TRANSDISCIPLINARITY: FROM A REAL EDUCATIONAL ESSENCE TO A NORMAL FUTURE IN SCIENTIFIC RESEARCH

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Abstract. *This paper is built with a dual purpose: to render, in natural and continuous manner, both the scientific narrative devoted to define the non-unidisciplinary science thinking and the contribution of transdisciplinarity in modern science, both in education and scientific research. After a brief introduction, based on redefining the specificity of inter-, multi-, and transdisciplinarity, trying to define the real difference between all of these concepts and, at the same time, to reveal the modern, intense and innovative expanding process of education and research in science, the second section describes the new contents of transdisciplinarity in the context of applying it as a real solution against the complex problems of reality in modern scientific education, and scientific research in general. The usual final remarks conclude in a balanced way this article 's diversity of transdisciplinarity's significances revealed through its lines in modern education and scientific* research, *underlining the evolution of transdisciplinarity from a real essence of education to a normal future in scientific research.*

Keywords: *science, discipline*, inter-, multi-, transdisciplinarity, scientific thinking, education, scientific research.

1. INTRODUCTION

The emergence, development and disappearance of sciences and scientific disciplines during milenia are closely related to scientific research, which invalidates them, restructures them, or contributes to either their gradual obsolescence, up to their disappearance as real impact in the topicality of the scientific universe, or their re-grouping, interrelationing and intersecting them continuously, validating or invalidating their methods and characteristic models.

The option to define modern science as a simultaneously distinctive and integrative, coherent and comprehensive way to address a specific and complex phenomenon of modern reality emerged from a combination of *theoretical* investigation with a practical simulating or prediction impact, into a segment of reality, defining *as an object of study*, through its methods, but especially with the help of *specific patterns of knowledge and interpretation*, having recourse to a new expression using the language of a multiplied inter-, multi-, and transdisciplinary type of thinking

This is briefly the essence of the mechanism of inter-, multi-, and transdisciplinarity, which has generated, and is still generating, ever new sciences. The methods and models of modern science, which have thus become essences of contemporary science, combine at least two or three types of thinking. A first example, excerpted from my own modest experience to avoid isolated research and unidisciplinary paper, bearing on methods, is the very method for analysing the concentration or diversification of contemporary processes, from specific markets to the linguistic expressions, from stocks to flows, from demographic phenomena to biological processes. Instrumentally, inter-, multi-, and trans-disciplinarity type of research simultaneously exploit the statistical thinking of concentration and diversification indices, which constitute a large family of indicators, the manner of mathematical thinking, mainly geometric, of concentration curves, the specific thinking of the biological cycle and the curve ABC, etc. [1] *Whether bridging disciplinary divides between different ways of knowing within academia* [inter-, and multidisciplinarity], *or extending the 'right to do research' to marginalized communities and groups* [transdisciplinarity], *a key feature of these processes is that of reflection – both of the world and of one's role in that world*." [3]

1.1. Inter-, multi-, and transdisciplinarity in modern education and scientific research

The terms inter-, multi-, and transdisciplinary have a common origin, as noted in the conceptualization of the discipline and science, defining forms of antinomy of a multiverse of disciplines and sciences ("*the former category already exceeding 8000 disciplines as distinct entities according to bibliometric classifications, and the latter approaching, in keeping with relatively recent surveys, 1200 well delimited sciences*") in relation to unidisciplinarity, addressed in a limited, closed and slightly derogatory sense, as a unique, isolating discipline. [2] For academic teaching or researching domain, unidisciplinarity, as modern significance, and not mandatory, means only to know everything related to a vast unique disciplinary field, but also to offer permanently an original education instrument and a clear research attitude in any logic scientific investigation. This general aspect is subject to a natural law of studying diversity in a homogeneous manner, or to the fact that the heterogeneity in the reality investigated in a scientific or disciplinary manner must be theoretically explained by homogeneity. [2]

The premises of the more and more intense development of this process are related to both the ontological nature of the sciences and disciplines separated from various areas of reality or specific universes composing their multiverse as a coherent set of a logical nature, and also of a general gnoseological essence, or, more specifically, strongly epistemological.

