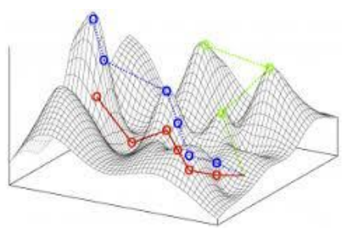
Journal of International Union for Interdisciplinarity and Transdisciplinarity in Complex Systems



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International Union for Interdisciplinarity and Transdisciplinarity
in Complex Systems - <<IUITCS>>

Content

Argument

Journal 3 of the “International Union for Interdisciplinarity and Transdisciplinarity in Complex Systems” - <<IUITCS>> proposes the expert submission of some notifications and comments from the point of interdisciplinary and transdisciplinary point of view related to the current international results and having a scientific and humanist profile. The texts of the Journal are referring to the high-performance university and academic studies. In order to put into light the concerns for the XXIst century interdisciplinarity and transdisciplinarity and to evidentiate, at the same time, the significances of the respective fields, Journal 3 will open with an argument review of the general issues and also of the structure related to them. In this edition, are shown and commented some interdisciplinary and transdisciplinary scientific aspects which find their place within complex systems, the forms which can be taken out from the results that have been granted the Nobel Prize in 2025.

Interdisciplinarity and transdisciplinarity existing in complex systems – current aspects

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Nowadays, within the international scientific segment, one may notice the continuous existence and requirement for a well-marked interdisciplinarity and transdisciplinarity, with pertinent significance. Thus, by means of interdisciplinarity, a "cross-fertilization" with epistemological level takes place; it pertains to the research and analysis of the knowledge hermeneutics obtained by means of an optimal redefinition of general concepts, logics, methods appplied to the scientific research and humanism, to the philosophy of the latter. It is to remark the "transversality" which characterizes interdisciplinarity, as well as the scientificity which is already to be remarked, making its presence still known within the transdisciplinary disciplines.

The complexity of the subject matters, as well as the considering of the close results among them, of the simultaneity in achieving the different research steps proper to the harmonizing of the languages used, of the limitations implied by the auxiliary aspects, sometimes having determinant influences on the scientific "targets", are also useful in an (upward) modification the intellectual attributes of the Human beings, obtainable in an interdisciplinary and transdisciplinary way.

The knowledge supposes integrativity and convergence, as well as forms exercitated on the study and research of a subject matter by two or more disciplines having, most times, as an objective, also obtaining a local "wholism".

Currently, some new methods are proposed to optimize the research field proper to interdisciplinarity and transdisciplinarity of complex systems, thus trying to avoid the possible redundancies, as well as heterogeneities, dissipations, non-integrativities, influences of the non-neighbouring results proper to non-harmonized langauges. Thus, a complementarity of interdisciplinarity and transdisciplinarity concepts takes place, implying the recent mechanisms of integrative research, but observing, however, the disciplines of an academic level, the requirements of the latter being maintained by means of an optimal reorganization and by means of specific intelligently built softwares. Thus, is generated the emergence of new disciplines, proper to the XXIst century. They imply professional competencies recently appeared, and <u>no discipline will be superior to another</u>.

Essentially, a number of six fundamental complex systems are considered: a) physical and chemical; b) bio-molecular and cellullar; c) physiological; d) organisms and populations; e) social-human and economic; f) engineering. Within those systems are to be found different research subject themes, such as those referring to emergence, complexity and bio-complexity, self-organization. The current forms, proper to the concerns taking place within complex systems, consider the (mathematical, physical, chemical, biological) modelling (existing in cognitive disciplines), the evolution and adaption, the colective behavior, the non-linear dynamics and bio-dynamics, the theory of games, the theory of systems, the theory of networks, each having, in turn, numerous distinct components which interact among one another. At the same time, the number of the level of scale is considered; the primary level is proper to the common, non-structured behavior. There is an intensive (vertical) hierarchy of the former within which, at a certain moment, appears a structure that assures quality by means of its processes and mechanisms. Thus, the optimal development of functionality, proportional with the hierarchic growth of the level of structure (including the biological one) takes place. E.g.: within the living processes there are: the common molecular matter (non-structured) (level I), the bio-structured one (level II), the noesi-structured one (level III). As concerns the extensive (horizontal) hirarchy, are considered the interior relationships, proper to the system and exterior ones (with third complex system, such as the environment), as well as the forms of evolution (one can notice that they take place also within the intensive (vertical) hierarchy). When considering that, are taken into account the general concept of system, the necessity of some optimal flows of energy to exist, for its functioning, as well as Newtonian space and time, quantum processes, biological information (including genetic + epigenetic), bifurcation, space of phases, statistic aspects, adaptativity and evolution.

There are essays that concern interdisciplinarity, where it is remarked the fact that in some West-European states, such as U.K., Holland, Belgium, Germany, France (*University of Paris "Sciences Po"*), there are concerns regarding the field of interdisciplinarity, but also in the USA (*The Center for Studies of Interdisciplinarity, The Faculty of Graduate Studies of British University Columbia, Fairhaven College of Bellingham-Washington, Stanford University (software of the types:Bio-X-biology, medicine, bio-mathematics (modelling in genetics and evolutionist biology, bio-computational disciplines)), bioengineary – University of Pensylvania*). To be remarked, too, in the USA – *Association for Interdisciplinarity Studies, International Network of Inter.&Transdisciplinarity*, *Philosophy of/as Interdisciplinarity Network, Center for Study of Interdisciplinarity – University of North Texas*. And so on. Thus, it is generated a new modality of approach, what, in fact, the philosophy of interdisciplinarity considers to represent an “ontological unity of disciplines”.

Interdisciplinarity and transdisciplinarity may be also found in humanist disciplines (general-theoretical philosophy, as well as theology – with its aspiration towards ecumenism, hermeneutics, semiotics, general antropology and antropology of culture, psychoanalysis, philology, linguistics and psycholinguistics, economy and bio-economy, legal disciplines, history, sociology, politology…), obtainable by means of establishing some connections existing among the classical domains and the new ones, which emerged in the XXth-XXIst centuries. It is also taken into account the perspective to come, by connecting the humanist disciplines with the non-humanist ones, some of those having a dominant actuality (artificial generative intelligence, computational legal studies and others).

For instance, it is to be remarked a domain with an interdisciplinary and transdisciplinary status + a great amount of instrumentalism, named “neuroscience”, which also contain domains such as mathematics and bio-mathematics, physics and mathematical physics, theory of operators (existing within quantum disciplines), biology (cellular, molecular, synthetic), biophysics, biochemistry, philosophy of science and epistemology, neurophilosophy, neurolinguistics and psycholinguistics, bio-psychology, medicine, genetics and epigenetics, medical imaging, bio-complexity, sciences of computation, nanomedicine, neuroetics, neuroinformatics, neuroengineering.

One should also remark the major concerns of bioetics that include interdisciplinary and transdisciplinary elements (contributions) in the following fields: biology, genetics and epigenetics, medicine and biotechnology, artificial intelligence and mathematical, physical, chemical, teological, antropological, legal, philosophical, sociological modelling…

There are important subject matters and also considerations, in time, belonging to remarkable thinkers, philosophers and logicians, such as Georg Cantor, Gottlob Frege, Edmund Husserl, Martin Heidegger, Karl Popper, Rudolf Carnap…, who generated and claimed some scientific and philosophical ideas, very significant in our days, too, for the thinking and judgement (interdisciplinary and transdisciplinary direction), some of which having futurist attributes, too.

