Journal of APF Command and Staff College (2025), 8(1), 238-287

Understanding Disciplinarity and Transdisciplinarity

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DOI: https://doi.org/10.3126/japfcsc.v8i1.77609

Article History:
Received: 1 November 2024
Accepted: 11 March 2025
Published: 20 April 2025

Keywords:
Disciplinarity, transdisciplinarity, knowledge integration, boundary-work, real world problems

To cite this article:
Kunwar, R. R. & Ulak, N. (2025). Understanding disciplinarity and transdisciplinarity. *Journal of APF Command and Staff College, 8*(1), 238-287. https://doi.org/10.3126/japfcsc.v8i1.77609

To link to this article:
https://doi.org/10.3126/japfcsc.v8i1.77609

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Abstract

This paper aims to explore and understand disciplinarity and transdisciplinarity in the global context. Discipline refers to branches of knowledge emerged in between 1750-1850. It provides shared concepts and language, accreditation to practitioners within their fields and, importantly, the epistemological and ontological security. Three categories of traditional disciplines include the natural sciences, the social sciences, and the humanities. This study is based on a review of a number of key papers which were identified during a literature review on disciplinarity and transdisciplinarity. An effort has been made to explore how transdisciplinarity as an approach came into existence in the academia. The concepts that can be described as an alternative combinations of four characteristic features of transdisciplinarity, namely (a) to relate to socially relevant issues, (b) to transcend and integrate disciplinary paradigms, (c) to do participatory research and, (d) to search for a unity of knowledge. This study incorporates introduction, review of literature, methodology, transdisciplinarity, types of transdisciplinarity, two domains of transdisciplinarity studies, knowledge integration, transdisciplinary education, boundary-

work and border-work, hybridization, social engagement, tamed and wicked problems, real world problem, life-world problem, complexity of problems and conclusion.

Introduction

"Life is multiple disciplinary. Disciplines are the result of the artificial fragmentation of knowledge" (Choi & Pak, 2006, p.357; Miller,2016, p.36).

It is necessary to differentiate between 'studying' and 'understanding'. According to the Collins Paperback English Dictionary (1986), study means: "to investigate or examine, as by observation, research," etc.; whereas understand means: "to know and comprehend the nature or meaning of …" (pp. 860-943; in Du Plessis, 2015).

The origin of the word 'discipline' is insightful, deriving from a root that signifies a disciple or follower. The discipline controls. It quietly establishes a hierarchy within that reflects the hierarchy without (Goodrich, 2009, p.461). Disciplines are not static but are dynamic. In addition to competition between individuals seeking academic stardom, internal competition between subfields and competition between departments over students, resources, faculty lines, research funding programs, and space on campus generates pressure to innovate (Jacobs, 2017, p.36). Disciplines can be intellectually messy. They have roots in diverse intellectual traditions, complex internal structures and fuzzy boundaries (Jacobs, 2017, p.38).

The etymology of "discipline," rather than defining the term, reveals the historical proliferation of its meanings. The term "derives from an Indo-European root... for both the Greek pedagogic term *didasko* (teach) and the Latin *(di) disco* or *'discere'* (learn or to learn); and *disciplina* itself already has in classical Latin the double sense of knowledge (knowledge systems) and power (discipline of the child, military discipline)" (Hoskin & Macve, 1986, p.107; in Shumway & Messer-Davidow, 1991, p.202; Alvargonzález, 2011, pp. 1-2). In the English language, "discipline" was used in Chaucer's time (14th century) to refer to branches of knowledge, especially to medicine, law, and theology, the "higher faculties" of the new university (Shumway & Messer-Davidow, 1991).

Most of the scientists and scholars in 1970s were found deep concerned with humans' lives in one way or another. Their objective was to eliminate the ignorance and seeking for advancement of knowledge. He was Jürgen Habermas (1972; in Russell, 2010, p.31) who raised the question i.e. 'How is reliable knowledge possible?' The question was raised because the contemporary society was influenced by ignorance. Mahan (1970) distinguished two types of ignorance: one that comes from the lack of knowledge, a paucity of riches that exists both at the social and individual level and another comes from embarrassment of riches whose application of knowledge is thwarted. This type of ignorance is characterized

by the expression: “we know more and more about less and less”. The removal of ignorance surrounding these human problems seems to require not only discovery of new knowledge but also synthesis of knowledge (Mahan, 1970). Such quest of knowledge gave birth to alternative disciplines.

The term *discipline* refers to a particular branch of learning or body of knowledge (Shumway & Messer-Davidow, 1991; Choi & Pak, 2006; Areekkuzhiyil, 2017; Repko, 2012, p.4; Tribe, 2000, p.810; Kunwar, 2018, p.127). Examples of a discipline include anthropology, architecture, biology, economics, engineering, history, science, and theology. Disciplines have contrasting substance and syntax, ways of organizing themselves and of defining rules for making arguments and claims that others will warrant. They have different ways of talking about themselves and about the problems, topics, and issues that constitute their subject matters (Schulman, 2002; in Areekkuzhiyil, 2017). Mary Taylor Huber and Sherwyn P. Morreale (2002; in Areekkuzhiyil, 2017) remarked that ‘each discipline has its own intellectual history, agreements, and disputes about subject matter and methods and its own community of scholars interested in teaching and learning in that field. Each discipline has its own defining elements phenomena, assumptions, epistemology, concepts, theories, and methods that distinguish it from other disciplines. A discipline defines boundaries and establishes the structure for knowledge (Oloruntimilehin, 2020).

As per the Oxford English Dictionary, “discipline” pertained to the disciple or scholar, while “doctrine” was the property of the doctor or teacher. As a result, “discipline” has been associated with practice or exercise and “doctrine” with abstract theory. Given this opposition, we can see why “discipline” might have been chosen to describe the new science based on empirical methods and claiming objectivity. To call a field as “discipline” is to suggest that it is not dependent on mere doctrine and that its authority does not derive from the writings of an individual or a school, but rather from generally accepted methods and truths. “Discipline” also referred to the “rule” of monasteries and later to the methods of training used in armies and schools. The concatenation of these two senses suggests that to be trained in a branch of knowledge is to be disciplined and ultimately to attain discipline, which is believed to be the quality of self-mastery (Shumway & Messer-Davidow, 1991).

The American Association for Higher Education and Accreditation (AAHEA) mentions that disciplines have contrasting substance and syntax...ways of organizing themselves and of defining rules for making arguments and claims that others will warrant. They have different ways of talking about themselves and about the problems, topics, and issues that constitute their subject matters (Schulman, 2002, pp. vi-vii; in Repko, 2012).

According to Jacobs (2017), the term discipline is a self-regulating body of researchers and scholars based in a university. In the liberal arts context, a discipline refers to fields in which there is a department, a major, and a doctoral degree. A field may be regarded as a discipline when professors with specified credentials are typically hired to conduct research and teach students in a particular domain (Jacobs, 2017).

Jacobs's (2017) question follows why do disciplines exist? The answer is disciplines are an organizational manifestation of the need for an academic division of labor. There are currently over 30,000 academic journals that employ peer review, and this total is growing by about 3% annually due to the creation of online journals and publications based in countries striving to join the international research community (author's analysis of Ulrich Periodical data). There is thus a need to divide the intellectual terrain into fields of inquiry, even while practitioners know full well that extant dividing lines are fuzzy and sometimes arbitrary. Jacobs (2017), in the same line, talks about the importance of the Journal of Economic Literature classification system that divides economics into 20 general categories, which in turn contain over 134 divisions and 811 areas of specialization (American Economic Association, 2015).

Michael Foucault (1984:118; in Peters & Appel, 1996, p.133) formulated disciplines as the principle of limitation and defined it as "a domain of objects, a set of methods, a corpus of propositions considered to be true, a play of rules and definitions, of techniques and instruments, which together decides what each discipline within its own limits recognizes as true and false".

Volgger and Pechlaner (2015, p.86; in Kunwar, 2018), categorized a discipline by the following criteria: (1) a web of interrelated concepts; (2) a particular logic structure that blinds the concepts; (3) testability within this web using its particular criteria and logical structure; (4) irreducibility to other disciplines. According to similar approaches, disciplines consist of webs of constructs (theories), methods (ways of producing and testing knowledge), and aims of application domains (Volgger & Pechlaner, 2015, p.86; Kunwar, 2018). Some authors additionally request the existence of a dedicated community, means of communication (such as journals), tradition and a set of values (King & Brownell, 1966; in Volgger, & Pechlaner, 2015). Disciplines shape scientific research (field of inquiry) by forming the primary institutional and cognitive units in academia, on which the internal differentiation of science into specialized curricula, professions and research is based (Stichweh, 1992; in Hirsch Hadorn et al., 2008, p.27). Members of a discipline are specialists who build a scientific community (Kuhn, 1963; in Hirsch Hadorn et al., 2008).

Disciplines provide scientists with frame of references, methodological approaches, topics of study, theoretical canons, and technologies (Petts, Owens, & Bulkeley, 2008; in Stock & Burton, 2011, p.1091). In addition, they provide shared concepts and language, accreditation to practitioners within their fields (i.e., recognition of competence by others within the shared institution), and importantly, the epistemological and ontological security that is required to progress science without constantly having to question the nature of science itself (Stock & Burton, 2011; Klein, 2008, p.121).

Mary Taylor Huber and Sherwyn P. Morreale (2002) add that "each discipline has its own intellectual history, agreements, and disputes about subject matter and methods" and its own "community of scholars interested in teaching and learning in that field" (p.2; in Repko, 2012). Disciplines are also distinguished from one another by several factors. These include the questions disciplines ask about the world, their perspective or worldview, the set of assumptions they employ, and the methods they use to build up a body of knowledge (facts, concepts, theories) around a certain subject matter (Newell & Green, 1982, p.25; in Repko, 2012).

Bardecki (2019) mentions that the "confusion and inconsistency over the use of the terminology has tended to hinder the development of a common understanding and usage". The distinction between these expressions is often unclear–terms are often undefined and/ or used with dramatically different meanings. In some circumstances, they are used as synonyms, whereas elsewhere significant efforts are made to differentiate their meanings. These issues occur broadly across academic writing in all disciplines (Bardecki, 2019).

The early universities such as Salerno, Bologna of Italy and Oxford and Cambridge of England, started with Faculties of Medicine, Philosophy, Theology, and Law. It was around these four areas that the totality of knowledge was contained. In fact, academics were versatile and omniscient, legitimate forerunners of the renaissance (the revival of European art and literature under the influence of classical models in the 15^{th}-16^{th} centuries, Wikipedia) thinkers and creators (Schulz, n.d.; Max-Neef, 2005, p.6). With the passing of time, faculties became more and more specialized. Thus arose and multiplied disciplines and sub-disciplines. According to Schulz (n.d.), there were already 1100 known scientific disciplines around 1950s, without including the humanities mentioned in a book published by University of Illinois (Max-Neef, 2005).

The association between disciplines, departments and institutes is a relatively modern phenomenon that begins to consolidate itself at the end of the XIX century. The history of academia shows that a disciplinary field is itself still in constant transformation, including specialization, differentiation, professionalization, disciplinarization and

academization (Blanckaert, 1993; Hofstetter & Schneuwly, 1998; Mucchielli, 1998; in Hofstetter, 2012) that have renewed its objects, methods and approaches, its relationship to other fields and its social and institutional context. It observes the actors at work, actors whose profiles, actions and networks are hybrid (Hofstetter, 2012). Godin (1998; Hessels & van Lente, 2008, p.751) criticizes the dichotomy between disciplinary research and interdisciplinary research. According to Godin (1998; Hessels & van Lente, 2008), the development of disciplines with specializations and hybrid formations is typical of any scientific practice. Knowledge production never occurs in isolation; it always involves the employment of elements from other disciplines. Whereas McGregor (2015) argues that disciplinary science isolates disciplines from each other and isolates them from their environments (McGregor, 2015, p.18). The breaking up of knowledge into separate disciplines "prevents (knowledge) from linking the contextualizing" (Morin, 2006, p.14; in McGregor, 2015). To offset this effect, he urges us to "recognize the inseparability of the separable" (p.16; in McGregor, 2015).