Interdisciplinarity designates establishing relationships between several disciplines and, beyond its aim, nuanced and diversified compared to unidisciplinarity, be it open, it involves phenomena, concepts and general laws that are common to several disciplines, investigated with common methods and models, it analyses and highlights, in a varied context, multifaceted issues and diverse opportunities for knowledge of reality [2] As the major induced hypothesis, interdisciplinarity favours horizontal transfer of knowledge from one discipline to another, level by level, which reshapes, permanently and by extension, the limits of a map tending towards completeness of the relief of knowledge, and requires cooperation with other disciplines. "*All the above aspects*

engender a process of specialization that constantly gives rise to new subdisciplines, and another one, of fusion, which anticipates the potential rebuilding of new disciplines. In statistical thinking, interdisciplinary is simultaneously disaggregative and aggregative, within completely different areas of scientific knowledge."[2] Basarab Nicolescu reconceptualises interdisciplinarity as a three-grade transfer of methods from one discipline to another, ontologically, logically and epistemologically [4], finally allowing to determine not only the epistemological isomorphisms but also the homomorphisms of a discipline into another, with a major impact on their development, and thus describes an extended typology of interdisciplinarity, from interdisciplinary fields to interdisciplinary levels, grades, and areas of reality and to interdisciplinary methods, models and even concepts

Among the transfers of methods and models specific to interdisciplinarity from one science to another, apart from the *applicative* and *epistemological* (cognitive) transfer, the transfer *generating new disciplines* is becoming increasingly significant and important (dominated by the transfer of methods and models), also caused by the high complexity of the problems investigated [2].

An illustration of the fact that this type of transfer is practical and continuous, can start with a first interdisciplinary transfer, that of statistical thinking in biology, defining biostatistics, and can continue with a transfer of the methods of the statistical-mathematical type in economics, configuring econometrics, the first science born at the intersection of three scientific ways of thinking, and can finally conclude with a third transfer, this time fluent and complex, that of the econometric model, within the space of financial economy, saturated with uncertainty, which generated, by the probability theory, the science of financial econometrics and the econometric financial model [5], bringing together a large family of models, and selecting only those of the ARCH and GARCH type, which represents an important proof of the specific approach of modelling interdisciplinarity.

The diversification, aiming at interdisciplinarity, of the ARCH and GARCH models began over three decades ago, and continues to date (Bollerslev in 2008). Financial econometric ARCH type models, where the variance depends on the previous series of square errors (the acronym is derived from AR – *autoregressive*, C – *conditional*, and H – *heteroskedasticity*), were introduced by Engle in 1982 and four years later, in 1986, were generalized by Bollerslev, together with Taylor, becoming GARCH (G, standing for *generalized*, was added to the old acronym. The GARCH model was established as financial econometric model increasingly powerful, simplifying assumptions, incorporating the asymmetry of the impact of the assets rate performance, separating volatility based on the trend in the short term. In 1987, Engle, Lilien and Robins proposed extending the classical GARCH model so that conditional volatility can generate a risk premium which should be incorporated in the expected return, and thus the GARCH variant in Mean appeared (GARCH -M).

The EGARCH (Exponential GARCH) model was devised by Nelson in 1991; in this model, specification of the conditional variant is done logarithmically, which means there is no constraint on estimates to avoid the negative variant (EGARCH is considered to be the best financial econometric model to determine the volatility of stock market indices and exchange rate). The typology of such models became more diversified every year: integrated GARCH (IGARCH-Integrated), followed by NAGARCH-Nonlinear Asymmetric GARCH, whose authors are Higgins & Bera (1992); GJR-GARCH, considered the most suitable GARCH model to explain and anticipate the indices of shares on financial markets, with the authors Glosten, Jagannathan and Runkle (1993); Treshold ARCH (TARCH), whose author was Zakoian (1994); QGARCH – Quadratic GARCH, devised by Sentana (1995); GARCH-X, proposed by Brenner, Harjes and Kroner (1996); fGARCH, or Family GARCH, devised by Hentschel (1997); Tobit-GARCH, devised almost simultaneously by Lee, Morgan and Trevor (1999), and improved by Wei (2002); Matrix EGARCH, authored by Kawakatsu (2006); FCGARCH (Flexible Coefficient GARCH), construed by Medeiros and Veiga (2008), etc.[6]