As compared to the period of about fifty years ago, currently, the situation of non-humanist sciences, but humanist ones, as well, has been much modifying; a feasible solution is the one generated by the approaches of interdisciplinarity + transdisciplinarity, since the functional framework of the latter is continuously optimally-rebuilt, based on significant ideas, intelligently applied.

As concerns the special significance pertaining to transdisciplinarity, one can distinguish three fundamental components. Transdisciplinarity is different from interdisciplinarity. The three components of transdisciplinarity refer to (I) the knowledge existing within disciplines, exterior connexions which may take place with other academically accepted domains (even border ones) (II), within the context (III) of some "evaluations" when (potentially) considering the levels of reality, where some of these are "felt" and "intuited" by the Human being, by means of some forms proper to neurophysiological perception, some others - not. Different forms of logics are used, too (in the superior-experencial, phenomenological, and not at all common, trivial situations) which do not fit into the forms of Aristotelian logics, but having, however, consistency (e.g.: logics of the third party included, third, polyvalent type of logics, the principles of tetralemma, others). In this sense, it has been accepted to include the issues of transdisciplinarity also in the category of those pertaining to complexity, bio-complexity, as well as chaordicity (appliable to situations when complexity and biocomplexity go beyond the human understanding). <u>An essential requirement of transdisciplinarity is represented by the characteristic of the temporal simultaneity of the three forms - I, II, III -, a fact that cannot exist within a strictly interdisciplinary framework</u>. Transdisciplinarity has also a methaphysical aspect (that goes beyond the common rationality of the human being, as it is, trivially known), an aspect which, sometimes, is no longer taken into account by the university and academic environment. This may, however, represent, in the context of the current period, but also in perspective, an interesting method of study, to be possibly considered also within the fundamental research which is complementary to logics, methodology and philosophy of science (sometimes, named classical). It is useful to remind, in the context of component III of transdisciplinarity the Borromean regions, too, which specially refer to the triad Real – Imaginary – Symbolic, where the Human being is at their intersection; the Real "zone" is not accessible to the latter, since it is different from the ontic reality (Heidegger).

To close the current essay, we also consider the situation of <u>the systems of complex systems</u>. In this context, a complexity of level 1 takes place, existent within each system and a complexity of level 2, more remarkable, which takes place among the (global) systems of complex systems, consequently including the systems of level 1. <u>When thinking of interdisciplinarity and</u>

transdisciplinarity existing within complex systems of level 1, it is necessary to take into account, at the same time, the systems of systems that have this form, which consequently also implies the intersystemic analysis of the relationships among the systems that include complex systems of level 1. This aspect makes a difference between some of the current concerns of the <<IUITCS>>, and the series of the objectives proper to the analysis of common complex systems. The interdisciplinary and transdisciplinary relationships existing within complex systems of level 1 and among the systems of complex systems of level 1 represent modern concerns that sometimes also have phenomenological aspects. Example: Social systems of a complexity of level 2, containing systems with a complexity of level 1, are currently represented by the European Union, as well as the United States. In the first case, the component states of the European Union represent complex systems of level 1 of complexity and in the second case, the complex systems with level (degree) 1 of complexity are represented by the states composing America. Between the two multinational forms, multistatal-regional, respectively (each having a complexity of level 2) containing systems of complex systems of level 1 of complexity, some relationships also take place. One can also remark examples in cosmology, as well as in other third domains. The category of complex systems of level 1 of complexity also may include the big systems (current scientific name), having numerous sub-systemic components. It is useful to remind, however, the fact that big systems can sometimes constitute systems of complex systems.

We close this segment of the analysis with a rhethoric question *(President of IUITCS)*, regarding interdisciplinarity and transdisciplinarity: *is it possible to metaphorically-mathematically join interdisciplinarity and transdisciplinarity?* Under these circumstances, trandisciplinarity, considered to be a formal operator, may be applied to interdisciplinarity and, at the same time, we may remark its character, situated "beyond" the borders of interdisciplinarity, as well as its integrative wholistic aspect. In the future, we will strive to answer that question and we will insert the answer into the IUITCS site.

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1. Martin Heidegger, *Science and Reflection*, 1954, pp. 155-182;

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Interdisciplinary and Transdisciplinary Aspects Existing in Complex Systems Identified in the Results Granted the Nobel Prize in 2025

Sorin Baiculescu[1] Adriana Godeanu Metz[2]

General introduction (references to the Nobel Prizes 2025, to the reasons for granting the former)

In the period 2nd – 9th October 2025 the Nobel Commitee *(in Sweden: Royal Swedish Academy of Sciences din Stockholm – the institution designed to grant the Nobel Prizes for Physics, Chemistry and Economy; Karolinska Institute in Stockholm – institution designed to grant the Nobel Prize for Medicine and Physiology; The Swedish Academy in Stockholm – institution designed to grant the Nobel Prize for Literature and Norway: Norwegian Nobel Committee, Nobel Peace Prize – Norwegian Nobel Institute in Oslo – institution designed to grant the Nobel Prize for Peace)* presented the Nobel Prizes for the year 2025. Those were granted for the following domains: Physics, Chemistry, Medicine and Physiology, Literature, Peace, Economy *(a prize funded, since the year 1968, by the Central Bank in Sweden (Sweriges Riksbank in Stockholm))* granted by the Royal Swedish Academy of Sciences in Stockholm. The structure is described as follows, for the year 2025.

Physics

John Clarke (California University (Berkeley), USA); Michwl H. Devoret (University of Yale, and University of California (Santa Barbara), USA). John M. Martinis (California University (Santa Barbara) and Google Quantum AI, USA).

Reason: “Macroscopic quantum tunneling and energy quantization in an electrical circuit”.

Chemistry

[1]President of International Union for Interdisciplinarity and Transdisciplinarity in Complex Systems (IUITCS), the Romanian Committee for the History and Philosophy of Science and Technics (CRIFST), Division of Logic, Methodology and Philosophy of Science (DLMFS), the Group for Interdisciplinary Research (GCI) – The Romanian Academy, Société Française de Philosophie (SFP) - associated member.
[2] Vicepresident of International Union for Interdisciplinarity and Transdisciplinarity in Complex Systems (IUITCS).

Susumu Kitagawa (Kyoto University, Japan); Richard Robson (University of Melbourne, United Kingdom (Australia)); Omar M. Yaghi (California University, Berkeley, USA).

Reason: "for Metal-Organic Frameworks (MOF'- Porous crystalline materials, forming types of molecular networks with large cavities (for their nanoscale dimensions) in 3D, (where metal ions are connected by organic molecules, generating internal "host" spaces for other molecules that can enter these cavities (voids) or whose structures can be modified.) According to the Nobel Committee for Chemistry: "for the development of new molecular architectures" (i.e., MOFs — author's note).

<u>Medicine and Physiology</u>

Mary E. Brunkow (Institute for System Biology, USA), Frederick J. Ramndell (California Institute for Biotechnology, USA), Shimon Sakaguchi (Osaka University, Japan).

Reason: "for highlighting peripheral immune tolerance" – the immune system's own mechanism that can be programmed not to attack its own tissues (author's note).

<u>Literature</u>

Laszlo Krasznahorkal (Hungary).

Reason: " For his captivating and visionary work, which, in the midst of apocalyptic terror, reaffirms the power of art".

<u>Peace</u>

"Maria Corina Machado" - Venezuela .

Reason: " For her efforts to promote democracy and civil rights in a context of increasingly widespread authoritarianism ".