As Hofstetter (2012) stated, the disciplinary field never ceases to evolve: the boundaries are moving between researchers and practitioners, between scientific research and educational and even internationalist militancy, between science and policy, between different disciplines. Today, disciplinary studies have gained momentum in recognizing the shift from "internationality to internationalism" (Hofstetter, 2012, p.322) in the field of knowledge production. The most important role for knowledge production is played by universities and departments including faculty members and researchers who are likely to suggest solutions for solving the problems faced by the individuals, communities, nations and, world. The term studies as mentioned above are plural because of the idea of interaction between disciplines (Klein, 1996, p.10; in Repko, 2012, p.11).

Academic disciplines are scholarly communities that specify which phenomenon to study, advance certain central concepts and organizing theories, embrace certain methods of investigation, provide forums for sharing research and insights, and offer career paths for scholars. It is through their power over careers that disciplines are able to maintain these strong preferences (Repko, 2012, p.4).

Discipline, according to Carter (2007; in Munar, Pernecky, & Feighery, 2016, p.344), the academic discipline emerged in between 1750-1850. Each scientific discipline came to be regarded as a distinctive field of experience, inquiry and practice sustained by regulatory systems that identify and authorize the statements which comprise its domain of expertise and legitimize its practitioners (Holmes, 2001, p.232; in Munar et al., 2016).

As far as disciplinary is concerned, Darbellay (2020) mentions that any discipline is characterized by an institutionalization/standardization of research and teaching practices in a given scientific community, socially and historically located and governed by a paradigm that defines the assumptions and the objectives of knowledge to be built. Discipline therefore implies the institutional juxtaposition of several communities of specialists, divided into as many faculties, departments and autonomous laboratories (p.237).

According to Repko (2012, p.5; Repko & Szostak, 2017, p.44), there are three broad categories of traditional disciplines and they are: *the natural sciences* tell us what the world is made of, describe how and what it is made of, structure into a complex network of interdependent systems, and explain the behavior of a given localized system; *the social sciences* seek to explain the human world and figure out how to predict and improve it; and *the humanities* express human aspirations, interpret and assess human achievements and experience, and seek layers of meaning and richness of detail in written texts, artifacts, and cultural practices.

Applied and professional fields also occupy a prominent place in the modern academy. These include business and its many fields such as finance, marketing and management, communications (and its various subfields including advertising, speech, and journalism) criminal justice and criminology, education, engineering, law, medicine, nursing, and social work (Note: many of these applied and professional fields claim disciplinary status) (Repko, 2012, pp. 5-6).

Oloruntimilehin (2020) discussed the various disciplines that are available today that were not in existence in the past. The whole sum of knowledge was considered as a single unit; however, this sum of knowledge was classified into different disciplines over some time for different reasons and this classification is continuous and still ongoing. However, in many discussions, disciplines are still treated critically as monolithic constructs also called mono-discipline (single discipline and oldest discipline) (Klein, 2008, p.121). The evolutionary process [according to Repko and Szostak (2017, p.23), the term process is used rather than method. Process allows for greater flexibility and reflexivity, particularly when working in the humanities] of disciplines as per Oloruntimilehin (2020) might have gone through the following phases: knowledge accumulation, specialization and fragmentation of knowledge, formation of novel disciplines, diversification and further specialization of knowledge within the discipline, and formation of new disciplines, breaking of disciplinary boundaries, and emergence of more specialized new disciplines.

They are Lawrence, Williams, Nanz, and Renn (2022, p.46) who highlighted that 54 disciplines existed in the year 1950 and more than 8,000 disciplines in the year

2000 (Lawrence et al., 2022; Nicolescu, 2014, p.21). In the course of doing disciplinary research, scholars like Bardecki (2019, p.1180) have identified twelve disciplinaries-multidisciplinary, interdisciplinary, disciplinary, transdisciplinary, cross-disciplinary, intradisciplinary, subdisciplinary, postdisciplinary, unidisciplinary, pluridisciplinary, extradisciplinary, and metadisciplinary. It is Darbellay (2020, p.236) who has mentioned hyperdisciplinarity as coined by Jantsch (1972), ulterdisciplinarity, paradisicplinarity, and supradisicplinarity. Pickering (1993), Vickers (1998), and Repko (2012) have identified antidiscipline (Pickering, 1993; Vickers, 1998), and Kelly (2007), and Veiga (2020) have used indiscipline in their studies.

However, two different disciplines are frequently used in the disciplinarity studies; they are crossdiscipline and postdiscipline. Crossdisciplinary refers to research and creative practices that involve two or more academic disciplines working together. This encompasses multi-, inter-, and transdisciplinarity (Oloruntimilehin, 2020). The benefits of cross-disciplinary research are widely acknowledged in a variety of disciplines, linking it with innovation, creative problem-solving, new meanings, and the ability to advance knowledge with intellectual breakthroughs (Aboelela, Larson, Bakken, Carrasquillo, Formicola, Glied, Haas, & Gebbie, 2007; Carayol & Thi, 2005; Choi & Pak, 2006; Morillo et al., 2003; Rafols et al., 2012; in Dellaportas, Xu, & Yang, 2020, p.1). According to Dellaportas et al. (2020),

> …cross-disciplinary research is more than bringing together theories or concepts from distinct disciplines but is constructed on two key dimensions: the 'integration' dimension (theories and methods) and the 'interaction' dimension (people and disciplines), in which scholars from unrelated disciplines work together to create epistemological shifts. Svedin et al. (1999; in Aagaard-Hansen, 2007) point out terminology as an important element of assessing cross-disciplinary projects.

The next most frequently used disciplinary type is postdiscipline. The term postdiscipline (Munar et al., 2016; Pernecky, 2020) is derived from prefix: from the Latin 'post-', expressing and after, not only in space or time but also in some other way a different new. Without making any value judgment on these approaches, the 'post-'particle evokes its use in the notion of 'postmodernism' and 'post-normal science' (Funtowicz & Ravetz, 1993; Darbellay, 2020, p.240). Pernecky's edited book *Postdisciplinary Knowledge* (2020) (Part-1-3) includes "Being, Thinking, Doing", "Doing, Thinking, Being", "Thinking, Being, Doing", " Making, Remaking, Demaking"(pp. 16-17).

Choi and Pak suggest that the phrase "multiple disciplinary" be used as a general term "for when the nature of involvement of multiple disciplines is unknown or unspecified" (2006). The term pluridisciplinary is substituted for multiple disciplinary to

avoid confusing multiple disciplinary and multidisciplinary, which represent two distinct forms of team members' engagement and interaction. Pluridisciplinary serves not only as a general term, but also as a rubric under which three forms or stages of teaming-multi, inter-, and transdisciplinary- are encompassed (p.351)

Many of the methodological and epistemological differences are expressed in different terms. In the cases where there are distinct jargons, this may pose an additional hurdle to overcome. More subtly, however, there are sometimes varying meanings of the same terms within different disciplinary discourses (Aagaard-Hansen, 2007).

Though the study focuses mainly on transdisciplinarity, multidisciplinarity, and interdisciplinarity have been briefly described and followed the differences between three different disciplines. Multidisciplinarity and interdisciplinarity have this in common: they seek to overcome disciplinary monism (Repko, 2012, p.19). The key concepts that stand out are multidisciplinarity, interdisciplinarity, and transdisciplinarity (Darbellay, 2005; Huutoniemy, Thompson Klein, Bruunc, and Hukkinena, 2010; Piaget, 1972; in Darbellay, 2020, p.236).

There are many scholars (Darbellay, 2005; Huutoniemy, Thompson Klein, Bruunc & Hukkinena, 2010; Mahan, 1970; Jantsch, 1972; Piaget, 1972; in Darbellay, 2020, p.236) who have recognized the key concepts that stand out are multidisciplinarity, interdisciplinarity, and transdisciplinarity. In the process of defining the key concepts of disciplinary studies, Trees, Trees and Fry (2005a; in Stock & Burton, 2011) proposed such terminologies under the umbrella of integrated research is used to define the concept, including collaborative, integral, integrated, complementary, combined, participatory, transepistemic, system-oriented, transprofessional, comprehensive, problem-oriented, cross-boundary, holistic, multidisciplinary, cross-disciplinary, interdisciplinary, and transdisciplinary (p.3). The terminologies as proposed by Trees et al. (2005a; in Stock & Burton, 2011) are widely acceptable concepts and it attempts to clarify the scope of integrated research.

The following key concepts of disciplinarity as cited by Parker (2016, p.3) and Repko (2008, pp. 171-178) are: Multidisciplinarity studies a topic from the perspective of several disciplines at one time but makes no attempt to integrate their insights. Multidisciplinary approaches tend to be dominated by the method and theory preferred by the home discipline (Parker, 2016). Interdisciplinarity studies a complex problem by drawing on disciplinary insights (and sometimes stakeholder views) and integrating them. By employing a research process that subsumes the methods of the relevant disciplines, interdisciplinary work does not privilege any particular disciplinary method or theory (Parker, 2016). Transdisciplinarity concerns that which is at once *between* the disciplines, *across* different disciplines, and

beyond all disciplines. Its goal is (a) the understanding of the present world, of which one of the imperatives is the unity of knowledge, and (b) the solution of mega and complex problems by drawing on and seeking to integrate disciplinary and *stakeholder views* on the basis of some overarching theory (Parker, 2016).

Although the terms multidisciplinary, interdisciplinary, and transdisciplinary are often used interchangeably, it is worth establishing, as clearly as possible, some differences in meaning. In order to establish and clarify these differences, the meaning of the prefixes 'multi', 'inter' and 'trans', when applied to the abstract noun 'disciplinarity'. The words disciplinary and disciplinarity are interchangeably used; however, disciplinarity should be understood as an abstract noun (Alvargonzález, 2011, pp. 1-3).

The study of Alvargonzález (2011) shows that the prefix 'multi', from the Latin *multus*, means 'many' ('multimillion'), 'much', 'multiple' or 'more than one' ('*multiparous*'). So, multidisciplinarity refers to an activity associated with many, multiple, or more than one existing discipline. The Latin prefix '*inter*' means 'among', as in the word 'international', or 'together', 'mutually' or 'reciprocally', as in the word 'interchange'. The Latin prefix '*trans*' means 'across', 'beyond' (as in 'transoceanic' or 'transilient'), 'transcending' (as in 'transubstantiation'), 'through' (as in 'transpiration') and 'change' (for instance as in 'transliterate') (Alvargonzález, 2011), 'on the far side of' (Choi & Pak, 2006).

More than 25 years ago, Hattery (1979; in Porter, Roessner, Cohen, & Perreault, 2006) observed that "interdisciplinary research has taken on continuously greater significance, as a function of the complexity of societal and scientific problems insoluble by single disciplines and single experts". A few years later, Klein (1986; in Porter et al., 2006) stated that "interdisciplinarity is an old concept, based as it is on such long-expressed values as integration, synthesis, the unity of knowledge, and a community of scholars". Boix Mansilla (2005) defined the goal of interdisciplinary understanding as:

> The capacity to integrate knowledge and modes of thinking in two or more disciplines to produce a cognitive advancement—e.g., explaining a phenomenon, solving a problem, creating a product, raising a new question—in ways that would have been unlikely through single disciplinary means (p.4; in Dezure, 2017, p.559).

Klein (1986; in Porter et al., 2006) noted that there are many interdisciplinary varieties, including general undergraduate education (core curricula), graduate education (particular interdisciplinary topics such as systems theory), professional training in integrative vocational contexts (medical school), and interdisciplinary fields of study (women's studies). According to Bernstein (2015), education itself, as a field that brings

together all other subjects in the context of organized teaching and learning, must also come into play in such a project.

In the research arena, interdisciplinary could pertain to problem-oriented studies (environmental remediation), research centers (materials science), or new fields (highly specialized—immunopharmacology, or quite broad—biochemistry). Professional attention to Interdisciplinary Research (IDR) arose in the 1970s and flourished into the 1980s. As Graff (2015; in Jacobs, 2017) has shown, the interdisciplinary roots of disciplines are evident in the formation of fields spanning the natural sciences, social sciences, and humanities (Jacobs, 2017). The emergence of the social sciences during the 19th and first half of the 20th century was influenced by the serious problems experienced by the country workers and the industrial working class due to major economic, social, and political transformations (Hirsch Hadorn et al., 2008, p.22). To deal with those problems, interdisciplinary studies seems to be a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession… (Klein & Newell, 1997, pp. 393-394; in Zalanga, 2009, p.58).