Interdisciplinarity is simultaneously a process of focusing or concentration on issues that are not only complex and global, but also placed at intersection points, at the border or in the interstitial spaces of several sciences or disciplines, but in this case, too, the interlocking of the methods and models, as well as the coordination of the research may end in adopting a common and general body of theory, methods and models, that is delineating a new field of knowledge or a new science. Interdisciplinarity proves relatively more innovative, heterogeneous, auxiliary, complementary and dissipative, but also unifying, apparently linear, but frequently structured and even restrictive, preserving the originality and creativity of sui generis scientific interrelation.

Multidisciplinarity involves simultaneous application of the thinking of several sciences, and also involves the study and research of a domain of reality being achieved from several angles, descended from the multiplied thinking of several sciences simultaneously. Both the researcher, and the researched area or the area of reality under multidisciplinary scrutiny, will ultimately be richer, depending on the outcome of the research. Multidisciplinarity, as a form of intertwining disciplines, consisting in the juxtaposition and additioning of certain elements of various disciplines, highlights their common issues, and entails a symmetrical communication between various specialists coming from different disciplines, who bring together their different way of thinking and turning to good account, their concepts or languages, methods or models, in their own axiometry. [2]

"*Simple or exaggerated multidisciplinarity does not mean mere juxtaposition or coexistence of several disciplines in the same area of reality, but rather a passage, through interdisciplinarity (permanent informational and methodological transfer from one discipline to another) to transdisciplinarity. Maximizing or to-the-extreme development of the trend of multidisciplinarity aims at the complete and complex dilatation of scientific knowledge, meaning a vast dissolving of sciences into a single one, a complex fusion into a huge single science or discipline*" [2].

"*Transdisciplinarity appears between disciplines (sciences), along them, and sometimes even over them*" [7], and is considered a superior final form of interdisciplinarity and even special kind of multidisciplinarity agreed and acquired as much as possible at the level of the individual researcher, which involves concepts, principles, language and finally even theory, in parallel with methods, methodology

and models, which tend to become universal, dynamically generated by the action of the many levels of reality (systems theory, information theory, theory of scientific modelling, etc.).

In my humble opinion transdisciplinarity [8] represents maximized interdisciplinary, but finally identifies itself with the *to-the-extreme* form of complex multidisciplinarity, defined as educational (academic) purposefulness, in the explosive sense of an ample dissolution of all disciplines or sciences into one, a complex fusion into a huge scientific universe (epistemological multiverse).

Transdisciplinarity as the future way of interaction of modern education and scientific research, and especially of the specific way of thinking, and finding adequate solutions to complex problems is able to induce formation trends and generate new real developments for the scientific research, with varying degrees of coverage with respect and appreciation to the methods or sciences origin [2, 9].

2. TRANSDISCIPLINARITY FROM THE FUTURE OF EDUCATION AND SCIENTIFIC RESEARCH

Both defining and understanding transdisciplinarity are the result of identifying and applying this concept in various educational and research contexts. The level of relevance of education in various fields is constantly correlated with the extent to which learning transcends the boundaries of disciplines or unidisciplinary messages as intrinsic processes of education to connect students and researchers and adapt to existing realities in the contemporary world all those who receive information [10].

A modern education and pragmatic research program will by definition be an exclusively transdisciplinary one, placed continuously in, between, but also over unidisciplinary investigative methods, shaped so as to solve pressing and complex real world problems and generate information and knowledge, even going to the point of identifying different perspectives on the world. In modern world, transdisciplinarity thus becomes the only viable solution to explore and process large amounts of data in a way that is closer to the holistic vision or approach, detailing the information layers and explaining their associations to a more and more complex reality.