<u>Economy</u>

Joel Mokyr (Iseael, USA), Philippe Aghion (Franve), Peter Howitt (Canada)

Reason: "for important contributions to modern economic growth theory based on innovation. "

The Nobel Prizes (Nobel medals and diplomas) are effectively granted to each laureate, by the King of Sweden (Physics, Chemistry, Medicine and Physiology, Literature), always at the same date of the year – 10th December –, in "Stockholm Concert Hall" and – according to the same principles – by the "Royal Swedish Academy of Sciences" in Stockholm (Economy). On the same day, in Oslo (Norway), in "Oslo City Hall", is held the ceremony of granting the Nobel Prize for

Peace by the "Chairman of the Norwegian Nobel Committee", in the presence of the King of Norway.

Abstract

In the following text, there are comments for each of the fields mentioned in the introduction, the significancies of the subjects for which were granted the Nobel prizes in the year 2025. In the second part, there are references to interdisciplinary and transdisciplinary aspects existing within complex systems, which also include the results granted the Nobel prize, for the respective period.

In the context, are put into light the importance and their perspective, in relationship with the border and futurist disciplines. It is useful to remark, when putting those aspects into light, the structure of the expertise of the Nobel Committee (specially) created with a view to identifying the Nobel distinctions granted in 2025.

<u>Physics</u>

Quantum tunneling (quantum transmission through a potential barrier) is generally observed at the subatomic level. It has been experimentally demonstrated that this phenomenon is also observable at the macroscopic level (at a scale ordinarily visible), having been recorded in macroscopic electrical circuits based on highly conductive materials (superconductors), while also exhibiting a pronounced level of discrete energy quantization.

From a broader perspective, this may support a deeper understanding of the overall reality underlying quantum computing, viewed as an application with significant technological potential.

From an interdisciplinary standpoint, one can identify a connection between quantum theory and the engineering theory of highly conductive (superconducting) circuits—distinct domains of theoretical physics and technological device engineering—as well as with hardware architectures associated with quantum computing.

Information theory is an additional component of this interconnected framework. Another interdisciplinary, and arguably even transdisciplinary, connection is provided by the development of quantum cryptography, which offers a high level of security for communications.

Building on this subject, the development of quantum computing based on superconducting circuits is expected to advance further, with particular emphasis on computer science, information theory, and the development of optimal quantum algorithms.

From the mathematical perspective, one may mention the theory of differential equations associated with complex analog systems operating at the quantum level, as well as theories concerning operators and spectral representations. In an interdisciplinary context, one may also highlight the emergence of quantum technology, quantum information, nanostructures, cryptography, and theories spanning both theoretical and applied physics.

From a transdisciplinary perspective, the 2025 Nobel Prize theme may also be associated with new considerations concerning quantum gravity, the concepts of the real and reality—which are distinct from one another—their spatiality, and their topology, including the notion of Borromean regions.

Chemistry

The Nobel Prize 2025 for chemistry was awarded for the remarkable results obtained in the metal-organic structures. Those results "transcend the boundaries of classical chemistry, giving rise to a major epistemic perspective and highlighting the intersection of different fields of modern science and technology. There is a profound interconnection between chemistry and physics—particularly condensed-matter physics—involving the analysis of electronic circuit networks, various aspects associated with quantum analysis in porous media, crystallography, molecular adsorption, and electronic transport. In this context, there is a conceptual transition from the traditional notion of a "chemical substance" to that of a "complex physical system."

In the same context, particular attention is given to material structures exhibiting emergent properties, leading to new concepts such as "molecular design," applicable to chemical sensors, adaptive catalytic materials, and other advanced applications.

Connections have also been established between chemistry and engineering, including CO_2 capture and hydrogen storage, as well as the incorporation into chemistry of the broader concept of a "universal energy infrastructure." This makes it possible to capture greenhouse gases, achieve more advanced water purification, and obtain water from a predominantly dry atmosphere.

In medicine, these developments may lead to new biosensors and major advances in the optimization of medical and biological imaging. This creates an interface between matter and quantum structures of living systems, including those present in human biological structures, as well as between informational-formal structures and the phenomenological structures of human consciousness. This latter aspect was discussed even prior to the 2025 Nobel-recognized work in the volume The Space of Experience, which introduced a new concept and was authored by one of the members of IUITCS, Dr. Sorin Baiculescu.

One may also consider the development of new informational models and simulations, which could be useful in artificial intelligence, particularly for the design and creation of new materials possessing molecular structures different from those of conventional materials.

The new molecular architectures characteristic of these materials also respond to fundamental requirements of transdisciplinarity, suggesting possible new levels of reality associated with novel materials and their remarkable architectures. These architectures are manifested in the composition, organization, and synthesis of advanced materials.

A transdisciplinary shift thus becomes possible, through which one can observe and demonstrate that a particular complex chemical structure may generate—or even create—a useful and well-defined "molecular space," rather than merely constituting a resulting molecular combination.

Emergent properties and collective behaviors consequently arise, which are also relevant to complex-systems theory, biocomplexity, and network theory. These aspects represent major areas of interest within IUITCS as well.

Within this framework, it is important to recognize that observability is not necessarily a strict requirement in every case. The construction of the human experimental reality assumes a primary position in the modern scientific world.

There is therefore a genuine intersection between chemistry, epistemology, the philosophy of science, and ontology, expressed through both interdisciplinary and transdisciplinary approaches. Matter becomes not merely a physical substance, but a relational space—an architecture of the material reality experienced by human beings—existing alongside its quantum, symbolic (informational-formal and phenomenological), and consciousness-related spaces, as also discussed in The Space of Experience.

We emphasize that all the preceding considerations relate to the concept underlying the 2025 Nobel Prize in Chemistry, designated by the acronym MOF, meaning "Metal-Organic Framework": a porous crystalline material forming a three-dimensional network—essentially a kind of molecular "scaffold" containing numerous internal voids.

In this sense, MOFs may be regarded as a remarkable and original scientific creation, opening new conceptual and technological perspectives at the intersection of chemistry, physics, materials science, engineering, information theory, and transdisciplinary approaches to reality.

Medicine and Physiology

The 2025 Nobel distinction was awarded for identifying the importance of the transcription factor FOXP3, which plays a role in controlling the development and maintenance of regulatory T lymphocytes (Tregs). The research demonstrated the mechanisms that ensure homeostasis between protection against infections and the prevention of autoimmune diseases. It also enabled the identification of new immunotherapeutic approaches applicable to the treatment of cancer, inflammatory diseases, and organ transplantation. The interdisciplinary dimension of the topic encompasses cell biology, genetics, immunology, bioinformatics, systems biology, and clinical medicine. The transdisciplinary dimension of the topic refers to forms of correlation and order existing within biocomplexity, to homeostasis and the relationship between order and its absence, to the self-organisation of living systems, self-regulation, and bioinformation. The preservation of the identity of physiological systems represents a subject of epistemological and philosophical interest, while also taking into consideration the associated emergent phenomena. A productive collaboration can be developed between immunological theories and the study of complex systems, mathematics and physics, structural chemistry, artificial intelligence (AI), and, as a future perspective, quantum computing.

Literature

The 2025 Nobel distinction was awarded for identifying the importance of the FOXP3 transcription factor in regulating the development and function of regulatory T lymphocytes (Tregs). The research demonstrated mechanisms that maintain homeostasis between defense against infections and the prevention of autoimmune disorders. It also enabled the identification of new immunotherapeutic approaches applicable to the treatment of cancer, inflammatory diseases, and organ transplantation.