In the 1950s seem to have been a time of retreat for interdisciplinarity. Elizabeth Bott (2010) remarked that:

> Ten years ago, interdisciplinary research was very much in vogue. But now its value is often questioned, partly because it has proved difficult to coordinate interdisciplinary group projects, partly because such projects have not always produced the spectacular integration of results that was expected. Speaking of her own experience, both went on to remark that interdisciplinary integration did not come in the overall results. Further discussion will be followed. We have to know about the ethnocentrism of disciplines…and fractal distinction (p.35).

Nissani (1995; Austin, Park, & Goble, 2008, p.561) has offered four criteria to rank interdisciplinary richness: number of disciplines involved, distance between them, novelty and creativity involved in combining disciplinary elements, and degree of integration. Interdisciplines are conceptualized as hybridized knowledge fields situated between and existing disciplines (Frickel, 2004, p.369; in Tanweer & Steinhoff, 2023, p.138) that share a common objective of study (Darbellay, 2015, p.166; in Tanweer & Steinhoff, 2023).The distinction between interdisciplinary and transdisciplinary is the integration of knowledge and unity of knowledge.

Nissani (1995) in an attempt to make clear that three disciplines (monodiscipline or unidiscipline, multidiscipline, and interdiscipline) are different in their nature. Accordingly,

he develops a concept of 'salad'. Here in this context, fruit (apple, mango, orange, etc.) may be served alone (disciplinary), in a fruit salad (multidisciplinary), or blended as a smoothie (interdisciplinary). Repko (2012, p.17) expanded the concept that the smoothie, the metaphor of the smoothie, while limited, illustrates four essential characteristics of interdisciplinary studies: the selection of fruits (i.e., the disciplines and their insights) is not random but purposeful with the end product clearly in view; the blending of fruits (i.e., the process of integration) changes the contribution of each fruit (i.e., disciplinary insight) (Newwell, 1998, pp. 547-548; Repko, 2012, p.17); the smoothie (i.e., the result of integration), compared to the ingredients used, is something new; and the activity involved in creating the smoothie (i.e., the interdisciplinary process) is limited in time and space to the research problem (Repko, 2012).

Extending this metaphor to transdisciplinarity, one might imagine using the smoothie as the basis for the new dessert (Austin et al., 2008). This concept has been adopted by scholars like Choi and Pak (2006, pp. 359-360) and Scmalz, Janke, and Payne (2019, p.391). In considering the three definitions and their respective purposes, Choi and Pak (2006) and Schmalz et al. (2019) further described the differences using food as an analogy. In this instance, they likened multidisciplinarity to a salad (where different foods come together but maintain distinct identity), interdisciplinarity to a melting pot like a stew (where components are married to create something different but individual ingredients are still identifiable), and transdisciplinarity to a cake (where ingredients are combined, but the final product is something completely new and the ingredients are, for the most part, indistinguishable).

While clarifying the differences between disciplinarity, multidiscipline, interdiscipline, and transdiscipline, Max-Neef (2005) states that disciplinarity is featured by specialization in isolation. According to Choi and Pak (2006) and Miller (2016, p.39), multidisciplinary is attributed to additive that draws on multiple disciplines but stays within disciplinary boundaries; interdisciplinary is attributed to integrative that analyzes, synthesizes, harmonizes links into a coordinated coherent whole; and transdisciplinary is attributed to holistic/transcendent that subordinates disciplines, looks at the dynamics of the whole system. In the same line, Klein (2017, p.22) has also distinguished between the the aforementioned three disciplinarities. Accordingly, Klein (2017) focuses on multidisciplinarity characterized by juxtaposing, sequencing, and coordinating meaning 'no cooperation' (Max-Neef, 2005); interdisciplinarity focuses on interacting, integrating, focusing, blending, and linking, meaning 'coordination from higher-level concepts' (Max-Neef, 2005), 'communication and collaboration across academic disciplines' (Jacobs & Frickel, 2009; p.44; in Tanweer & Steinhoff, 2024, p.137); and transdisciplinarity is

attributed to transcending, transgressing, and transforming. In a nutshell, Darbellay (2020, p.237) distinguishes between interdisciplinary and transdisciplinary which focus on 'what is between' and 'what is beyond,' respectively. Likewise, transdisciplinary research occurs when the collaborative process is taken one step further, often spontaneously emerging from interdisciplinary research when discipline-transcending concepts, terminology, and methods evolve to create a higher-level framework and a fundamental epistemological shift occurs (Max-Neef, 2005; Giri, 2002; in Austin et al., 2008). This step requires mutual interpretation of disciplinary knowledge (Gibbons, Limoges, Nowotny, Schwartzman, Scott, & Trow, 1994; Austin et al., 2008) and a coherent reconfiguration of the situation.

Klein (1990; pp. 40–48; in Yazici, 2016) explains interdisciplinarity means the overt or covert interaction of disciplines to enrich and change their theoretical frameworks in the face of the complexity of questions. However, transdisciplinarity means the overt interaction of disciplines for humanitarian ends. Accordingly, it can be claimed that both approaches are integrative, but their goals are different from each other (Yazici, 2016, p.223).

The discourse of transdisciplinarity in the twenty-first century has opened up to consider more intersubjective, participatory, and subjective approaches, from qualitative, participatory and subjective approaches, from qualitative, ethnographic, and action research to personal anecdotes, refection, narrative studies and in the case of Montuori (2008, 2012a, 2013), autoethnography (self-theory practice) and personal history (Augsburg, 2014, p.244).

Both disciplinarity and transdisciplinarity has been studied by many different scholars of different disciplines globally. The question arises that what is disciplinarity and transdisciplinarity in general? How disciplinarity could be understood as the new knowledge production in the academia? The main objective of this study is to understand disciplinarity and transdisciplinarity in better way through the excavation of available literatures to grasp the knowledge found in global brain. It is firmly believed that the outcome of this study will be useful to the policy makers, researchers, academics, government, planners, organizations and students. This study includes introduction, review of literature, methodology, transdisciplinarity, types of transdisciplinarity, two domains of transdisciplinarity studies, knowledge integration, transdisciplinary education, boundary-work and border-work, hybridization, social engagement, tamed and wicked problems, real world problem, life-world problem, complexity of problems and conclusion. The whole sub-headings after methodology are included under the umbrella of review of literature. The authors were highly inspired to work on this subject through the study of Mode 2 and

transdisciplinary approach developed by Gibbons et al. (1994; Kunwar, 2018; Kunwar & Ulak, 2023, 2024).

Review of Literature

The term review is used to refer to the whole process of bringing together a body of evidence (literature) that can be drawn from research and other sources (Mays, Pope, & Popay, 2005, p.7). An effective and well-conducted review of research methods creates a firm foundation for advancing knowledge and facilitating theory development (Webster & Watson, 2002; in Snyder, 2019, p.333). It can also help to provide an overview of areas in which the research is disparate and interdisciplinary. In addition, a literature review is an excellent way of synthesizing research findings to show evidence on a meta-level and to uncover areas in which more research is needed (Snyder, 2019). In this study, the present authors adopted narrative review which is unsystematic in its nature and has no specified search strategy or specific protocol as such; only a topic of interest has been overviewed. Therefore, this is a simple review paper that tries to explore disciplinarity and transdisciplinarity domains. The researchers, however, made attempts to review important literature based on knowledge, theory, and paradigms (Kuhnian model) within the framework of a review of literature. A review article can serve as a platform for future research (Paul & Criado, 2020).

"Science as prediction has been distinguished from science as observation here because public policy generally demands from science prediction rather than observation. And since science is generally less proficient in predicting than it is in observing, public policy often asks of science more than science can give" (Weinberg, 1977, p.349). Probably the best-known, simple and the short definition of public policy has been offered by Thomas Dye (1972), 'anything a government chooses to do or not to do' (p.2; in Howlett & Cashore, 2014, p.17).

According to Pohl, Truffer, and Hirsch Hadorn (2017, p.321), from 1966 until 2014, 450 publications on the transdisciplinarity topic have been traced so far. The search on this was performed through Web of Science on January 16, 2015 (http://www.transdisciplinarity.ch/en/td-net/Literatur/Publicationsradar.html).

Mahan (1970) goes further than Jantsch (1972), whom he does not cite, criticizing both the compartmentalization of the traditional disciplines and ideals of detachment and aloofness associated with disciplinary inquiry. Mahan's study of the literature in the philosophy of the social sciences indicates that although transdisciplinarity may have been a new term, the concerns giving rise to such a notion were already present as undercurrents in the writings of the mid-twentieth century scholars he cites. Although he does not provide

a concise definition of transdisciplinarity, the following gives a sense of what he thinks it means and how it can improve the quality of academic work (Mahan, 1970, pp. 194-195; in Bernstein, 2015).

While reviewing transdisciplinarity, Bernstein (2015) comments that the need for transdisciplinary research to integrate knowledge has frequently been mentioned as a goal by those developing theory in this area. In this regard, Burger and Kamber (2003; in Bernstein, 2015) write of the integration of knowledge at the problem level, the research level, and the solution level. Given the highly abstract level of these discussions, it is hard to know how such integration of knowledge would work in practice (p.11).

As far as trasndisciplinarity is concerned, there has been studies made by important thinkers, especially in recent years (Gibbs, 2015; Hirsch Hadorn et al., 2008; Klein, 2008; Leavy, 2011; Nicolescu, 2002; in Mylonakou-Keke, 2015, p.1891), thinkers who come from various disciplines. These studies have contributed significantly to the theoretical foundation of transdisciplinarity, its epistemological and methodological dimensions, its research potential, and its practical applications (Mylonakou-Keke, 2015) that is connected to the key objective of the transdisciplinary research integrating scientific and experiential knowledge, which is based on the concept "science with society" (khokhobaia, 2018).

There is a shifting knowledge context in contemporary society that implies changing roles of certain educational institutions such as universities (Apostel et al., 1972; in Alvargonzález, 2011, p.22). Certain authors suppose that, to respond to new educative demands, transdisciplinarity has a wide potential: it includes problem focus, evolving methodology, and collaboration between different people and institutions. The triple helix relationship, university-industry-government, is an example of a new collaboration framework between institutions (Etzkowitz et al., 1997; Russell et al., 2008; Alvargonzález, 2011; Kunwar & Ulak, 2023, 2024). As somebody has said, 'The world has problems, but universities have departments'. Hence, universities have to evolve and adapt to new requirements (Brewer, 1999, pp. 329-332; Pohl, 2010, p.66; Alvargonzález, 2011, p.22).

The transdisciplinary approach is a versatile approach that can be applied to any field of study (Sharia & Sitchinava, 2023). Transdisciplinary approaches are recognized as effective methods of studying complex issues in modern scientific and educational fields. A specific research design can be selected based on the specifics of a particular research issue in different disciplines. This approach is close to the following concepts: case study, citizen science, cooperative education, critical thinking, design thinking, sustainable development, indigenous knowledge, knowledge transfer, learning in transformation, participatory action research, performative knowledge, real-world lab, research integrity, research-based education, science communication and so on (Khokhobaia, 2018).

They were Pohl and Hirsch Hadorn (2008, p.112) who used a term problem field in transdisciplinarity research and a starting point for transdisciplinary research which is socially relevant. Augusburg (2014) mentions that transdisciplinarity as a research approach addresses complex societal problems such as those related to sustainability. Sustainability as a popular model has become a part of transdisciplinary studies too. Brandt, Ernst and Gralla et al. (2013) identified five key challenges to undertaking transdisciplinary approaches to sustainability science: 1) lack of coherent framing; 2) integration of methods; 3) research process and knowledge production; 4) practitioners' engagement; and 5) generating impact (p.1).

Transdisciplinarity offers a different philosophy and approach, both of how to effectively address issues/problems and how to improve and change difficult situations that have been experienced in the modern world, in different and multiple levels of reality and under conditions of complexity and uncertainty. Addressing these problems, transdisciplinarity achieves dynamic collaboration and integration of disciplines, epistemologies, and methodologies (Mylonakau-Keke, 2015). Recently, Mylonakau-Keke published an article shortly entitled "The Emergence of Syn-epistemic Wholeness"…(2015, pp. 1890-1907), in which dialectic synergy and Syn-epistemic concept are highlighted in the context of studying transdisciplinary research proposing Syn-epistemic as an alternative to transdisciplinarity.