A transdisciplinary research or investigation is often described as an innovative orientation, placed over a whole previous less uni-, and more and more inter- or even multidisciplinary universe. Continuity and creative approach can naturally transcend scientific research beyond the initial limits of standard unidisciplinary spaces, but also usually interdisciplinary and even those established as multidisciplinary. Transdisciplinarity is also conceptually replaced by the transcendence and comprehension of the investigation, the characteristic context and the frame of reference of these researches suddenly becoming ascendant. Intense relativization requires transdisciplinarity in research that requires a complex methodological set, as well as a major impact on the general level of scientific knowledge previous and especially of isolated or insufficiently intersected disciplines [11].

Transdisciplinarity is increasingly identified with the natural solution to the need for permanent change in the way of thinking of modern research and academic education, by trying to ensure scientific exhaustivity or academic comprehensibility, especially in an era of disciplinary big bang and excessive specialization and even manages to it confers "the long-sought harmonization of perceptible mentalities and intelligible knowledge" [12].

The term transdisciplinarity appeared relatively recently, being introduced, as such in scientific language, only in 1970, by the Swiss psychologist Jean Piaget [7; 13-17]. In 1972, in his essay entitled *Interdisciplinarity: Problems of teaching and research in universities*, Jean Piaget was the first to use the word transdisciplinarity in writing, defining "*a higher stage succeeding interdisciplinary relationships […] which would not only cover interactions or reciprocities between specialised research projects, but would place these relationships within a total system without any firm boundaries between disciplines*" [18].

After more than half a century, transdisciplinarity has remained a major educational goal, especially an academic one, but also an essential criterion of scientific research, outlining a synthesis of disciplines that ensure the highest level of complexity and abstraction, implicitly investigation, integrating and overcoming inter-, cross- and even multidisciplinarity [19]. In 1985, in the volume of Basarab Nicolescu, "*Nous, la particule et le monde,*" awarded by the French Academy, the author proposes from the perspective of quantum physics the unification of meanings between, inside and beyond by the prefix "*trans*" [20].

Everythind starts from the double and at the same time sad finding that sometimes the sum of all the competencies turns into an unwanted incompetence by a teacher or researcher, but also from the apparent impossibility of in-depth communication between the more and more numerous scientists of the Earth, so called experts of some disciplines, more heterogeneous.The generous intention to form academic and research teams can give rise to some of the most unexpected combinations, especially in complex situations, related to solving large-scale projects, for example bringing together physicists and neurophysiologists, mathematicians and poets, politicians and computer scientists etc. Basarab Nicolescu remains the one who stressed for the first time the major importance of transdisciplinarity in overcoming these obstacles, seemingly insurmountable for any of the neophytes of academic disciplinary language or terminology specific to excess research, in a world, where as he also noted ironically "we have all become neophytes of others" [21].

Epistemologically applied interdisciplinarity, but also the birth of new disciplines in various academic and research interstices, intensifies any type of knowledge, while crossdisciplinarity multiplies the area of disciplinary application of techniques and methods through creative methodological borrowing, and multidisciplinarity dilates the image or microscopic dilated image of the overall evolution, as well as of the understanding of the depth of the changes. Transdisciplinarity remains obsessed with its specific transposition: "at the same time placing itself between disciplines and within various disciplines and beyond any discipline." The finality of the transdisciplinary approach naturally becomes the understanding of the present world, and one of its major justifications is the complex unity of knowledge modern reality [22]. According to the classical educational approach, transdisciplinarity can be appreciated as being an absurdity, from a narrow unidisciplinary point of

view, not subject to a first practical investigation, and its form of scientific research becomes unreal, the cause being precisely the focus on ”concomitant action of several levels of reality, of the logic *tertium non datur* and of the complexity” [12].

In its essence, modern transdisciplinarity has no choice but to abdicate from the conventionalism of classical scientific investigation, proving clear intentions of non-discipline, through an inclusive and unconventional approach to modern education and scientific research. This is more like a disordered and chaotic symphony of methodological approaches specific to generalized or universal knowledge, able to describe an enigmatic, abyss-like investigative process, armed with a little more creative anticipation than usual, along with a more well positioned approach of the adaptive and receptive nature of the researcher in a constantly evolving scientific universe [23]. There are some relative similarities between transdisciplinarity and multidisciplinarity according to the overlapping characteristic approaches, caused by their declared intentions to wide more and more to cover the reality and the tendency towards the extended or with a higher degree of validity. One can find also significant differences, starting from the ontological structure and the definitive way to generate scientific information.