The interdisciplinary dimension of the subject encompasses cell biology, genetics, immunology, bioinformatics, systems biology, and clinical medicine.

The transdisciplinary dimension of the subject refers to patterns of correlation and order existing within biocomplexity, to homeostasis as involving the relationship between order and its absence, and to the self-organization, self-regulation, and bioinformation of living systems.

The preservation of the identity of physiological systems constitutes a subject of epistemological and philosophical interest, while also taking into consideration the associated emergent phenomena. This perspective may generate productive interactions between immunological theories and complex-systems theory, mathematics and physics, structural chemistry, artificial intelligence (AI), and, prospectively, quantum computing.

Peace

Receiving the 2025 Nobel distinction involves interdisciplinary aspects of sociology (social cohesion) and psychology (the psychological behavior of social groups), as well as bioethics, international law, and various fields of political science. From a transdisciplinary perspective, aspects of pacifism, human dignity, and the construction of resilient and cohesive societies can also be highlighted.

Economy

The 2025 Nobel Prize in Economic Sciences also encompasses interdisciplinary aspects of economic history and innovation management, sociology, engineering, and technology, with all these dimensions being examined within the broader framework of rigorous economic analysis.

From a transdisciplinary perspective, one may also identify a range of analyses concerning knowledge as a driver of progress and the dynamics through which older technologies are replaced by new ones—as is currently occurring with artificial intelligence and quantum computing—in relation to emerging forms of (scientific) transhumanism and posthumanism.

The ethical dimensions of socially beneficial economic development are also addressed. Education and culture occupy a particularly important place in the considerations surrounding the Nobel-recognized subject of 2025.

Interdisciplinarity

Julie Thompson Klein and Thorsten Philipp

Interdisciplinarity (Julie Thompson Klein and Thorsten Philipp (authors contributed equally)

Interdisciplinarity is both a programmatic term in higher education policy and a catch-all phrase across disciplines and fields. Hence, it labels many types of ben-eficial cooperation between forms of expertise, including equality among participants in teamwork. Further read through an etymological lens, the term implies a process conceived as operating between (lat. inter) and across disciplines (lat. disciplinae), even in some instances independently of them. Whether the process results in methodological connections between disciplines or even new communities of practice depends on the complexity and purpose of a given activity (Apostel 1972; NASEM 2005). Interdisciplinarity has also been presupposed in the past semantically and conceptually. Disciplines are individual bodies of knowledge, defined within their boundaries. Increased cross-fertilizations, however, have fostered and facilitated greater boundary crossing, ranging from assimilating approaches borrowed from other disciplines to formation of interdisciplinary fields. Beyond this broad definition, however, a linguistic question arises from inconsistent terminology across domains and a political question marked by diverging research and education policy interests. The range of intentions and outcomes varies by context. Interdisciplinarity can refer to an act of translation between representatives of individual branches of knowledge, a methodical way of acquiring and generating new knowledge, a normative organizational and top-down objective, the answer to a complex question or solution to a complex problem, dialogue about preconditions and possibilities, limits for collaboration between disciplines, implications for teaching and research, and a transitional phase in the emergence of new disciplines or new interdisciplinary strands. Thus, interdisciplinarity can begin with exchanging ideas about complex problems or questions, continue formally integrating methodologies and epistemologies, be applied in exchanges of data, and ultimately even restructure research and teaching. From a historical standpoint, interdisciplinarity has been predominantly con-strued as an academic endeavor that combines openness and contextual aware.

Julie Thompson Klein and Thorsten Philipp 196ness, while still recognizing disciplinary boundaries. The combination influences willingness and ability to cooperate in collaborative work (Briggs and Michaud 1972, 192). Background Regardless of approaches or contexts, the most common motivations for transdisciplinary work are criticism of narrow approaches in single disciplines, rigid and inappropriate institutional structures, and excessive specialization and isolation of individual disciplines. Furthermore, indicating a gap between current needs and traditional classifications (Barthes 1987, 15), interdisciplinarity – similarly to trans-disciplinarity – emerges in response to problems and questions too complex to be assigned to any one discipline or to be solved by any single branch of knowledge. Thus, interdisciplinarity is also an outgrowth of realization that traditional disciplinary patterns of thought and practice are inadequate in pressing global issues such as climate change, disease, urbanization, migration, food insecurity, and digital trans-formation. At the same time, interrogating and challenging established organiza-tional systems of academic research and education fuels demand for transcending disciplinary boundaries and bridging the divide between society and science. Here too, a historical perspective is illuminating. The term interdisciplinari-ty is conventionally dated to the 1920s in the context of social-scientific research on problems of the day and in alternative forms of general education and core curricula. During the 1930s and 1940s, the new field of area studies also arose, as well as problem-focused research such as the Manhattan Project to create an atomic bomb. Discussions around it, though, are much older and have influenced development of modern disciplines since their beginnings (Klein 1993, 19). By the 1960s and early 1970s the word appeared more widely as a level for educational experimentation and new fields such as environmental, urban, and culture-based topics that arose from sociopolitical movements outside the academy. From the 1980s onward, the term became more prevalent in industrialized nations in science-based fields and, concomitantly, philosophy of science and science policy. Up to this historical point, subject differentiation and organization according to disciplines had been regarded as indispensable, while failure to adhere to disciplinary boundaries was deemed pejoratively as incompetence, "outsiderism", and dilettantism (see Hentig 1971, 866). Like any system, disciplines are decision- and experience-based constructs whose influence, stability, and boundaries result from socialization and institutionalization: power and resources, monopolization of knowledge, path dependencies, and hegemonies shape parameters of research and education. As a result, early interdisciplinary initiatives were regarded as anomalous or marginal. It has become apparent, not just since Foucault's habilita.

Interdisciplinarity197tion thesis was rejected at Uppsala University in 1958 because it was deemed irreconcilable with the self-image of history as a discipline (Edelberg 2017, 286; Eribon 1989, 106–9), that disciplines can be used effectively as instruments of power to deny recognition and exclude the participation of alternative practices. Popper's dictum – "We are not students of some subject matter, but students of problems" (1963, 88) – captures the criticism of failure to respond to societal challenges. Moreover, when interdisciplinarity is associated with innovation, and height-ened in funding policies and grant applications, thinking within disciplinary boundaries is rather associated with amateurism, and narrow and decontextu-alized objectives (see Davis 2007; Nissani 1997; Palang 2003, 56). Nonetheless, the connecting threads across motivations and contexts is the responsibility for questions and problems that rigid disciplinarity cannot address. Interdisciplinarity is thus also a result of continuous accountability renegotiation. From a philosophical standpoint, since the world in its complexity can be apprehended neither encyclo-pedically nor categorically, interdisciplinarity does not represent overcoming, let alone abolition of disciplines. Rather, it explores their non-linear rhizome-like con-nections (see Deleuze and Guattari 1976): Individual disciplines remain the dominant structure of organization and classification. Interdisciplinarity is thus not just a program to reform university structures and educational systems, but should also be understood as a learning mode to recognize and deal with justice conflicts, path dependencies, hierarchies, control regimes, and techniques of marginalization. At the same time, the increased number and size of scientific and professional teams has also resulted in increased awareness of collaborative learning dynamics and research. Moreover, heightened attention is being paid today to the involve-ment of stakeholders in government, industry, and communities, including the coproduction of knowledge in transdisciplinary problem-oriented research. In fact, inter- and transdisciplinarity originate from the same malaise and offer different, complementary though interconnected methods of dealing with it. While interdisciplinarity originally encompassed purely scientific exchange, transdisciplinarity aims at the collaboration of diverse knowledge producers at the interface of science and society, theory and practice. A semantic, conceptual, and historical discernment, though, remains difficult. In contrast to earlier emphasis on episte-mology, problem-solving today looms larger in interdisciplinarity discourse. This development is apparent on a global scale. In the past, literature has been dominated by accounts from Europe and North America and in the English language. However, as examples indicate, bound-ary-crossing discourses are expanding awareness of inter- and trans-disciplinarity in the Global South. A growing body of reports from science-policy bodies and educa-tional commission documents increased calls for support in both research and education. Gleed and Marchant's (2016) interdisciplinarity survey report includes examples from the Americas, Europe, the Asia-Pacific, the Middle East, and North Africa.