The word 'Synergy' is comprised of the concepts of: harmonious collaboration, mutuality, coordination of synchronization, common interest, and dynamic state. The dialectic synergy involves the dynamics among continuous interactions and collaborations among situations, such as Functional interaction, Ongoing feedback, Mutual reinforcement, Co-creation, Collaborative action and "Co-evolution" (Co-development). The dialectic synergies taking place in the Transdisciplinary Social Pedagogic Model result in Syn-epistemic Wholeness. This term consists of: (a) the compound word "Syn-epistemic", whose prefix syn [a Greek preposition meaning "along with" and is mainly used as a first component of compound words ('synthesis'-according to Mays et al. (2005), the term synthesis is used to refer to the stage of a review when the evidence extracted from the individual sources is brought together in some way.)] and the adjective epistemic, [the Greek adjective epistēmikós derives from the Greek word epistḗm(ē): knowledge, science], thus relating knowledge to science; and (b) the noun wholeness, which means an entirety, a whole which, according to ancient Greek philosopher Aristotle "the whole is greater than the sum of the parts" (Metaphysics) (Mylonakou-Keke, 2015, p.1902).

Such a focus on reconceptualizing knowledge for the age of global markets, especially in terms of how it is produced, including that of Gibbons et al. (1994), is strengthened

by recent statements that a new post-epistemological conceptual framework is needed to understand knowledge since the conditions taken for granted by traditional epistemologists no longer apply to today's networked, globalized, postmodern, neoliberal environment (Allen, 2004, Harris, 2009, Weinberger, 2011). Post-epistemology and transdisciplinarity share several characteristics, according to López-Huertas (in Bernstein, 2015, p.12): a) sensitivity to social demands and social welfare; b) the resurrection of the subject as a reaction to . . . classical ideas about it and about knowledge (a reification of the subject and knowledge); and c) the criticism of . . . how nature and reality are conceptualized. (López-Huertas, 2013, p.403; in Bernstein, 2015).

Recently, Pechlaner and Philipp (2024) have focused on wicked problems through integrated policy-making approach where a variety of global developments, crises and trends keep having massive impacts on our world- not only, but particularly since the beginning of the 21st century (Hill & Prossek, 2012; in Pechlaner & Philipp, 2024, p.288). Climate change, poverty, health, migration, security, technological developments, and digitalization are the discussions about the role of artificial intelligence as a current peak- diverse topics and contexts that are often summarized under the same concise term: global megatrends. Global megatrends are complex dynamics of change that describe the development and change of the world and have impacts on society, science, economy, and politics (Petersen, 2022; in Pechlaner & Philipp, 2024). As a result, wicked problems are created in different areas and contexts. Wicked problems are now lively discussed in a wide range of economic sectors, academic disciplines, and political domains (Head, 2022; Pechlaner & Philipp, 2024).

Overall, the study connects to the terms 'strategic research' and 'strategic science' that appear in a variety of sources. This is very closely related to policy study (Irvine & Martin, 1984; in Hessels & van Lente, 2008) and the strategic research is defined as: 'basic research carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognized current or future practical problems' (Hessels & van Lente, 2008).

Research Methodology

This study is based on secondary sources in which the available literatures are reviewed. It is an extensive unsystematic review of works carried out by research scholars of disciplinarity and the transdisciplinarity research for the purpose of understanding academic knowledge in a better way. This study is not a commercial project and the authors decided to work on their own to understand disciplinarity and transdisciplinarity in a better way.

The majority of the researchers seemed to be following global research methodology along with disciplinary research-based methodology. As far as transdisciplinary research is concerned, it is a new integrated disciplinary theory. Transdisciplinarity as a new study in academia will automatically encourage the researchers to explore whether they have their own methodological domains or not. In this regard, Nicolescu (2010) wrote, in the absence of a methodology, transdisciplinary would be just talking and empty discourse and therefore, a short-term living fashion (p.21). While writing about methodology on transdisciplinary studies, Nicolescu (2002, p.122; in Leavy, 2011, p.71) writes the transdisciplinary method does not replace the methodology of each discipline, which remains as it is. Instead of the transdisciplinary method enriching each of these disciplines by bringing them new and indispensable insights, which cannot be produced.

This study demands comparing methods for cross-disciplinary research. In this regard, O'Rourke (2017, p.276) highlights how a survey of the methods of interdisciplinary and transdisciplinary research supports the suggestion that they are "fragmented," that is distributed in unconnected ways across the intellectual landscape (Bammer, 2013a; in O'Rourke, 2017). Therefore, research is only one mode of cross-disciplinary activity as many education and training programs are cross-disciplinary in nature as they are based on the context of practical as well as problem-solving that excludes a research component and often exhibits cross-disciplinary. Bammer (2013) identifies six categories of concepts and methods, and they are: "system view, scoping, boundary setting, framing, values, and harnessing and managing differences" (p.30; in O'Rourke, 2017, p.283).

Leavy (2011) summarizes transdisciplinary as using any number of research methods designed to address the issue or problem at hand, including traditional qualitative or quantitative methods, hybrid methods, cross-disciplinary methods, multi-methods, mixed methods (p.70) including social network analysis, extended case method and participatory research methods (van Manen, 2001; in Leavy, 2011), ethnomethodology and action research, problem structuring methods or methodological bricolage (Pohl & Hirsch Hadorn, 2008; Horlick-Jones & Rosenheads, 2007, p.595).

Transdisciplinarity

Petrie (1992; in Evans, 2014) writes about transdisciplinarity as "the notion of transdisciplinarity exemplifies one of the historically important driving forces in the area of interdisciplinarity, namely, the idea of the desirability of the integration of knowledge into some meaningful whole". The terms ''transdisciplinary'' and ''transdisciplinarity'' have a 50-year history (Jantsch, 1970; Jantsch, 1972; Piaget, 1972; in Lawrence et al., 2022, p.46). Transdisciplinary endeavors set out to create synthesis between disciplines (Aboelela et al., 2006).

The origins of "transdisciplinarity" can be traced back to the work of education theorists in the 1960s and 1970s in response to the perceived inadequacy of the terms multi- and interdisciplinarity in representing new forms of theory and research which transcended discipline-specific knowledge (Nicolescu, 2002; in Bardecki, 2019). Transdisciplinarity was first defined during an international conference on interdisciplinarity that took place in Paris (University of Nice) and was jointly sponsored by the Organization of Economic Corporation and Development (OECD) (Bernstein, 2015) in 1970 as "a common system of axioms for a set of disciplines" (Klein, 2004, p.515; Augsburg, 2014, p.233; Apostel et al., 1972; Kocklemans, 1979; McGregor, 2015, p.10), by psychologist Jean Piaget (1972), Mathematician André Lichnerowicz (1972), and astrophysicist Erich Jantsch, an Austrian thinker (1972). Of the three definitions, Jantsch's became the most influential with much of the subsequent scholarship on transdisciplinarity.

While defining transdisciplinarity approach, Pohl and Hirsch Hadorn (2007, p.70; 2008, p.29) write that there are about four core concerns which show up in definitions of transdisciplinarity or related terms: 1) First the focus on life-world problems; 2) the transcending and integrating of transdisciplinary paradigms; 3) participatory research; and 4) the search for unity of knowledge beyond disciplines.

In transdisciplinarity, the traditional boundaries of disciplinary research are transcended to converge inherently different disciplines to form a new unified framework beyond the discipline. The goal of transdisciplinarity is to have an understanding of the present world through the unifying of knowledge and the solution of mega and complex problem by drawing on and seeking to integrate disciplinary and stakeholder views based on some overarching theory (Oloruntimilehin, 2020). Transdisciplinarity "represents the highest form of integration"; it involves "the application of cross-disciplinary concepts as well as scholars from multiple disciplines to combine knowledge and skill from diverse disciplinary domains" (Dellaportas et al., 2022; Oloruntimilehin, 2020). Multidisciplinarity and interdisciplinarity have this in common: they seek to overcome disciplinary monism. "Transdisciplinarity is perhaps above all a new way of thinking about, and engaging in, inquiry" (Bernstein, 2015, p.1). Transdisciplinarity integrates the natural, social, and health sciences in a humanities context and transcends their traditional boundaries. […] (Choi & Pak, 2006, p.351, 359). Transdisciplinarity remains "a rather elusive concept that continues to evolve (Jahn, Bergmann, & Keil, 2012, p.1; McGregor, 2015).

Transdisciplinary research discusses about problem and solution approach. The starting point for transdisciplinary research is a socially relevant problem field. A problem field (violence, hunger, poverty, disease, environmental pollution) refers to an issue in the life world. Problem fields are socially relevant when those involved have a major stake in

the issue, when there is a societal interest in improving the situation, and when the issue is under dispute (Pohl & Hirsch Hadorn, 2008, p.112). Transdisciplinary research deals with the problem fields as per Pohl & Hirsh Hadorn (2007, p.20) that it can: grasp the complexity of the issue, take the diverse perspectives on the issue into account including life-world and scientific perceptions of problems, link abstract and case-specific knowledge, and develop knowledge and practices that promote what is perceived to be the common good (Pohl & Hirsch Hadorn, 2007; Pohl, 2010; Hirsch Hadorn et al., 2008).

Conceived as a concept in the early seventies (Apostel et al., 1972; Kocklemans, 1979; in McGregor, 2015, p.10), it has only just recently gained momentum and grudging acceptance as a necessary paradigmatic, methodological and intellectual innovation. The definitions of transdisciplinarity usually propose a progression from multidisciplinarity through interdisciplinary to transdisciplinarity. In transdisciplinarity, the whole system is oriented around an overall purpose like "progress" or "ecological balance". For Rosenfield (1992; in Pohl, 2010), the progression lies in the shared conceptual framework. The words *transdisciplinarity* and *transdisciplinary*, with their basic meanings involving transcending the established framework of traditional academic disciplines (Kessel & Rosenfield, 2008; in Berstein, 2015, p.5; Jantsch, 1970; Jantsch, 1972; Piaget, 1972; Mahan, 1970; in Lawrence et al., 2022, p.46). Transdisciplinarity definitions included the roots in the "unity of knowledge" a book written by J.B. Jeffrey (1950; Scholz, 2020; in Lawrence et al., 2022).

Unity of knowledge was first coined by Nicolescu in 1996. Its goal is the understanding of the present world. Oloruntimilehin (2020) highlighted four points of transdisciplinarity which are: crosses disciplinary and scientific/academic boundaries; common goal setting; integration of disciplines and non-academic participants; and development of integrated knowledge and theory among science and society (Rainsford, 2009; in Oloruntimilehin, 2020). The quest for unity continued in movements such as Transcendentalism, the unity of science and theory of consilience (Wilson, 1998; Klein, 2014, p.69). *Consilience: The Unity of Knowledge* is a 1998 book that discusses methods that have been used to unite the sciences and might in the future unite them with the humanities. This book defines consilience as "literally a jumping together" of knowledge by the linking of facts and fact-based theory across disciplines to create a common ground work of explanation (Wilson, 1998). Consilience as a theory reflects to the unity of knowledge achieved by connecting different fields such as natural sciences, social sciences and arts (Wilson, 1998).

Lawrence et al. (2022, p.47) have compiled 16 widely varying definitions from the literature of the last half century. The whole 16 definitions are grouped into 'unity of

knowledge' transdisciplinarity and 'social engagement' transdisciplinarity (Lawrence et al., 2022, p.48). Transdisciplinarity is a reflexive research approach that addresses societal problems by means of interdisciplinary collaboration as well as the collaboration between researchers and extra-scientific actors; its aim is to enable mutual learning processes between science and society; integration is the main cognitive challenge of the research process (Jahn et al., 2012, p.4).

In course of studying unity of knowledge, Lawrence et al. (2022) identified seven key characteristics, they are: 1) a focus on theoretical unity of knowledge, in an effort to transcend disciplinary boundaries; 2) the inclusion of multidisciplinary and interdisciplinary academic research; 3) the involvement of (non-academic) societal actors as process participants; 4) a focus on specific, complex, societally relevant, real-world situations or problems; 5) working in a transformative manner, i.e., going beyond the focus on real-world problems to proactively support action or intervention; 6) an orientation toward the common good (including the betterment of society and a humanistic reverence for life and human dignity that qualifies on "social systems, institutions, and environments" as mentioned by Pohl and Hirsch Hadorn (2007, 2008); and 7) reflexivity, i.e., consciously contemplating the broader context and ensuring the compatibility of the project's components and tasks throughout the course of the project (p.47).

Russell, Wickson, and Carew (2008) noticed that transdisciplinarity "is a practice, not an institution" (p.470; in Jahn et al., 2012, p.2) and Klein (2004) states that it is "simultaneously an attitude and a form of action" (p.521; in Jahn et al., 2012). According to Miller et al. (2008; in Jahn et al., 2012), Russell et al. (2008) and Klein (2004) proposed their views on transdisciplinarity "epistemological pluralism" which stresses on internal reflexivity as an essential part of transdisciplinarity research (Jahn et al., 2012).

