lambert (1991) describes area studies as a “highly variegated, fragmented phenomenon, not a relatively homogeneous intellectual tradition.” Much of what may be called “genuinely interdisciplinary” work occurred at the juncture of four disciplines that provided the initial bulk of area specialists: history, literature and language, anthropology, and political science. At that hybrid intellectual space, a historically informed political anthropology developed using material in local languages. Blending of disciplinary perspectives occurred most often at professional meetings and in research by individual specialists. Broadly defined themes have been the dominant pattern in scholarly papers, creating a collective “multidisciplinary” perspective, and the topic of any one event “drives the disciplinary mix.” At the same time, area

studies is “subdisciplinary” in the sense that research by individuals has tended to concentrate on particular subdomains, while the field at large is “transdisciplinary” in the broad scope of its endeavors.

Instrumental ID versus Critical ID

In an analysis of forms of interdisciplinary explanation, Mark Kann identified three political positions. Conservative elites want to solve social and economic problems, without concern for epistemological questions. Liberal academics demand accommodation but maintain a base in the existing structure. Radical dissidents challenge the existing structure of knowledge, demanding that interdisciplinarity respond to the needs and problems of oppressed and marginalized groups (1979, pp.187-88). These conflicting motivations are apparent in the faultline dividing *Instrumental* and *Critical* forms. *Methodological ID* is “instrumental” in serving the needs of a discipline. During the 1980s, though, another kind of *Instrumental ID* gained visibility in science-based areas of economic competition, such as computers, biotechnology and biomedicine, manufacturing, and high-technology industries. Peter Weingart treats this type of activity as *Strategic* or *Opportunistic ID* (2000, p.39). In this instance, *Interdisciplinarity* serves the market and national needs.

In contrast, *Critical ID* interrogates the dominant structure of knowledge and education with the aim of transforming them, raising questions of value and purpose silent in *Instrumental ID*. New fields in Miller’s *Life Experience* category were often imbued with a critical imperative, prompting Douglas Bennett to call them a “sacred edge” in the reopened battle over inclusion

and exclusion (1997, p.144). Older fields, such as American studies, also took a “critical turn” in the 1960s and 1970s, and a “new interdisciplinarity” emerged in humanities (Klein 2005, pp.153-75). Salter and Hearn (1996) call interdisciplinarity the necessary “churn in the system,” aligning it with a dynamic striving for change that disturbs continuity and routine. This imperative is signified in a new rhetoric of “anti,” “post,” “non,” and “de-disciplinary” that is prominent in cultural studies, women’s and ethnic studies, literary studies, and postmodern approaches across disciplines. An increasing number of faculty in humanities and social sciences, Lattuca reports, do interdisciplinary work with an explicit intent to deconstruct disciplinary knowledge and boundaries, blurring the boundaries of the epistemological and the political (2001, pp.15-16, 100).

The disciplines are also implicated in *Critical ID*. Giles Gunn’s typology of interdisciplinary approaches to literary studies identifies four approaches to mapping. The simplest strategy is on disciplinary ground, tracing the relationship of one discipline to another, such as “literature and ...” philosophy or psychology and so forth. The map changes, though, if another question is asked. What new subjects and topics have emerged? New examples appear, including the history of the book, psychoanalysis of the reader, and the ideology of gender, race, and class. Each topic, in turn, projected further lines of investigation. “The threading of disciplinary principles and procedures,” Gunn found, “is frequently doubled, tripled, and quadrupled in ways that are not only mixed but, from a conventional disciplinary perspective, somewhat off center.” They do not develop in linear fashion but are characterized by overlapping, underlayered, interlaced, crosshatched affiliations, collations, and alliances with ill-understood and unpredictable feedbacks. The final and most difficult approach to mapping is rarely acknowledged. Correlate fields and disciplines have changed, challenging assumptions

about the strength of boundaries while working to erode them. “The inevitable result of much interdisciplinary study, if not its ostensible purpose,” Gunn concluded, “is to dispute and disorder conventional understandings of relations between such things as origin and terminus, center and periphery, focus and margin, inside and outside (1992, pp.241-43, 248-49).

The distinction between *Instrumental* and *Critical* forms is not absolute. Research on problems of the environment and health often combine critique and problem solving. Nonetheless, a clear division appears in the classification of motivations. Observing trends in the medical curriculum, Bryan Turner (1990) affirms that when interdisciplinarity is conceived as a short-term solution to economic and technological problems, pragmatic questions of reliability, efficiency, and commercial value take center stage. In social medicine and sociology of health, in contrast, interdisciplinarity emerged as an epistemological goal. Researchers focused on the complex causality of illness and disease that factors in psychological, social, and ethical factors missing from the hierarchical biomedical model.