Julie Thompson Klein and Thorsten Philipp 198 Debate and criticismIt is no surprise that the postulate of interdisciplinarity has spawned a plethora of literature, but a systematic definition of terminology and practices remains elusive. Attempts at systematization are numerous, misunderstandings emerge, and some argue "Babylonian confusion", despite clear patterns of consensus (Klein 2017, 21). In addition, appropriate evaluation criteria need to be used in assessing funding, publications, research performance, and program review. Disappointments are hardly surprising in light of the high expectations associated with interdisciplinarity. They include communication issues, empty phrases, political declarations of intent that dominate "interdisciplinary hype" (Jacobs 2009), and alignment with innovation and commercialization. The overarching concept has been misinter-preted as a panacea (Segal 2009). Some claim that it has supplanted disciplinarity as the primary raison d'être of research and education. The paradox of interdisciplinarity, however, refutes the latter claim. Science-policy bodies and educational commissions are increasingly endorsing it. Obstacles persist on all levels. Key continuing hindrances include jargon and translation problems, discipline-based publication criteria and rigid discipline-based worldviews, concern about lack or loss of hierarchical status, insufficient incentive structures, and inadequate compensation structures accompanied by the need for increased financial support. In addition, cooperation across disciplines requires time to build trust in teams and wiliness to compromise, as well as joint goal setting, power sharing, and equitable work distribution. Sufficient opportunities for profile and career promotion are also needed. Since interdisciplinarity is aligned increasingly with complex and often global problems, long-term change in institutional structures is essential, too (Abbott 2007, 134). Mindful of the many obstacles and disincen-tives, Gleed and Marchant (2016, 7ff.) call for a robust “architecture” of programs in all countries, facilitated by physical and social spaces including centers, networks, and graduate education and research training. On the other hand, scholars, practitioners, and educators disagree on when students should be exposed to interdisciplinarity. The traditional hierarchy of expertise prioritizes mastery of a specialized body of knowledge first. However, pertinent skills are called for across contexts.To illustrate, the Education Reimagined’s Partnership for 21st Century Learningcited four significant competencies that are also aligned with interdisciplinarity: communication, collaboration, critical thinking, and creativity. In comparison, the World Economic Forum’s Future of Jobs Report 2020 (Zahidi et al. 2020) listed critical thinking, creativity, and coordination in problem-solving as among the top-ten skills students need. Spelt et al.’s (2009) systematic review of relevant liter-ature in higher education spans multiple contexts. Some are not exclusive to interdisciplinarity, including disciplinary knowledge, ability to communicate, and critical thinking. Recently, though, there has been increasing interest in understanding Interdisciplinarity199 the nature of interdisciplinarity, integration, and collaboration. Other abilities deemed crucial for dealing with complex questions and problems include curiosity and respect for other disciplines, empathy and emotional intelligence, and ethical concerns. Spelt et al. add the pedagogical goal of fostering collaboration in curriculum development and teaching, whereas Borrego and Newswander (2010) include capacity for teamwork, along with grounding in disciplines, integration and broad perspective, interdisciplinary communication, and critical awareness. Current forms of implementation in higher educationGiven the plurality of approaches, forms of implementation differ as well: from student-initiated research and living labs to large-scale interinstitutional pro-grams and projects. They also include new subdisciplines and disciplines as well as integrated fields. Interdisciplinarity in research was initially organized in graduate colleges and project-based clusters of limited duration, but it has become well-established in dedicated units such as Berlin’s Einstein Center Digital Future, Stanford University’s Bio-X institute, and the Global Institute of Sustain-ability and Innovation at Arizona State University. Furthermore, it increasingly gained a place in curricula of many universities. In Europe, more study programs with interdisciplinary aspirations have emerged since the introduction of bachelor’s degrees. For example, Philosophy, Politics, and Economics, developed at Oxford in 1920, then subsequently adopted in one form or another by several other universities. Attempts to establish the Anglo-American liberal arts tradition in other countries (e.g. since 2012 at University College Freiburg) follow a similar trajectory. All of these examples, however, do not conclusively prove that interdisciplinary aims are always achieved. In many cases, the term is merely a catchphrase. Proactive attention is required.Universities and colleges need discursive spaces where experiences are shared and exchanged across boundaries, and integration and collaboration are explicitly cultivated in educational and training programs. Otherwise, thought patterns formed by preparation in individual sciences are not overcome, or at most are relativized and reorganized only to a modest degree. As a result, the goal of integrating interdisciplinarity into students' personal and professional identities diminish. Interdisciplinarity is often viewed solely as a phenomenon of application, while theory-building and reflection on epistemological, didactic, and methodological dimensions is short-changed (Philipp 2021, 169). Interdisciplinary learning further requires expansion of university-based counseling and guidance services and exposure to a range of forms and methods (Briggs and Michaud 1972, 228–29).Two accounts in the authoritative Oxford Handbook of Interdisciplinarity fur-nish deeper understanding of current forms and strategies of implementation. In

reporting on administrative structures, Holley (2017) sketches a typology of interdisciplinary programs organized into categories of students, faculty, curriculum, funding, and institutional location. Curriculum spans institutional- and student-designed programs and activities, theme-based learning communities, capstone or culminating classes within disciplinary majors, topic-based multidisciplinary course sequences, and prescribed coursework in recognized interdisciplinary fields or on emergent topics or interests. Holley concludes that no single model exists: forms may be autonomous, freestanding units or located within an established college or university, including new and renovated buildings that are centers for theme-based research with some educational and training opportunities. Institution-wide prioritizing of interdisciplinarity is rare. Related pedagogies are also implementing interdisciplinary learning. DeZure (2017) reported that interdisciplinary teaching and learning do not claim any unique set of pedagogies. Following suit, teachers employ an array of instructional methods to support integrative learning outcomes. Dubbing them "productive pedagogies", DeZure aligns them with a broad-based shift from mastery of content to competencies, and the elevated importance of integrative and interdisciplinary learning outcomes. DeZure also reports proliferation of interdisciplinary curricula and programs both in disciplinary departments and beyond them, as well as pedagogies that promote active and discovery-based learning. Illustrating the constructivist philosophy of learning, teachers also engage students in team- and problem-based learning. The more the pedagogy engages students in experiences based in the complexities of the real world, DeZure adds, the more interdisciplinary approaches to problem solving and authentic assessment are advanced. "Inclusive pedagogies" also recognize multiple perspectives, to ensure all voices are heard. Finally, Vienni Baptista and Klein (2022) illustrate the expanding scope of examples in a wide range of countries, spanning Africa, Europe and the United Kingdom, Russia and the South

Caucasus, Latin and North America, Australia, and Japan. The overarching commonality is the need to address complex societal problems, including the global pandemic, climate change, and sociopolitical inequities. However, contexts differ in individual chapters. Political history, for example, was a decisive factor in countries where universities reflect top-down, centralized, and hierarchical relationships from the Soviet system. Mokiy and Lukyanova (2022) report a continuing authoritarian leadership style in Russia, though autonomous nonprofit organizations are advancing the potential for problem-focused interactions with civil society – even though transdisciplinary participation with stakeholders is a new concept in Russia, Armenia, and Georgia. Further south, in Ghana, Akua-Sakyiwah (2022) situates reform efforts against the backdrop of dependence on colonial masters and development partners and the dominance of Western forms of knowledge. Yet material realities differ from the North, including irregular financial support from the government.