Basically scholars describe the structure of transdisciplinary research (the research project is the system build by the collaborative research process (Pohl & Hirsch Hadorn, 2008), project as a system (the element of the system are the problem field, researchers from particular discipline and actors of governmental and other public institutions, the private sector, the civil society or another sector of society). In transdisciplinary research, the order of the phases and the amount of resources dedicated to each phase depend on the kind of problem under investigation and on the state of knowledge (Pohl & Hirsch Hadorn, 2008, pp. 34-35; Pohl & Hirsch Hadorn, 2008, p.112). Such kind of project is called as a system. The elements of the system are: the problem field, researchers from particular disciplines and actors of governmental and other public institutions, the private sector, the

civil society or another sector of society. The term 'system' refers to the interaction of these elements during the research process, namely by discussing what the problem is about, by investigating the problem, by deliberating about values and goals and by developing strategies and measures to address the problem (Pohl & Hirsch Hadorn, 2007, p.20; Pohl et al., 2017, p.324; Pohl & Hirsch Hadorn, 2008, p.143). According to Jantsch (1972, p.103), the term "system" basically means that the emphasis of an analysis shifts from the elements to the way they interact (Jantsch, 1972, p.103). Ison (2008, p.247) has added inverted commas to the verbs such as "discussing", "investigating", "deliberating" , & "developing" to which Ison (2008) has coined the term systems praxeology, including understanding research practice as a particular systemic dynamic.

Systems thinking as a term introduced by Meadows et al. (1972; Pohl & Hirsch Hadorn, 2008) connected to environmental or sustainability research through the world model. They modeled the development of the world as interactions between resource usage, population growth, pollution, and economic and agricultural growth. Checkland (1994; in Pohl & Hirsch Hadorn, 2008) supplemented this hard systems thinking with soft systems thinking. Both differ in the way they qualify the model's relation to the life-world: in hard systems thinking the models are models of the world; in the soft systems thinking the models are "models which embody a particular stated way of viewing the world" (Checkland, 1985, p.764; in Pohl & Hirsch Hadorn, 2008). As a consequence, the challenges of integrating perspectives in soft systems thinking are different from the challenges of integrating findings from different disciplines in a model of the world. This invites understanding what system thinking is. In this regard, Meadows et al. (1972; in Pohl & Hirsch Hadorn, 2008, p.114) introduce systems thinking to environmental or sustainability research through the world model. Checkland (1994; in Pohl & Hirsch Hadorn, 2008) categorized system thinking into 'hard and soft system'. Both differ in the way they qualify the model's relation to the life-world: in hard system thinking the models are models of the world; in the soft systems thinking the models are "models which embody a particular stated way of viewing the world".

The way they conduct the research is known as teamwork. According to Lorimer and Manion (1996; in Chi & Pak, 2006, p.357), "a team is a small number of consistent people committed to a relevant shared purpose, with common performance goals, complementary and overlapping skills, and a common approach to their work". In this kind of study the research team may organize its collaboration as common group learning, deliberation among experts or integration by a sub-group or individual (Rossini & Porter, 1979; in Pohl & Hirsch Hadorn, 2008, p.115). It is important to know about common group learning which means that integration takes place as a learning process of the whole group. According to Austin

et al. (2008, p.559), 'teamwork is not magic, and simply 'getting along' or communicating information to one another does not constitute collaboration' (Hinojosa et al., 2001, p.210; in Austin et al., 2008). Collaborative research whether multidisciplinary, interdisciplinary or transdisciplinary, has openness to a multiplicity of perspectives that holds significant promise for research teams (Austin et al., 2008).

It is noteworthy to highlight three arguments based on collaboration and interface between disciplinary groups that incorporates both strengths and weaknesses forwarded by Stember (1990, p.1) and adopted and modified by Manolakelli (2022) that focuses mainly on intellectual, practical and educational perspectives. From an intellectual perspective, ideas in many fields can be improved and furthered by theories, concepts and methods from other fields. From practical perspective, the problems our world is facing at the moment are not organized according to academic disciplines and continue to be increasingly complex, messy and interconnected. From educational perspective, interdisciplinary studies are now mainstream requirements and take many forms. Öberg (2011; in Parker, 2016, p.3) uses the term transacademic to describe work that involves both academic and non-academic participants.

Max-Neef (2005) sees "transdisciplinarity, more than a new discipline or super-discipline is, actually, a different manner of seeing the world, more systematic and more holistic" (p.15) requiring the breakdown of epistemological (science of science) barriers not only among disciplines but also at the level of institutional arrangements (Bardecki, 2019, p.1181).

Types of Transdisciplinarity

While studying the transdisciplinarity approach, the scholars have made effort to develop typology of transdisciplinarity. It is Max-Neef (2005; Stock & Burton, 2011) who classified transdisciplinarity into two types and three types by Nicolescu (2008). Max-Neef's (2005) typology reveals that there are "*weak transdisciplinarity*" (following traditional method and logic) and "*strong transdisciplinarity*" (models of reasoning-rational and relational i.e., non-linear). While describing the importance of transdisciplinarity before indicating his typology, Nicolescu's (2008) writes, "we can arrive in a formulation of transdisciplinarity that is both unified and universe; unity in diversity and diversity through unity is inherent to transdisciplinarity. Nicolescu's (2008) three typologies are: theoretical transdisciplinarity, a phenomenological transdisciplinarity, and an experimental transdisciplinarity"(p.12). As Nicolescu (2008, pp. 12-13) including Michael Gibbons, Helga Nowotny, Jean Piaget and Edgar Morin emphasizes that a theoretical transdisciplinarity is a concept of the human life-

world and lived meanings. A phenomenological transdisciplinarity emphasizes on "models connecting the theoretical principles with the already observed experimental data, in order to predict further results and an experimental transdisciplinarity emphasizes a large number of experimental data collected not only within the framework of knowledge production, but also in fields such as education, psychoanalysis, the treatment of pain in terminal diseases, drug addiction, art, literature, history of religions, and so forth (Nicolescu, 2008). According to Jacobs (2017), a field may be regarded as a discipline when professors with specified credentials are typically hired to conduct research and teach students in a particular domain. This definition focuses on the social organization of a field and makes no direct claims about its internal coherence or boundaries, although some degree of intellectual integration is needed before a field can become institutionalized. All fields are intellectual amalgams with ideas, metaphors, and methods borrowed from other domains.

Two Domains of Transdisciplinary Studies

As far as two domains are concerned, one has been dominated by the French scholars and another dominated by Swiss, Zurich or German school. The French school of thought is pre-dominated by physicists Basarab Nicolescu and another philosopher named Edgar Morin popularly known as the Nicolescuian transdisciplinarity. Nicolescu (2010, pp. 18-19) opined that the inclusion of the meaning "beyond disciplines" in 1985 and developed this idea over the years in articles, books, and various official international documents. A key date in this development is 1994, when the Charter of Transdisciplinarity was adopted by participants at the First World Congress of Transdisciplinarity (Convento da Arrbida, Portugal).

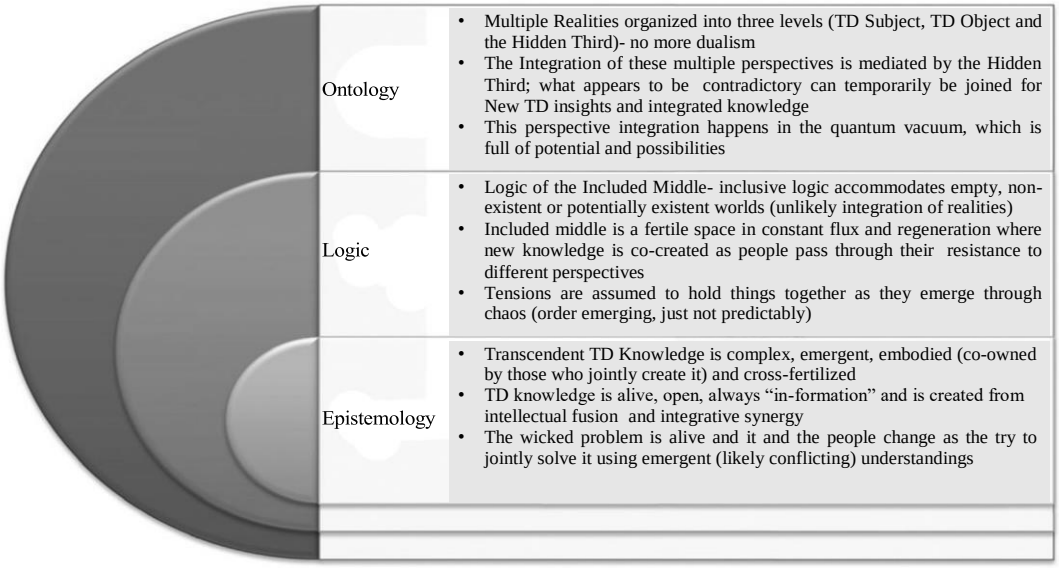
Nicolescu (2002; in McGregor, 2015) describes transdisciplinarity as multidimensional and supported by the following three pillars (Philosophical axioms): a) Knowledge as complex and emergent (epistemology); b) Multiple levels of reality mediated by the Hidden Third (Ontology); and, c) the logic of the included middle, which contrast with classical exclusive logic (Nicolescu, 2008; McGregor, 2015). Nicolescuian transdisciplinarity is complexity (Nicolescu, 2010). He believes that complexity is a modern form of ancient principle of universal interdependence, in that "everything is dependent on everything else, everything is connected, nothing is separated" (Nicolescu 2004; in McGregor, 2015).

As far as Nicolescuian theory is concerned, Nicolescu (2005, 2008, 2010, 2012, 2014) has proposed three axioms as a new research methodology. Axioms are understood as principles or pillars in transdisciplinary studies. Nicolescu (2005, p.5) highlights that the most important achievement of transdisciplinarity in present times is, of course, the formulation of the methodology which is accepted and applied by researchers. The

axiomatic character of the transdisciplinarity methodology is an important aspect. Three axioms of the transdisciplinarity methodology are: 1) The ontological axiom: There are, in Nature and in our knowledge of Nature, different levels of Reality and, correspondingly, different levels of perception; 2) The logical axiom: The passage from one level of Reality to another is insured by the logic of the included middle; and 3) The complexity axiom: The structure of the totality of levels of Reality or perception is a complex structure: every level is what it is because all the levels exist at the same time (Nicolescu, 2005).

Figure 1

Three Axioms of Transdisciplinary Methodology



Source: McGregor (2014, p.207; here the term TD refers to Transdisciplinarity)

The first two get their experimental evidence from quantum physics, but they go well beyond exact sciences. The last one has its source not only in quantum physics but also in a variety of other exact and human sciences. All three are in agreement with traditional thinking, present on the earth from the beginning of historical times. Axioms cannot be demonstrated: they are not theorems. They have their roots in experimental data and theoretical approaches and their validity is judged by the results of their applications. If the results are in contradiction with experimental facts, they have to be modified or replaced (Nicolescu, 2005).

Nicolescu also wrote frequently about levels of Reality—subjectivity, objectivity, and what he called "The Hidden Third between the subject and the object" (Nicolescu, 2012; Bernstein, 2015). The Hidden Third is basic apophatic feature of the future unified

knowledge. This is new brain of knowledge (Nicolescu, 2006; in Nicolescu, 2012). The Hidden Third is an interaction term which allows the unification of the transdisciplinary Subject and the transdisciplinary Object while preserving their difference (Nicolescu, 2012). Peirce's (1976; in Nicolescu, 2012) view on Reality totally corresponds to the transdisciplinary view on Reality.

Nicolescu (2012) as cited by McGregor (2015) identified 10 Realities which are organized along three levels. Level one is the internal world of humans, where consciousness and perspectives flow – the TD-Subject (comprising four Realties: political, social, historical, and individual). Level two is the external world of humans where information flows – the TD-Object (comprising three different Realities: environmental, economic, and cosmic/ planetary). Peoples' experiences, intuitions, interpretations, descriptions, representations, images, and formulas meet on this third level (p.15).