The correct positioning of the researcher in a specific trans- and multidisciplinary space gives him support and utility as long as he adopts inclusion as a research method and can naturally overcome unidisciplinary barriers, through complex adaptive efforts, focused on flexibility, creativity and interaction. Both the methodological incorporation process and the process of accepting the knowledge generated by other academic and scientific communities can show different characteristics in the usual case of transdisciplinarity from that of multidisciplinarity.

The persistence of validation processes, along with the longevity of scientific truths, clearly differentiates them, transdisciplinarity being relatively less exposed to methodological precariousness and relativization of technological evolution, compared to multidisciplinarity.

Similar to creative and complex approach of the profound poetry and higher mathematics, the uniqueness of transdisciplinary approach is conferred by the dominant creativity and the structured deepening of reality's problems and never by a simple improvisation or randomly validating circumstances. Thus any teacher or researcher that aspires to solve complex problems of reality can use the entire proccess of knowledge based on transdisciplinarity, the complex interaction incorporating unique changes on several levels, structures, themes, modeling, being guided by the transdisciplinary process, rather than by a complex research question as in the case of multidisciplinarity. Both types of multi- and transdisciplinary research are inclusive, but while multidisciplinary research is relatively stable as an investigative ensemble and methodological potential, the transdisciplinary research remains always complementary and evolving, constantly offering innovation, free thinking, aspiring to authenticity ...

Modern science foreshadows a growing appreciation of transdisciplinary education and research, both in the immediate future, both on medium and long term, beggining from the mere finding that these human activities succeed in the transdisciplinary context to identify a common group of axioms. in a continuous multiplication, for an ever-expanding set of disciplines, intensely capitalizing on a systemic logic but also a higher order synthesis of interdisciplinary relations. Thus the future can emphasize the accentuated superiority of transdisciplinary contributions, compared to inter- and even multidisciplinary. As Eric Jantsch, an Austrian astrophysicist, has pointed out transdisciplinarity has demonstrated its superiority since his terminological birth, in objective relationships that are found in reality and do not reside in deeds [24].

This has been and continues to be the major asset of transdisciplinary education and research, where scientific issues are meant to be more clearly defined, objective, static and neutral, to which the future will certainly amplify the unity of knowledge and research, focusing on the “imperative of disciplinary integration” is becoming more and more intense. Despite its growing popularity and prospects, transdisciplinarity is still far from being fully established academically and in line with current funding practices, which support it less effectively in universities and research institutions [25]

3. SOME FINAL REMARKS

This article’s essence is based on a specific approach, with the help the original vision of Basarab Nicolescu, a romanian physicist, who seems to have grown and thought in the beneficent shadow of the Anton Dumitriu, being strongly marked by the history of logic, and by Dan Barbilian's transcendency from poetry to mathematics with the help of the hermeticism of the same Ion Barbu, with his justified and inimitable poetics [26-29]

Inter-, multi-, and transdisciplinarity have become, in the current multiverse of modern education and scientific research, important processes with respect to their impact in the vast area of scientific thought, but also in their taxonomy, if we only mention the famous problem of circularity of formal systems, a problem that finds that the wish to express knowledge in a formal way is illusory and that there are, relatively simple assertions or theorems in the major formal logical systems or in the related systems, which cannot be solved in that system, as the respective assertions and theorems in the model analyzed are neither provable nor indemonstrable, such as Gödel's famous question [30].

Of all these currents that clearly challenge unidisciplinarity, transdisciplinarity dominates and even continually transcends all boundaries of academic disciplines to connect researchers, who have already accessed its advantages, to the complexity of modern reality and amplifies the importance of how concepts are integrated. theories and knowledge derived from different fields of investigation, pragmatic methods and highly appropriate tools. All this can provide answers to the expectations of different groups of economic and social actors, identifying synthetic solutions according to their own standards, in increasingly diverse problem areas such as migration, emerging technologies, public health, changes with global impact, etc.

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