Interdisciplinarity 201 Brazil also illustrates the impact of political history and, today, international momentum for solving complex societal issues. Since the 1980s, after 21 years of military dictatorship, reform has occurred against the backdrop of redemocratiza-tion. Litre, Lindoso, and Burstyn (2022) characterize several Brazilian universities as avant-garde social spaces. Interdisciplinary initiatives have grown in graduate programs, but they are subject to centralized government regulation of education. Innovative programs are also judged by traditional metrics, regarded as incubators rather than mature initiatives, and stigmatized as too general, shallow, and un-evenly institutionalized. The Center for Sustainable Development at the University of Brasilia, though, illustrates potential in a geographical area rich in ecological and social diversity, while located strategically in the country's capital. Accounting for China, Pearce (2022) cited precedents for interdisciplinarity and transdisciplinarity in the conception of knowledge as an integrated corpus, the common good, and holistic knowledge and education for character develop-ment and ability. However, dominance of the Soviet model of higher education between 1949 and 1966 prioritized a socialist agenda for economic development. Between 1966 and 1976, the Cultural Revolution shut down higher education, except for military institutions. In addition, China's state-driven technocratic approach does not foster holistic consideration of complex societal and cultural factors. At the national level, interdisciplinarity is aligned more with solving problems than a general concept. As these case studies indicate, it is critical to recognize similarities and differences when comparing lessons from different countries and regions. Interdisciplinarity will have to prove itself less as a method and more as a fundamental academic and everyday attitude of graduates, particularly in post-secondary education. It is not the abundance of areas of application, but the ability to reappraise scientific methodology and to provide reflection spaces for interdisciplinarity-induced learning experiences which will determine whether the university remains the most crucial pillar of disciplinary and interdisciplinary knowledge structures. References Abbott, Andrew Delano. 2007. Chaos of disciplines. Chicago: University of Chicago Press.Apostel, Léo, ed. 1972. Interdisciplinarity: Problems of teaching and research in universities. Paris: OECD.Akua-Sakyiwah, Beatrice. 2022. A contextual approach to institutional change: Transdisciplinarity in Ghanaian higher education. In Institutionalizating interdisciplinarity and transdisciplinarity: Collaboration across cultures and communities, eds. Bianca Vienni Baptista and Julie Thompson Klein, 107–23. London: Routledge.

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Transdisciplinarity as a Discipline and a *Way of Being*: Complementarities and Creative Tensions

Cyrille Rigolot

Abstract

Transdisciplinarity is generally defined by the inclusion of non-academic stakeholders in the process of knowledge production. Transdisciplinarity is a promising notion, but its ability to efficiently address the world's most pressing issues still requires improvement. Several typologies of transdisciplinarity have been proposed, generally with a *theoretical* versus *practical* dichotomy (Mode 1/Mode 2), and effort has focused on possible linkages between different types. However, in the last two decades, transdisciplinarity has significantly matured to the extent that the classical *theoretical* versus *practical* distinction appears clearly limited. In this paper, a reframing of the debate is proposed by considering transdisciplinarity as a new discipline and as a *way of being*. The conception of transdisciplinarity as a discipline can be related to the recent development of the broader discipline of "integration and implementation sciences" (i2S), to which "practical" Mode 2 transdisciplinarity is a major contributor. When transdisciplinarity is considered as a *way of being*, it is inseparable from personal life and extends far beyond the professional activities of a researcher. To illustrate this conception, the work and life of Edgar Morin can be used as an exemplary reference in conjunction with other streams of thought, such as integral theory. Transdisciplinarity as a discipline and transdisciplinarity as a *way of being* have complementarities in terms of researchers' personal dispositions and space for expression in academia. The proposed distinction also raises the question of the status of consciousness in transdisciplinary projects, which may be a fruitful controversial topic for the transdisciplinary research community.

Introduction

In the context of unprecedented worldwide crises, transdisciplinarity is increasingly mentioned as a promising way of producing knowledge and decision-making (Lang et al., 2012). Transdisciplinarity is often characterized by the inclusion of non-academic stakeholders in the process of knowledge production (Scholz and Steiner, 2015). The notion of transdisciplinarity emerged in the 1970s and developed in different streams that correspond to different communities and contrasting research practices (Klein, 2014). Several typologies have been proposed to characterize these different streams and their relationships. In one of the most common typologies, based on the work of Gibbons et al. (1994) in the sociology of science, Scholz and Steiner (2015) distinguish two modes of transdisciplinarity: "Mode 1" transdisciplinarity, which is mostly theoretical, is motivated by a general search for a "unity of knowledge" and corresponds to an "inner-science activity", while "Mode 2" transdisciplinarity, which is mostly practical, is typically characterized by the inclusion of stakeholders in participatory problem-solving approaches that are applied to tangible, real-world problems (Scholz and Steiner, 2015). Mode 1 transdisciplinarity is typically associated with the quantum physicist Basarab Nicolescu's proposal of a methodology based on three axioms: (1) levels of reality, (2) the principle of the hidden third, and (3) complexity. These axioms are extensively developed in the literature (Nicolescu, 2010; McGregor, 2015a). In another famous typology, Max-Neef (2005) proposes distinguishing "weak transdisciplinarity", which can be applied "following traditional methods and logic", and "strong transdisciplinarity", notably inspired by Nicolescu's work, which is characterized by a specific quantum-like logic and breaks with the assumption of a single reality (Max-Neef, 2005). From this perspective, transdisciplinarity is more than a new discipline or a super-discipline; it is "a different manner of seeing the world [that is] more systemic and holistic" (Max-Neef, 2005). As a last example, Nicolescu (2010) distinguishes three forms of transdisciplinary: (1) theoretical (referring to his own work and that of his collaborator, Edgar Morin), (2) phenomenological (corresponding to Gibbon's Mode 2), and (3) experimental (which is based on existing data in a diversity of fields, such as education, art, and literature).

Transdisciplinarity is often described as a promising notion, but its ability to efficiently address the world's most pressing issues still requires improvement. Although several transdisciplinary projects with non-academic stakeholders have led to significant improvements in addressing important issues, many other projects have been disappointing as the benefits claimed for participation are often not realized (Frame and Brown, 2008). One common response to overcome these limitations is to provide a better link between different types of transdisciplinarity regardless of the typology used. For example, for Scholz and Steiner (2015), a major challenge for transdisciplinarity is to better link Mode 1 and Mode 2 as a way to maintain high quality standards and to prevent transdisciplinarity from "being increasingly used for labeling any interactions between scientists and practitioners". For Max-Neef (2005), efforts are needed to perfect transdisciplinarity as a world vision "until the weak is absorbed and consolidated in the strong". Nicolescu (2010) also stresses the need to acknowledge both the diversity and the unity of his three types of transdisciplinarity (theoretical, phenomenological, experimental). In line with these different calls, some approaches have been proposed to better link different types of transdisciplinarity. For example, Rigolot (2020) suggests that quantum theory can be used as a source of insight to narrow the gap between Mode 1 and Mode 2 transdisciplinarity.