In order to avoid any ambiguity, Nicolescu (1985, 2000; in Nicolescu, 2012) defines "reality" in a sense which is used by scientists, namely in terms of "resistence" (p.15). Nicolescu suggests distinguishing between the words "Real" and "Reality", "Real" designating which *is*, while "Reality" is connected to resistance in our human experience. The "Real" is by definition veiled for ever (it does not tolerate any further qualifications) while "Reality" is accessible to our knowledge. Real involves non-resistance while reality involves resistance (Nicolescu, 2012). According to Nicolescu (2012, p.26), a unified theory of levels of Reality is crucial in building sustainable development and sustainable futures. The individual level of Reality, the spiritual level of Reality and the cosmic level of Reality are completely ignored. Reality depends on us. Reality is plastic.

When it comes to Swiss camp, transdisciplinarity was promoted by two initiatives of environmental research in the early 1990s: The scientific journal GAIA- Ecological Perspectives for Science and Society launched in 1991 and the "Swiss Priority Program Environment" (SPPE) initiated in 1992. The German philoshoper Mittel-straß (1992; in Pohl, 2010) introduced transdisciplinarity as:

> [T]ransdisciplinarity refers to knowledge or research that frees itself of its specialized or disciplinary boundaries, that defines and solves its problems independently of disciplines, relating these problems to extra-scientific developments" (Zimmermann, n.d.; in Pohl, 2010, p.68).

The boon of Swiss Zurich or German School is transdisciplinarity as a research approach to addressing complex societal problems such as those related to sustainability. Transdisicplinarity is conceptualized as problem focused with an emphasis on joint problem

solving at the science, technology, and society interface that goes beyond the confines of academia (Augsburg, 2014, p.235).

The second International Transdisciplinary Conference was held in Zurich in 2000 (McGregor, 2015; Augsburg, 2014, pp. 234-235). This conference sheds light on the process of development of transdisciplinary research. The scholars of Switzerland and Netherlands focused on three different transdisciplinary approaches, the Transdisciplinary Case Study (TCS) approach, the Institute for Social-Ecological Research (ISOE) model and the Interactive Learning and Action (ILA) approach. In the development of transdisciplinary research in the Netherlands, the scholars distinguished academic-theoretical line, a governmental policy line and an academic-empirical line (Bunders, Broerse, Keil, Pohl, Scholz, & Zweekerhorst, 2010, p.130).

The Zurich approach of shifting the discourse on transdisciplinarity from science-theory-driven deliberation to asking what this new way of doing science means in (research) practice was widely adopted. Russell et al. (2008; Jahn et al., 2012), for example, notice that transdisciplinarity 'is a practice, not an institution (Russell et al., 2008, p.470; Jahn et al., 2012) and Klein (2004; Jahn et al., 2012) states that it is simultaneously an attitude and a form of action' (Klein, 2004, p.521; Jahn et al., 2012). The Zurich camp conceptualizes transdisciplinarity as a new type of research, called Mode 2 research (Gibbons et al., 1994; Kunwar & Ulak, 2023, 2024). The Mode 2 knowledge is transdisciplinary from a structural standpoint. Nowotny characterizes Mode 1 science as having a clear separation between science and society, while in Mode 2 boundaries between science and society are transgressed (Alvargonzález, 2011). The main proposition of the study is the emergence of a knowledge production system that is 'socially distributed'. To clarify this assertion the authors introduce a distinction between Mode 1 knowledge production, which has always existed, and Mode 2 knowledge production, a new mode that is emerging next to it and is becoming more and more dominant (Hessels & van Lente, 2008). According to Gibbons et al. (1994) and Nowtony et al. (2001) as cited by Hessels and van Lente (2008, p.741) and Kunwar and Ulak (2023, 2024), five main attributes of Mode 2 summarize how it differs from Mode 1 are as follows: 1) Mode 2 knowledge is generated in a context of application; 2) Mode 2 is transdisciplinarity; 3) Mode 2 knowledge is produced in a diverse variety of organizations, resulting in a very heterogeneous practice; 4) Reflexivity- compared to Mode 1, Mode 2 knowledge is rather a dialogic process, and has the capacity to incorporate multiple views; and 5) Novel forms of quality control.

Simultaneously, post-normal science as a theory was invented along with Mode 2 research (Funtowicz & Ravetz, 1993; Nowotny, 2003; Kunwar & Ulak, 2023, 2024). In

order to easily understand post normal science, it is essential to understand what normal science is. Normal science needs to be liberated from its dogmatic style and, simultaneously philosophy of science needs recasting (Funtowicz & Ravetz, 1993, 1994, 1999; in Alvargonzález, 2011). 'Normal science' in the Kuhnian sense is not an adequate mode of knowledge production in this situation, as it assumes that problems can be divided into small-scale problems that can be handled without questioning the broader framework or paradigm (Hessels & van Lente, 2008; Funtowicz & Ravetz, 1993).

The next important aspects of transdisciplinary studies is 'Post-normal science', a prescriptive approach (Hessels & van Lente, 2008, p.745; Funtowicz and Ravetz, 1993), but it has led to the development of a research community working on the further development of the program. The concept originates from policy-relevant science fields and starts from an acknowledgement of the limitations of rational decision-making. This theory was derived from their interest in Ecological Economic studies that considered the epistemological and governance challenges (Hessels & van Lente, 2008). Closely related to Mode 2 knowledge and post-normal science, there is a new branch of activities called transdisciplinary research.

Knowledge Integration

One additional term is "integration". In this regard, Leavy (2011) focuses only on the integration that is achieved when there is collaboration between disciplines. When there is "transdisciplinarity, there is collaboration with high levels of integration causing the development of new conceptual theoretical and methodological frameworks" (2011; in Mylonakou-Keke, 2015, p.1891).

Integration refers to the process of combining and reconciling research and experience-based knowledge and perspectives of the academic and non-academic participants. Integration also means jointly developing a shared theoretical understanding of the issue at stake (Pohl, 2010, p.70). The English word integration also can be traced back to the Latin world integrate meaning "to make whole". As a verb integrate means "to unite or blend into a functioning whole". Over the centuries, says Klein (2012; in Repko, 2012, p.262), the idea of integration was associated with holism, unity and synthesis (Klein, 2012, p.284; in Repko, 2012).

Knowledge, according to Nicolescu (2012, p.21), is neither exterior nor interior: it is simultaneously exterior and interior. From environmental perspectives, Raymond et al. (2010; in Enengel et al., 2011) propose five dimensions of knowledge types: a) local versus generalized knowledge, b) the level of formal processes used to generate knowledge

(informal–formal), c) extent of expertise (novice–expert), d) extent to which knowledge is articulated or accessible to others (tacit–implicit–explicit), and e) extent to which knowledge is embedded in and reflects traditional cultural rules and norms (traditional–local ecological–scientific ecological). Academic discourse is a privileged form of argument in the modern world, offering a model of rationality and detached reasoning. It is seen to depend on the demonstration of absolute truth, empirical evidence or flawless logic, representing what Lemke (1995) refers to as the discourse of "Truth" (p.178; in Hyland, 2011, p.194). It provides an objective description of what the natural and human world is actually like (Hyland, 2011). …every discipline claiming its own truth…and having its laws, norms and terminology (Nicolescu, 2012). Within each form are unique concepts and propositions that have tests to validate their truth.

The challenges of wicked problem-oriented research come along with the different types of knowledge transdisciplinary research. Swiss researchers suggested distinguishing three such types of knowledge (proClaim, 1997; in Pohl, Truffer & Hirsch Hadorn, 2017, p.325; Hirsch Hadorn et al., 2008, p.30; Pohl et al., 2008, p.414; Wiesmann et al., 2008, p.436; Pohl & Hirsch Hadorn, 2008, p.118; Ison, 2008, p.246: Enengel, Muhar, Penker, Freyer, Drlik, & Ritter, 2011): knowledge about what is (systems knowledge); knowledge about what should be (target knowledge); and knowledge about how to come from where we are to where we should be (transformation knowledge). These three forms of knowledge is similar to Aristotle's (2003; in Hirsch Hadorn, 2008) forms of knowledge, namely: science (*epistême*); life-world action (*praxis*); production (*poiêsis*); and prudence (*phronêsis*)- now transformed as goals of transdisciplinary research (Hirsch Hadorn et al., 2008, p.20, 31).

The definition of 'systems knowledge' as knowledge of the current status which is knowledge about the origins and development of problems including their interpretation 'life-world'; of 'target knowledge' as knowledge about a target status which is knowledge about needs for change, desired goals and better ways of acting. 'Transformation knowledge' as knowledge about how to make transition from the current to the target status which is knowledge about technical, social, legal, cultural and other means of transforming existing ways of acting in desired directions (proClaim, 1997; in Pohl and Hirsch Hadorn, 2008, p.118; Pohl, C, van Kerkhoff, Hirsch Hadorn, & Bammer, 2008, p.414; Hirsch Hadorn et al., 2008, p.30).

Transdisciplinary Education

Transdisciplinary education as an important concept forwarded by Nicolescu on the activity of those engaged in transdisciplinarity and the potentialities for transdisciplinary education. While studying "The Transdisciplinary Evolution of Learning", Nicolescu (1999; in

Augsburg, 2014) linked the four pillars of a new kind of education forwarded by a report to UNESCO chaired by Jacques Delors (1996; in Augsburg, 2014, p.236)—learning to know, learning to do, learning to live together with, and learning to be—to personal characteristics important to those engaged with transdisciplinarity. Nicolescu (1999; in Augsburg, 2014) believes that individual creativity plays a critical role, as does permanent inquisitiveness, adaptability, flexibility, and the capacity to build bridges. Nicolescu (1999) appreciated the necessity of being grounded in a discipline or profession, but also of being open to access of another "should it become necessary or desirable" (Augsburg, 2014, p.237). Khokhobaia (2018) mentions that transdisciplinary approaches have been actively used in the European education system over the last decade.Various transdisciplinary research programs and projects have been successfully implemented in different countries, such as Austria, Germany, Switzerland, etc. These projects were related to various problems such as regional development, urban mobility, technology management, industrial networks, etc.

Boundary-work and Border-work

The organization of universities into departments ostensibly defined by discipline has led some to believe that "a discipline is at bottom nothing more than an administrative category" (Jencks & Riesman, 1968, p.523: in Shumway & Messer-Davidow, 1991, p.208) that groups certain specialties together for reasons of historical accident and administrative convenience. This interpretation conflicts with two facts; that disciplines are social forms that are not contained by single universities and that disciplinary practitioners, who consider themselves to be members of disciplinary communities, engage in a differentiating activity called "boundary-work". Boundary-work entails the development of explicit arguments to justify particular divisions of knowledge and of the social strategies to prevail in them. As Thomas F. Gieryn (1983, p.783) observes, "The intellectual ecosystem has with time been carved up into 'separate' institutional and professional niches through continuing processes of boundary-work designed to achieve an apparent differentiation of goals, methods, capabilities and substantive expertise" (Gieryn, 1983; Shumway & Messer-Davidow, 1991). Boundary-work is performed for various purposes. When the point is to establish or protect a discipline, boundaries mark it as a territory to be possessed by its owners, not appropriated by others, and they indicate the relations it may have with other disciplines. But these same boundaries may be redefined if the discipline is attempting to expand into new territory. When the point is to regulate disciplinary practitioners, boundary-work determines which methods and theories are included, which should be excluded, and which may be imported (Shumway & Messer-Davidow, 1991).

Horlick-Jones and Sime (2004) suggest that a specific form of transdisciplinary working ('border-work') is necessary in order to address the generalizing, decontextualizing and reductionist tendencies of discipline-based inquiry. Border-work as per Horlick-Jones and Sime (2004) show the linkages between scholarship and practice, as well as across disciplinary boundaries. Border-work as a concept, as described by Horlick-Jones and Sime (2004) is ethnographically-based action research, what they called "border work," that could "embody the active ways in which people make sense of their worlds; and to resist instrumental conceptions of human agents in terms of quasi-mechanical metaphors" (p.442). McGregor (2004, 2009, 2015, p.20) while reviewing the concept of border-work of Horlick-Jones and Sime (2004) writes, everyone involved now owns the new knowledge because it was co-created.

The border-work refers to the intellectual work that occurs when people living on the borders of the academy (university disciplines) and other sectors (civil society, industry, government) engage in knowledge generation to address wicked problems. This new knowledge is open and alive because the wicked problems the knowledge addresses are alive, emerging from the life world (Horlick-Jones & Sime, 2004; Nicolescu, 2005; in McGregor, 2015).