Transdisciplinarity

In the OECD typology, *Transdisciplinarity* (TD) was defined as a common system of axioms that transcends the narrow scope of disciplinary worldviews through an overarching synthesis, such as anthropology construed as the science of humans. Conference participants Jean Piaget and Andre Lichnerowicz regarded TD as a conceptual tool capable of producing interlanguages. Piaget treated it as a higher stage in the epistemology of interdisciplinary relationships based on reciprocal assimilations, and Lichnerowicz promoted “the mathematic” as

a universal interlanguage. Erich Jantsch imbued TD with a social purpose in a hierarchical model of the system of science, education, and innovation (*Interdisciplinarity* 1972). The intellectual climate of the times was evident in the organizing languages of the OECD seminar -- logic, cybernetics, general systems theory, structuralism, and organization theory. Since then, the term has proliferated, becoming a descriptor of broad fields and synoptic disciplines, a team-based holistic approach to health care, and a comprehensive integrative curriculum design driven by the keyword "transcending." In a defining essay on the Transdisciplinarity <td-net> website, Christoff Kuffer notes that TD research has developed in different contexts, fostering different types with different goals (http://www.transdisciplinarity.ch/bibliographie/Transdis_e.html). Four major trendlines define the current heightened momentum.

Current TD Trendlines

One trendline is the contemporary version of the historical quest for systematic integration of knowledge. This quest spans ancient Greek philosophy, the medieval Christian *summa*, the Enlightenment ambition of universal reason, Transcendentalism, the Unity of Science movement, the search for unification theories in physics, and E. O. Wilson's theory of consilience. Reviewing the history of discourse on TD, philosopher Joseph Kockelmans (1979) found it has tended to center on educational and philosophical dimensions of sciences. The search for unity today, though, does not follow automatically from a pre-given order of things. It must be continually "brought about" through critical, philosophical, and supra-scientific reflection. It also accepts plurality and diversity, a perspective prominent in the Centre International de Recherches et Études Transdisciplinaire (CIRET). CIRET is a virtual meeting

space where a new universality of thought and type of education is being developed informed by the worldview of complexity in science (<http://perso.club-internet.fr/nicol/ciret>).

The second trendline is akin to *Critical ID*. Transdisciplinarity is not just "transcendent" but "transgressive." In the 1990s, TD began appearing more often as a label for knowledge formations imbued with a critical imperative, fostering new theoretical paradigms. Ronald Schleifer (2002) associated the new interdisciplinarity in humanities with new theoretical approaches and transdisciplinary or cultural study of social and intellectual formations that have breached canons of wholeness and the simplicity of the Kantian architecture of knowledge and art. The transdisciplinary operation of cultural studies, Douglas Kellner specified, draws on a range of fields to theorize the complexity and contradictions of media/culture/communications. It moves from text to contexts, pushing boundaries of class, gender, race, ethnicity, and other identities (1995, pp.27-28). Dölling and Hark associate transdisciplinarity in women's and gender studies with critical evaluation of terms, concepts, and methods that transgress disciplinary boundaries (2000, pp.1196-97). And, in Canadian studies, Jill Vickers links trans- and anti-disciplinarity with movements that reject disciplinarity in whole or in part, while raising questions of socio-political justice (1997, p.41).

The third trendline is an extension of the OECD connotation of overarching synthetic paradigms. Miller defined TD as "articulated conceptual frameworks" that transcend the narrow scope of disciplinary worldviews. Leading examples include general systems, structuralism, Marxism, sociobiology, phenomenology, and policy sciences. Holistic in intent, these frameworks propose to reorganize the structure of knowledge, metaphorically encompassing the parts of material fields that disciplines handle separately (1982, p.21). More recently, a variant of this trendline has emerged in North America in the notion of

“transdisciplinary science” in broad areas such as cancer research. TD science is a collaborative form of “transcendent interdisciplinary research” that creates new methodological and theoretical frameworks for defining and analyzing social, economic, political, environmental, and institutional factors in health and well-being (Rosenfield 1992; Stokols *et al* 2006).

The fourth trendline -- trans-sector TD problem solving – is prominent in Europe and North-South partnerships. A new form of *TD* was evident in the late 1980s and early 1990s in Swiss and German contexts of environmental research. By the turn of the century case studies were being reported in all fields of human interaction with natural systems and technical innovations as well as the development context (Klein *et al* 2001). The core premise of this trendline is that problems in the *Lebenswelt* -- the life-world -- need to frame research questions and practices, not the disciplines (Kuffer, Hadorn, Bammer, van Kerkhoff, and Pohl 2007). Not all problems are the same, however. One strand of TD problem solving centers on collaborations between academic researchers and industrial/private sectors for the purpose of product and technology development, prioritizing the design of innovative milieus and involvement of stakeholders in product development. A different type of TD research arises when academic experts and social actors contribute local knowledge and contextual interests cooperate in the name of democratic solutions to controversial problems such as sustainability and risks of technological modernizations such as nuclear power plants (Kuffer <http://www.transdisciplinarity.ch/bibliographie/Transdis_e.html>).