In this paper, another strategy is proposed by reframing the entire debate. Each of the mentioned typologies of transdisciplinarity has important limitations, and the very idea of a typology itself has become limited. As discussed in the next section, the notion of a Mode 1 transdisciplinarity and the related "theoretical" transdisciplinarity in Nicolescu's terms were somewhat misleading notions from the start. In contrast, Mode 2 transdisciplinarity has evolved considerably in the last two decades, particularly with regard to its openness to shared methods and theories. The hierarchy introduced by Max-Neef (2005) between weak and strong transdisciplinarity also seems questionable. To move forward, rather than proposing another typology, it might be more fruitful to engage a dialog between transdisciplinarity as a new discipline and as a *way of being*. The next section presents the emergence and main characteristics of both the discipline and the *way of being*. Transdisciplinarity as a discipline can be seen as emerging from "Mode 2" transdisciplinarity as a result of a "bottom-up" mutualization of methodologies and theories. As an exemplary illustration, it can be related to the recent stimulating development of "integration and implementation sciences" (i2S) (Bammer, 2017; Bammer et al., 2020), although the correspondence is not exact (i2S is larger than transdisciplinarity as a discipline). Insights from complex thought (Morin, 2008) and integral theory (Wilber, 1995; Esbjörn-Hargens, 2009) are used to illustrate transdisciplinarity as *a way of being*. The third section of this paper presents the complementarities and creative tensions between a transdisciplinary discipline and a *way of being* before concluding with the added value of the proposed approach.

Mode 2 transdisciplinarity and the discipline of "integration and implementation sciences"

The emergence of a new academic discipline requires a broad research community with a common purpose that collaborates not only on a practical level but also on methodological and theoretical levels. Following this approach, transdisciplinarity as a discipline can be understood in terms of Mode 2 transdisciplinarity and insights from integration and implementation sciences. The notion of Mode 2 transdisciplinarity was adopted in the Zürich congress in 2000 by the major academic transdisciplinarity research community, which ultimately became the Swiss-based TD-net Network for Transdisciplinarity Research (McGregor, 2015a). The "Zürich approach" discarded the notion of transdisciplinary as a methodology with axioms, as proposed by Nicolescu, which was later labeled “Mode 1” (Scholz and Steiner, 2015) or “theoretical” (Nicolescu, 2010) transdisciplinarity. According to Klein (2014), the Zürich congress 2000 was a pivotal event in the evolution of transdisciplinarity discourses. Originally, Mode 2 science was characterized by six principles (Gibbons et al. 1994) that would later be used as a basis for an “ideal-type” Mode 2 transdisciplinarity (Scholtz and Steiner, 2015): (1) Mode 2 knowledge is produced in the context where it will be applied; (2) it has its own distinct characteristics beyond disciplinary knowledge; (3) Mode 2 is heterogeneous in terms of skills, viewpoints and participants’ experiences; (4) structures are seen as transient and evolving rather than rigidly hierarchical; (5) the resulting knowledge is socially robust and relevant for the actors involved; (6) the quality of the produced knowledge is ensured by adequate criteria and procedures (McGregor, 2015a). Following the principles of Mode 2, Scholtz and Steiner (2015) identified a possible “kernel” of transdisciplinary processes, which can be seen as a common purpose for the related community, in “the mutual learning among scientists and practitioners about a complex, societally relevant problem”.

As Mode 2 transdisciplinarity emerged at the expense of the methodology proposed by Nicolescu (2010), it became characterized by the adjective “practical” by contrast. Because the Zürich approach refused to embrace an overarching methodology (i.e., Nicolescu’s methodology), it became associated with “the refusal to formulate any methodology” (Nicolescu, 2010) and, correlatively, with an aversion to theoretical developments. However, recent breakthroughs have led to a move beyond what now appears as an over-simplification, as exemplified by the development of a new discipline of integration and implementation sciences (I2S) (Bammer, 2017). Integration and implementation sciences (i2S) does not strictly correspond to transdisciplinarity as it encompasses many other approaches, such as system dynamics, sustainability sciences and action research (Bammer, 2017). However, there is a significant overlap, as indicated in the definition of i2S as “a new discipline providing concepts and methods for conducting research on complex, real-world problems” (Bammer, 2017). In particular, the domain of application of i2S includes topics such as the synthesis of disciplinary and stakeholder knowledge, the understanding and management of diverse unknowns and the provision of integrated research support for policy and practice change (Bammer, 2017). As noted by Bammer (2017), the development of the i2S discipline was motivated by the difficulty of interdisciplinarity (including transdisciplinarity) in fitting into the mainstream and the fragmentation of methods and academic communities, which led to extensive “reinventing of methods”. A major advance has been to build a methods repository, which is also open to theoretical exchanges and development (Bammer et al., 2020). In a post on the i2S blog[Footnote1] presenting discussions held at the 2015 TD-net conference, a group of researchers discuss the role of theory specifically for transdisciplinary research. For this group, "theory makes clear what transdisciplinary researchers value and stand for", which is why they feel "a responsibility to build and articulate it". This group also insists on the specificities of transdisciplinarity research and the importance of "holding theory lightly and approaching and using it pragmatically". While the distance from Nicolescu's overarching approach clearly remains, such recent reflections unambiguously break with the previous view of a mostly practical transdisciplinarity that is methodology and theory averse.