Horlick-Jones and Sime (2004, p.445) tentatively propose the name 'border-work' for activity, reflecting an awareness of the difficulties of crossing what are, in effect, policed boundaries. Horlick-Jones and Sime (2004) following different scholars such as Reason & Bradbury, (2001), Harper, Randall, & Rouncefield (2000), Heath & Button (2002), Garfinkel (1967), Jagodzinski, Reid, & Culverhouse (2000) and Lioyd & Busby (2001) accomplished such forms of practice have led to make common cause with a number of areas of scholarship which are concerned with the specific detail of everyday situations:
1) 'action research', in which learning is achieved through engagement with the resolution of existing real-world problems, 2) 'workplace studies', a practice-based literature firmly rooted in a form of sociology concerned with the modes of practical reasoning deployed by people in everyday situations by which they interactionally produce 'social facts' (ethnomethodology), and 3) design work informed by ethnographic and other insights into human behaviour (Horlick-Jones & Sime, 2004).

Hybridization

The beauty of transdisciplinarity is hybridity and contextualization that bring together imperatives of transcendence, problem-solving and transgression (Doucet & Janssens, 2011; in Klein, 2014, p.73). Transdisciplinarity synthesizes new disciplines and theories to form a hybrid concept shared equally among the disciplines (Oloruntimilehin, 2020). Hybrids are

"interstitial cross-disciplines" such as social psychology, economic anthropology, political sociology, bio-geography, culture and personality, and economic history. And, professional preparation led to new fields with a vocational focus such as social work and nursing (Klein, 2014). Klein (2014) expresses that the general process of development, based on studies of innovation in social sciences that has been called 'Hybridization'.

Social Engagement

'Social engagement' as a concept under the theme of the definition of transdisciplinarity came out as one of the important groups after the unity of knowledge forwarded by Lawrence et al. (2022, p.48). Social engagement has been studied by different scholars of different disciplines. The question arises what is social engagement?

Social-level engagement, as per Johnston (2018) is defined as a collective state of engagement that can be represented in behavioral forms (collective action, group participation), cognitive (shared knowledge), and affective forms (orientation, intention and experience) and is an outcome of a dynamic socially situated system. The notion of social engagement is derived from the idea of collective action and outcomes (p.26).

According to Rachmad (2022), social engagement is defined in the theory as the active involvement of individuals in social activities that benefit both themselves and their communities. The core principles of the theory emphasize the importance of effective communication, understanding shared values, and fostering positive interactions to build strong personal and professional relationships. This, in turn, creates a more cohesive and supportive community. The theory arises from the observation that many individuals feel isolated and less involved in their communities, leading to social problems like decreased participation, lack of solidarity, and mental health issues. By improving social engagement, these problems can be mitigated, enhancing the well-being of individuals and communities (pp. 13-14).

Tamed and Wicked Problems

Problem focus and problem-solving are terms frequently used when describing the transdisciplinary approach. However, these terms are also used for other cross-disciplinary approaches and for characterizing research in general (Kuhn, 1992/1662; in Mobjörk, 2010). Consequently, a specific definition is required when talking about problem focus/ problem-solving in relation to transdisciplinarity. Transdisciplinarity can be described in relation to 'societal problems' or 'life-world problems' (Wickson, Carew, & Russel, 2006; Schmidt, 2008; in Mobjörk, 2010; Pohl & Hirsch Hadorn, 2008), but these descriptions of societal or life-world problems inherently reflect a notion of the existence of a 'pure'

scientific problem. Transdisciplinarity defines a research focused on problems that cross the boundaries of two or more disciplines, aiming at a holistic approach. It also implies concepts or methods that were originally developed by one discipline, but are now widely used by others (Zaman & Goschin, 2010, p.7).

While focusing on the problem and its solution, Mylonakou-Keke (2015) proposed seven key features of transdisciplinarity research, which are: transdisciplinary research is problem/ issue/driven that manifest in the real world; the problem is complex, multidimensional, with the different dimensions being heterogeneous; to solve the problem the holistic approach, which combines the integration of different disciplines, epistemologies and methodologies, is necessary; the primary objective is to improve and change a problematic situation and solve a problem, through an evolving, dynamic methodology that is iterative and an ongoing part of the research process; the solution or the improvement of the problem comes from the production of new knowledge that is a result of interrelated knowledge management processes and progression of learning; dynamic interaction between theory and practice; and many and high levels of collaboration between all stakeholders (including researchers) and the broader community are required (pp. 1894-1895).

By the 1990s, the word began to be used more widely to refer to the use of novel paradigms and practices beyond those of the traditional disciplines (Schleifer 2002; in Bardecki, 2019). In a disciplinary research project, the problem is framed by disciplinary standards, such as the state of knowledge, methods, and theories (i.e., the disciplinary paradigm in Kuhn's terminology) (Kuhn, 1996; in Pohl, 2010, p.70). The few existing methods and approaches to problem framing often have an explorative character.

Transdisciplinarity offers a different philosophy and approach both of how to effectively address issues/problems and how to improve and change difficult situations and multiple levels of reality under conditions of complexity and uncertainty. Addressing these problems becomes precisely effective because of the way transdisciplinary achieves collaboration and integration among disciplines (Mylonakou-Keke, 2015, p.1890).

Transdisciplinary research is needed when knowledge about a societally relevant problem field or 'chronic societal problems' (Somerville & Rapport, 2002) is uncertain, when the concrete nature of problems is disputed. Problem-solving research comprises the phase of problem identification and problem structuring, the phase of problem investigation and the phase of bringing results to fruition (usually termed "implementation") (Pohl & Hirsch Hadorn, 2007, pp. 42-43; Hirsch Hadorn et al., 2008, p.35; Pohl, 2010, p.70) to which Somerville and Rapport (2002) call it as 'new solutions'. According to Manderson (one of the participants in the Colloquium; in Somerville & Rapport, 2002), a solution is

also a mixture in which different particles have been dissolved, creating a new liquid in which those particles have lost their particularity. A solution is not just a forging together of different substances; each of the elements losses its original form and character and transforms itself into something new.

The way scholars of transdiscipline carried out their research on problems is based on 'messes' and 'difficulties' (Ison, 2008). The term 'messy' and 'turbulent' was first coined by Russell Ackoff in 1974 (Ison, 2008; Head, 2018). Both messy and turbulent problems include the complex and contested issues that display many of the features typical of 'wicked' intractable problems (Ackoff, 1974; Ansell, Trondal, & Ogard, 2017; Dunn, 1988; Horn & Weber, 2007; Ney, 2009; in Head, 2018) argued, in proposing his notion of mess that what decision makers deal with are messes not problems (Ackoff, 1974a, b; in Ison, 2008).

According to Ackoff (1974), every problem interacts with other problems and is therefore part of a system of interrelated problems, a system of problems…a mess…The solution to a mess can seldom be obtained by independently solving each of the problems of which it is composed…efforts to deal separately with such aspects of urban life as transportation, health, crime, and education seem to aggravate the total situation (p.21; in Head, 2018, p.3).

Transdisciplinarian scholars have strongly focused on the solution of wicked problems which later became very popular. Problem studies should go through two types of problems historically known as 'tamed' (well-structured) and 'wicked' (ill-structured) which were developed by Horst Rittel (design theorists) and Melvin Webber (urban designer and theorist) in 1973. Head (2018) mentions that tamed problem are well-defined and well-structured, with agreed technical parameters and a relatively solid knowledge base (p.6). While distinguishing tamed problems from wicked problems, Rittel and Webber (1973, p.160; Pohl et al., 2017) mention that tamed problems have a clear goal and mission (e.g., solving a mathematical equation, analyzing the chemical structure of a compound, building an atomic bomb or landing on the moon) and proposed solutions which can clearly be judged as success or failure. A problem is tamed if addressing it does not include questioning the mission, or whether the problems are solved either by specifying and adapting the knowledge of the disciplines and fields relevant for the problem at hand or by carrying out use-inspired basic research if innovation is required. In contrast, addressing societal problems usually includes deliberating what the problem is about and whether, and how, and by whom it should be addressed. Camillus (2008) as cited by Head (2008) commented

on the pros and cons of wicked problems. The attraction of the 'wicked problem' concept is that it seems to provide additional insights concerning why many policies and programs generate controversy, fail to achieve their stated goals, cause unforeseen effects, or are impossibly difficult to coordinate and monitor. Even the business management literature is rediscovering 'wicked problems' as a way of understanding the role of business strategy in making sense of chaotic economic behavior under conditions of risk and uncertainty.

Head (2018) while working on forty years of wicked problems, reviewed on 'scientific' approaches to social policy and planning addressing on complex, and contested, social problems. This provocative claim, that scientific-technical approaches would not 'work' for complex social issues, has engaged policy analysts, academic researchers and planning practitioners since the 1970s (Head, 2018; Rittel & Webber 1973).

Rittel and Webber (1973, p.155; Pohl et al., 2017) conceptualize such problems as wicked design problems followed by Buchanan (1992, p.15), Conklin (2005), Abbott (2010), Brown (2010, pp. 62-63), Bernstein (2015, p.8), and Lawrence et al. (2022). Wicked problems differ from tamed problems as their nature and scopes are different.

Not all problems are wicked. In contrast, a 'tame problem' is one for which the traditional linear process is sufficient to produce a workable solution in an acceptable time frame. According to Conklin (2005, p.9), a tame problem: 1) has a well-defined and stable problem statement, 2) has a definite stopping point, i.e. when the solution is reached, 3) has a solution which can be objectively evaluated as right or wrong, 4) belongs to a class of similar problems which are all solved in the same similar way, 5) has solutions which can be easily tried and abandoned, and 6) comes with a limited set of alternative solutions. Tame does not mean simple–a tame problem can be very technically complex (Conklin, 2005).

The concept of a wicked problem emerged in the late 1960s and early 1970s based on experiences with the complex interrelationships between various social and environmental aspects of city planning (Rittel & Webber, 1973; Lawrence et al., 2022). The term "wicked" is not intended in the moral sense of being "evil"; instead, it is in the sense of being malignant. Ten key characteristics of wicked problems were defined in the seminal work and modified by Rittel and Webber (1973, pp. 161-167) and cited by Lawrence et al. (2022) are: 1) Wicked problems have no definitive formulation; 2) Wicked problems have no ends to their causal chains—"no stopping rule" (i.e., one is never completely "done" dealing with the wicked problem); 3) Wicked problems do not have "true-false" solutions, rather "good-bad" or "better-worse" ones; 4) Wicked problems offer no "immediate" or "ultimate" tests for a solution; 5) Wicked problems mean that every attempt at a solution is consequential, i.e., there is no opportunity to innocuously learn by trial and error since every attempt counts significantly;

6) Wicked problems do not have an "exhaustively describable" set or series of solutions; 7) Every wicked problem is unique—having at least one "distinguishing property that is of overriding importance". ; 8) Every wicked problem points to other wicked problems—each also being a symptom of the other; 9) The discrepancies that characterize a wicked problem can be explained in multiple ways, and the choice of explanation affects how the wicked problem will be approached and possibly resolved; and 10) Wicked problems pose particular difficulties for those aiming to resolve them (or as Rittel and Weber originally stated it: ''The planner has no right to be wrong'') (p.44).

The scholars of transdisciplanary research (Lawrence et al., 2022; Jahn et al., 2012; Horlick-Jones & Sime, 2004; Hirsch Hadorn et al., 2008; Rittel & Webber, 1973) have gone through wicked problems, complex problems and real world problems in order to understand solution for human problem faced by people globally and locally. The powerful fragmenting forces of wicked problems, social complexity and technical complexity; the confusion, chaos, and blame created by failing to distinguish these forces; the lack of tools and techniques for 'defragmenting' project dynamics (Conklin, 2005). Conklin (2005) has stressed on the dialogue mapping process as a powerful approach for addressing the problem of fragmentation, as it allows a diverse group of people to generate coherence around wicked problems.

The concept of the wicked problem, first identified and defined by the design theorists Horst W. J. Rittel and Melvin M. Webber (1973), has grown from being a discussion point in the policy sciences to a focal concern in recent transdisciplinary literature (McGregor, 2015a; in Bernstein, 2015), who also uses another commonly found expression, "wicked messes"). Wicked problems, including conflict and sustainability, that transcend the resources for any single disciplinary or even traditional interdisciplinary approach for solution have become primary sources of material for contemporary transdisciplinary work. These are pressing problems, even crises, reaching in multiple domains or dimensions and involving not just academic disciplines and the interplay among them but also practitioners seeking solutions in the real world outside the academy (Bernstein, 2015). Some projects on wicked problems involve using multiple prongs of research to solve ever-present yet multifaceted social justice problems including crime or poverty, and focusing on issues such as education, health, sanitation, and housing (Lawrence, 2010; in Bernstein, 2015).