The fourth trendline also intersects with two prominent concepts -- “*Mode 2* knowledge production” and “postnormal science.” In 1994, Gibbons, et al. proposed that a new mode of knowledge production is fostering synthetic reconfiguration and recontextualization of knowledge. *Mode 2* is characterized by complexity, hybridity, non-linearity, reflexivity,

heterogeneity, and transdisciplinarity. New configurations of research work are being generated continuously, and a new social distribution of knowledge is occurring as a wider range of organizations and stakeholders contribute heterogeneous skills and expertise to problem-solving. Gibbons, et al. initially highlighted *Instrumental* contexts of application and use, such as aircraft design, pharmaceuticals, electronics, and other industrial and private-sectors. In 2001, Nowotny, Gibbons, et al. extended the *Mode 2* theory to argue that contextualization of problems requires participation in the agora of public debate, incorporating the discourse of democracy that is also voiced strongly in *Critical ID*. When lay perspective and alternative knowledges are recognized, a shift occurs from solely “reliable scientific knowledge” to inclusion of “socially robust knowledge” that dismantles the expert/lay dichotomy while fostering new partnerships between the academy and society.

Post-normal science, in Funtowicz and Ravetz’s (1993) classic definition, breaks free of reductionist and mechanistic assumptions about the ways things are related and how systems operate. “Unstructured” problems are driven by complex cause-effect relationships, and they exhibit a high divergence of values and factual knowledge. Weingart finds a common topos among claims for new modes of knowledge production, postnormal and postmodern science, and newer forms of inter- or transdisciplinary research. They are all oscillating between empirical and normative statements, positing more democratic and participatory modes while resounding the same theme that triggered the escalation of *Interdisciplinarity* in the context of higher education reform during the 1960s. Now, though, claims are framed in the context of application and involvement of stakeholders in systems that are too complex for limited disciplinary modes portrayed as being too linear and narrow for “real-world” problem solving. New TD and counterpart ID forms, though, are not without their own “blind spots,” failing to recognize the

opportunistic dimensions of both presumably “internal” academic science and strategic research for non-scientific goals (2000, pp.36, 38).

New Implications for Old Taxonomy

The most recent authoritative typology appeared in a report issued by the National Academies of Science in the United States. *Facilitating Interdisciplinary Research* identifies four primary drivers of interdisciplinarity today:

- (1) the inherent complexity of nature and society
- (2) the desire to explore problems and questions that are not confined to a single discipline,
- (3) the need to solve societal problems
- (4) the power of new technologies.

(*Facilitating* pp.2, 40).

Drivers (2) and (3) are not new. They have intensified however, in recent decades. Some research programs, the report indicates, have grown so large that they are stimulating new understanding in multiple fields. This phenomenon occurred in the broad-based effort to prove the theory of plate tectonics, global-climate modeling, the development of fiber optic cable, and the Human Genome Project. New fields and interdisciplines also continue to emerge from interactions between researchers with a common interest, such as computational biology. New topic-based domains outside or between disciplines fundamentally transform the disciplinary

identities of collaborating researchers while fostering new skill sets. Interdisciplinary research adds value to traditional fields as well. Researchers in nanoscience, for example, bridge several disciplines while using their nanoscience experience to open new disciplinary research directions and applications, such as incorporating nanostructures into bulk materials.

Driver (3) is not new, either. Yet, it has escalated with a force anticipated in 1982, when the OECD concluded that *Exogenous ID* had gained priority over *Endogenous University ID*. The *Endogenous* originates within science and still carries the aim of realizing a unity of science. The *Exogenous* originates in “real problems of the community” and the demand that universities perform their pragmatic social mission (*University and the Community* 1982, 130). Driver (4) is the newest catalyst gaining force. Generative technologies such as magnetic resonance imaging are enhancing research capabilities in many fields through development of new instrumentation and informational analysis that enhance studies of human behavior through brain mapping and crossfertilizations of cognitive science and neuroscience. New quantitative methods and advanced computing power are also facilitating the sharing of large quantities data across disciplinary boundaries (Yates 2004, pp.133, 135).

In a recent issue of the journal *Science*, Alan Leshner contended that “new technologies are driving scientific advances as much as the other way around,” facilitating new approaches to older questions and posing new ones (2004, p.729). The cumulative effects of boundary crossing examined in this chapter defy conventional assumptions about what constitutes a discipline. “Thirty years ago,” Norm Burkhard observed, “the difference between a physicist and a chemist was obvious. Now we have chemists who are doing quantum-level, fundamental studies of material properties, just like solid-state physicists. There’s almost no difference” (Facilitating p.54). Assumptions about interdisciplinarity are also implicated. In one of the earliest efforts to

situate *Interdisciplinarity* within conventional taxonomy, in a chapter on “The Variety of Rational Enterprises” in his landmark book *Human Understanding*, Stephen Toulmin contrasted “compact” and “would-be disciplines” with “non-disciplinary activities” such as ethics, philosophy, and interdisciplinary research projects. The year was 1972, the same year that the book from the 1970 OECD conference was published. Over the next three and a half decades, new taxonomies emerged, registering the proliferation of the genus *Interdisciplinarity* propelled by new species of integration, collaboration, complexity, critique, and problem solving. Clearly, the rules of taxonomy have changed.

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