Transdisciplinarity as a *way of being*

To date, most academic debates about types of transdisciplinarity have focused on the Mode 2 or Zürich transdisciplinarity approach, on the one hand, and the theoretical work of the quantum physicist Nicolescu (2010), on the other hand (Scholtz and Steiner, 2015; Bernstein, 2015; McGregor, 2015a). Although these debates have yielded stimulating insights regarding, for example, the complementarity of Mode 2 transdisciplinarity with Nicolescu's axioms, they may have reached a limit. In particular, Nicolescu's propensity for theoretical developments and his background as a quantum physicist have contributed to the idea of a "theoretical" transdisciplinarity, as he labels it, and even further to a Mode 1 transdisciplinarity, typically associated with the image of the "ivory tower" (Scholtz and Steiner, 2015). To move the debate forward, the work of the French philosopher Edgar Morin can be used as a key reference for further exploration. Morin's work and "complex thought" are widely acknowledged as a major contribution to domains such as philosophy, sociology and biology but, surprisingly, to a lesser degree to transdisciplinarity (compared to Nicolescu). However, Morin is a cosignatory with Nicolescu of the seminal "charter of transdisciplinarity" (Nicolescu et al., 1994). Morin himself did not engage in academic debates about transdisciplinarity as Nicolescu did (which is indicative of Morin's approach to transdisciplinarity as a *way of being*). As summarized by Montuori (2013), "*Morin's work does not come from an attempt to escape life for an ivory tower (…) but from an effort to immerse himself in it more deeply*". As several other commentators have noted, Montuori (2013) shows how Morin's transdisciplinary work and well-known "complex thought" are deeply integrated with his own life experiences, including events such as the death of his mother and his participation in French resistance, about which Morin constantly reflects in journals and autobiographies. Morin is also deeply engaged in the public and political debate in France. He played a significant role, for example, in the emergence of ecological questions in the public debate (Morin and Kern, 1993). For Montuori (2013), Morin's transdisciplinary approach "*does not seek to* *simply solve a problem, but is rather a quest for meaning derived from personal experience*".From his own life experiences (such as the lies around his mother's death when he was a child and his disillusionment with the French communist party), Edgar Morin developed a particularly strong sense of distrust towards self-deception and illusion. He became aware (and then theorized) that every form of knowledge is a construction resulting from specific sources and choices that themselves depend on historical contingencies and personal preferences (Morin, 2008). Consequently, transdisciplinarity as a *way of being* cannot be fairly represented by the biased perception of only one key author, including Edgar Morin. For Gidley (2016), a diversity of authors and research fields are complementary to Morin's way of thinking. For example, integral theory shows particularly stimulating complementarities (Gidley, 2016; Kelly, 2018). In line with the search for a unity of knowledge in Morin's and Nicolescu's works (Klein, 2014), integral theory is an attempt "to integrate as many approaches, theories and thinkers as possible in a common framework" (Esbjörn-Hargens, 2009). On the basis of the philosopher Ken Wilber's seminal work (1995), integral theory has been presented as a "theory of everything" that aims to gather "separate paradigms into an interrelated network of approaches that are mutually enriching" (Esbjörn-Hargens, 2009). Among other authors (e.g., Gidley, 2016; Kelly, 2018), Sue McGregor (2015b) has identified some strong complementarities between integral theory and transdisciplinarity, for example, with regard to the consideration of different levels of reality. For this author, integral theory can be seen as an *"internal life- and world-processing orientation"* (McGregor, 2015b), which precisely corresponds to the broad definition of transdisciplinarity as a *way of being* adopted in the present paper. A stimulating complementarity between Integral theory and Edgar Morin's complex thought lies in the integration of spiritual knowledge: whereas integral theory insists that there is some truth everywhere and gives strong credit to religions as holders of truth, Morin is open to spiritual knowledge but is also constantly skeptical (Montuori, 2013; Kelly, 2018). This skepticism is related to Morin embodied distrust towards self-deception, errors and illusions, which he sees constantly in knowledge production, including in the realm of science (Montuori, 2013; Kelly, 2018).

Complementarities and creative tensions

Some important characteristics of the i2S discipline were developed by Bammer et al. (2020) and can be used as a basis for characterizing transdisciplinarity as a discipline (although the i2S discipline is larger) in comparison with transdisciplinarity as a *way of being*. When transdisciplinarity is seen as a discipline (as part of i2S), it applies to particular issues or "wicked" problems (Bammer et al., 2020). More precisely, expertize in integration and implementation is required at different stages of the problem-solving process, from delimiting the problem to accommodating solutions. Bammer et al. (2020) also identify different realms where expertize can be found, which are related to communities of professional scientists or associated with academic research projects or research domains (such as unknowns and innovation). From the explorations of Bammer et al. (2020), it appears that the production of specific knowledge for the discipline of integration and implementation sciences occurs primarily in a community of professional scientists. On the other hand, from the perspective of a transdisciplinary *way of being*, every problem in real life can be framed as complex (Morin, 2008). Moreover, the relevant skills, knowledge and know-how to overcome such complex problems have been developed from ancient times and far beyond academia (Wilber, 1995). The *way of being* lens is also useful to make sense of why the first main practical application domain of Morin's complex thought was education (Morin, 2002; Gidley, 2016). Transdisciplinarity as a new discipline and transdisciplinarity as a *way of being* partly overlap. Notably, the transdisciplinary *way of being* provides relevant "dispositions" to engage in the transdisciplinary discipline (McGregor, 2015b). For example, participation in the public debate (agora) can be seen both as a possible characteristic of a transdisciplinary *way of being* (as exemplified by Edgar Morin) and as essential for the contextualization of problems in research projects (McGregor, 2015b). Reciprocally, a transdisciplinary discipline provides specific skills and a much-needed space for the expression of the transdisciplinary *way of being* in academia (Ross and Mitchell, 2018).

However, tensions may also occur between transdisciplinarity as a discipline and as a *way of being*. In particular, this distinction raises the question of the status of consciousness in transdisciplinary research projects. In line with the developmental approach of the psychologist and epistemologist Jean Piaget, who coined the term transdisciplinarity (Nicolescu, 2010), a transdisciplinary *way of being* is embedded in an evolutionary approach to consciousness. A typical expression of Edgar Morin is that "we are at the prehistory of the human mind", meaning that much of the human mental capacity remains to be explored. To a large extent, Morin's approach is consistent with the deep exploration of transpersonal psychology by integral scholars (Gidley, 2016; Kelly, 2018). Transpersonal psychology refers to the integration of the spiritual and transcendent aspects of the human experience with the framework of modern psychology. The transpersonal is defined as "experiences in which the sense of identity or self extends beyond the individual or personal to encompass wider aspects of humankind, life, psyche or cosmos" (Walsh and Vaughan, 1993). Correlative with this conception, in the current context of worldwide unprecedented crisis, the transdisciplinary *way of being* encourages consideration of ideas such as a whole civilization change (Morin, 2011) based on an evolution of human thought or consciousness (Botta, 2019). However, many transdisciplinary scholars may hesitate to consider these ideas in the solution space of research projects. In particular, the potential tension is apparent in relation to integral theory, which explicitly and significantly includes spiritual knowledge and often associates an evolution of consciousness with processes of "awakening" (Wilber, 1995). Although integral theory is currently used by a large number of transdisciplinary scholars (Esbjörn-Hargens, 2009), it may be considered by other transdisciplinary scholars to be non-scientific and misleading. This tension is mostly implicit and seldom discussed in the literature, but it can manifest concretely as part of transdisciplinary research projects. Tension can particularly occur between a search for consensus that integrates and respects diverse stakeholders' viewpoints *as they are* and the aim of transforming ways of thinking (including those of scientists themselves). In the first case, transdisciplinarity (as a discipline) is a *means* by which scientists contribute to problem solving. In the second case, transdisciplinarity (as a *way of being*) is also a solution that must be enhanced in society at large.

Conclusion

Transdisciplinarity is a promising notion, but its ability to efficiently address the world's most pressing issues has been intensively debated. To date, most debates have been structured by identifying several types of transdisciplinarity, generally with a *theoretical* versus *practical* dichotomy, and their possible linkages. In the last two decades, important efforts to mutualize methodologies and theories have led to the emergence of a discipline of integration and implementation, which enables the conception of transdisciplinarity as a discipline. Somewhat paradoxically, such a discipline seems to emerge from "Mode 2" transdisciplinarity as a result of a "bottom-up" mutualization rather than from the so-called Mode 1 "inner-science" transdisciplinarity. This distinction shows the interpenetration of Mode 2 and Mode 1 transdisciplinarity and the limits of existing typologies of transdisciplinarity. On the other hand, when transdisciplinarity is taken as a *way of being*, the need for knowledge and know-how for integration and implementation extends far beyond the scope of research projects and appears constantly and ubiquitously in real life. The relevant resources can be found not only in academia but also in domains such as literature and religion, keeping in mind the constant risks of errors and illusion (including in science itself). Compared to existing typologies, the consideration of transdisciplinarity as a discipline and a *way of being* could generate new insights in the ongoing debate about the potential and effectiveness of transdisciplinary approaches. Complementarities can be considered in terms of personal dispositions for the discipline and of a space for expression for the *way of being* in academia. The proposed reframing also sheds light on the status of consciousness in transdisciplinary research projects. In a sense, consciousness can be seen as a critical "unknown" for the activity of integration and implementation and a major topic for further investigation.

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