Rittel and Webber (1973; Head, 2018, p.1) challenged the conventional assumption that scientific approaches to social policy and planning provide the most reliable guidance for practitioners and researchers who are addressing complex, and contested, social problems. This provocative claim, that scientific technical approaches would not 'work' for complex

social issues has engaged policy analysis, academic researchers and planning practitioners since the 1970s. But this has given birth to ongoing debates about knowledge and power in the policy and planning professions. As Head (2018) argued while reviewing policy analysis and experience for forty years, it helps scholars to understand policy problems and their issues and solutions with the help of methods (analytical tools, managerial capacities and consultative processes) to have more effective policy responses.

Wicked problems are connected to uncertainties (Head, 2014, p.666). There are, according to Koppenjan and Klijn (2004; in Head, 2014) three different types of uncertainty: 'Substantive' uncertainty (gaps and conflicting understandings in the knowledge based); 'Strategic' uncertainty (unpredictable perspectives); and institutional (wicked problems are likely to be messy and uncoordinated). In the same line but in different aspect, Janicke and Jorgens (1999, pp. 175-176; in Head, 2014) identified four important dimensions of uncertainty: *scientific uncertainty*, *political uncertainty*, uncertainty about the *consequences* of specific possible interventions, and uncertainty about the future framework of *investment incentives* to support technical innovation (renewable energy, water reuse, green building in the study of effective environmental policy (p.667).

By contrast, other problems are seen as more enduring and intractable, and thus more likely to defy resolution. Examples at a national and a local level might include poverty and inequality, family violence, drug control, criminal behavior and environmental pollution. At an international level, enduring complex problems might include sustainable development, climate change policy response, terrorism, international business regulation and illicit migration (OECD, 2011, 2015; in Head, 2018). These and relate issues, such as those underline the Sustainable Development Goals (SDGs) of the United Nations (2015), have become the central to the policy agenda of international networks.

A wicked problem is a complex issue that defies complete definition for which there can be no final solution since any resolution generates further issues, and where solutions are not true or false or good or bad, but the best can be done at the time. Such problems are not morally wicked, but diabolical (characteristics of devil or evil) in that they resist all the usual attempts to resolve them (Rittel & Webber, 1973; Brown, Deane, Harris, & Russell, 2010).

Real World Problems

Real world problems are issues and risks that are causing losses or are likely to cause losses in the near future. This term is commonly used in science, mathematics, engineering, design, coding and other fields whereby students may be asked to propose solutions to problems that are currently relevant to people and planet as opposed to theoretical, insignificant or personal problems (Spacey, 2023).

The features of real world problems are characterized by difficult situations, enduring issues and global issues. The key concepts of real world problems are life situations and problem solving approach. Spacey (2023) has identified 104 real world problems and all 104 real world problems are incorporated into eight different subheading which are as follows: 1) Social issues (problems and risks that impact the quality of life of people and communities); 2) Environmental problems (destruction of the natural environment of planet Earth and its eco systems); Economic problems (problems, instability and risks that impact the economic processes and markets that sustain the quality of life of nations); 4) Education issues (education systems and institutions that failed to deliver efficient and effective); 5) Government and political (problems related to government and the political process); 6) Local issues (problems that are specific to a place such as a city, town or neighborhood like access to education, aging infrastructure, aging population, air pollution, corruption, cost of living, crime rates, disaster preparedness, discrimination, economic decline, food deserts, housing shortages, poor emergency services, inadequate waste management, lack of green spaces, lack of soft infrastructures, noise pollution, police accountability, public health crisis, public safety & security, quality of education, quality of life, social isolation, substance abuse, traffic accidents, traffic congestions, unemployment, walkability, water quality, youth unemployment); 7) Global problems (problems that require international cooperation as they span borders); 8) Intractable problems (root problems that appear to be difficult to solve due to their overall complexity, pervasiveness or entrenchment like, corruption, crime and violence, discrimination, disease, injustice, pollution, poverty, racism, war and conflict). These are broad problems that have received much attention without any clear solution (Spacey, 2023).

As Richard Feynman (n.d.; in O'Leary, 1999) states that "we are the very beginning of time for the human race. It is not unreasonable that we grapple with problems…Our responsibility is to do what we can, learn what we can, improve the solutions, and pass them on". It was the 2000 Jury Conference on transdisciplinarity that adopted and popularized a more pragmatic approach. Emphasizing its ties to the context (of a "real world" problem setting), participants agreed that transdisciplinarity "is an additional and mainly demand driven form of research" (Klein et al., 2001, p.8; in Jahn et al., 2012, p.2). The scholars gave emphasis to their studies on real world problems (Spacey, 2023), Repko (2012, pp. 33-38), Horlick-Jones and Sime (2004, p.445), Choi and Pak (2006, pp. 357-358), Jahn et al. (2012, p.2), O'Leary (1999), Stock and Burton (2011, p.1096), Mylonakou-Keke (2015, p.1892), and Klein (2017) and Nicolescu (2012) paid attention on complex problem whereas Pohl and Hirsch Hadorn (2008) gave emphasis on complexity of problem, human problem and life-world problem.

Life-World Problems

According to Pohl and Hirsch Hadorn (2008), life-world refers to the human world prior to scientific knowledge. While philosophy (led by Edmund Husserl who coined the term) uses this concept within the framework of both phenomenology and constructivism as a possibility of critiquing and explaining science, Schütz's interpretive sociology links 'life-world' with the concept of the everyday world as a system of meaning: 'Life-world' can be described as the structural properties of social reality as grasped by the agent (pp. 428-429).

The term 'life-world' is used for what the phenomenologist Edmund Husserl (1859-1983; in Hirsch Hadorn et al., 2008, p.20; Kunwar, 2021, pp. 103-104) called 'Lebenswelt'-meaning the ongoing lived experiences, activities and contacts that make up the world of an individual or cooperate life. Alfred Schütz (1899-1959; in Hirsch Hadorn et al., 2008) introduced the term 'life-world' into sociology to describe the structural properties of social reality as grasped by the agent-the agent's life-world (Schütz & Luckmann, 1973; in Hirsch Hadorn et al., 2008). Jürgen Mittelstraß used the term in defining 'transdisciplinarity' as a form of research that transcends disciplinary boundaries to address and solve problems related to the life-world (Mittelstraß, 1992; in Hirsch Hadorn et al., 2008).

The *'Handbook of Transdisciplinary Research'* focuses on transdisciplinary as a form of research that is driven by the need to solve problems of the life-world. Transdisciplinary research develops descriptive, normative and practice-oriented knowledge in order to help solve, mitigate or prevent life-world problems. A problem-field (e.g., violence, hunger, poverty, disease, environmental pollution) refers to an issue in life-world (Pohl & Hirsch Hadorn, 2008).

Complexity of Problems

In transdisciplinary research a problem of the life-world is framed as a node in a web of heterogeneous factors. Taking into account the complexity of a problem means addressing interrelations among the social, natural, technical, legal, etc. factors that constitute the problem and might influence the impact and acceptance of proposed solutions. The situation is complicated, since interactions among factors may change over time. So, ideally, the dynamic interdependencies of a range of empirical insights, value orientations and policy options (such as technologies, economic incentives and regulations) are captured (Pohl & Hirsch Hadorn, 2008, p.114).

The transdisciplinary challenge with complexity of problems is that of inter relating the broad range of factors to come up with an integrated understanding of the problem and integrated suggestions for dealing with the problem. Therefore, Jantsch (1972)

and scholars after him (Bammer, 2005; Robinson, 2008; Pohl & Hirsch Hadorn, 2008) consider systems thinking, whether hard or soft, to be a constituting conceptual basis of the transdisciplinary research perspective. As far as systems theory (Midgley, 2003; in Pohl & Hirsch Hadorn, 2008) (an overview) is considered to be a discipline – namely in the sense of a formal discipline that can be applied to a wide range of problems– systems thinking is a disciplinary contribution to the transdisciplinary challenge of integration (Pohl & Hirsch Hadorn, 2008).

It was Jantsch (1972) who used systems theory while discussing about transdisciplinarity (pp. 105-106; in Pohl & Hirsch Hadorn, 2008, p.113) when it was being held forward as a grand synthesis of knowledge (integration of knowledge; Jantsch, 1972; in Pohl & Hirsch Hadorn, 2008, p.29; Oloruntimilehin, 2020). As far as systems theory is concerned, Checkland (1995; in Mylonakou-Keke, 2015, p.1897) approaches every system as a whole; it studies the interactive and interdependent connection of the parts of its subsystems and acknowledges that different properties from just the some of the parts emerged from the whole.

Conclusion

Learning by knowing is an impetus for understanding disciplinarity and transdisciplinarity. Disciplines are not static but are dynamic; however, disciplines can be intellectually messy. They have roots in diverse intellectual traditions, complex internal structures and fuzzy boundaries. Disciplines provide scientists with frame of references, methodological approaches, topics of study, theoretical cannons, and technologies. Though there are many types of disciplines, Bardecki (2019) has identified twelve disciplines. However, the scholars seem to be following three key-concepts such as: multidisciplinarity, interdisciplinarity, and transdisciplinarity (Darbellay, 2005; Huutoniemy, Thompson Klein, Bruunc, and Hukkinena, 2010; Piaget, 1972; in Darbellay, 2020, p.236).

The discourse of transdisciplinarity has expanded and shifted since its origins in the early 1970s. The 1990s brought a landmark in the field of transdisciplinarity as a problem field that plays the role for solution through collaboration and teamwork of different academics, researchers, practitioners, non-academics such as civil society, organizations and other stakeholders from the life sciences, social sciences and humanities (Augsburg, 2014, p.244).

In transdisciplinarity, the traditional boundaries of disciplinary research are transcended to converge inherently different disciplines to form a new unified framework beyond the discipline. The goal of transdisciplinarity is to have an understanding of the present world through the unifying of knowledge and the solution of mega and complex

problem by drawing on and seeking to integrate disciplinary and stakeholder views based on some overarching theory (Oloruntimilehin, 2020). Transdisciplinarity "represents the highest form of integration"; it involves "the application of crossdisciplinary concepts as well as scholars from multiple disciplines to combine knowledge and skill from diverse disciplinary domains" (Dellaportas et al., 2022; Oloruntimilehin, 2020). Multidisciplinarity and interdisciplinarity have this in common: they seek to overcome disciplinary monism. "Transdisciplinarity is perhaps above all a new way of thinking about, and engaging in, inquiry" (Bernstein, 2015, p.1). Transdisciplinarity integrates the natural, social and health sciences in a humanities context, and transcends their traditional boundaries. […] (Choi & Pak, 2006, p.351, 359). Hirsch Hadorn et al. (2010), as cited by Enengel et al. (2011) write more recent contributions emphasized 1) addressing life-world problems, 2) promoting the common good, and 3) integrating non-academic actors in knowledge generation. Transdisciplinarity remains "a rather elusive concept that continues to evolve (Jahn et al., 2012, p.1; McGregor, 2015).

Mode 1 knowledge production, which has always existed, and Mode 2 knowledge production, a new Mode that is emerging next to it and is becoming more and more dominant. Mode 2 knowledge consists of: 1) knowledge is generated in a context of application; 2) transdisciplinarity; 3) knowledge is produced in a diverse variety of organizations, resulting in a very heterogeneous practice; 4) Reflexivity; and 5) Novel forms of quality control.

Transdisciplinarity concerns that which is at once *between* the disciplines, *across* different disciplines, and *beyond* all disciplines. Its goal is (a) the understanding of the present world, of which one of the imperatives is the unity of knowledge, and (b) the solution of mega and complex problems by drawing on and seeking to integrate disciplinary and *stakeholder views* on the basis of some overarching theory (Parker, 2016).

Alfonso Montuori (2008, p.ix; in Bernstein, 2015) writes "Transdisciplinarity is perhaps above all a new way of thinking about, and engaging in, inquiry". In fact, there is no transdisciplinarity without disciplinarity. In spite of this fact, the above considerations provoked, around 1990, a more or less violent war of definitions. This war is not yet finished (Nicolescu, 2010, p.20).

Problem field has become one of the integral parts of transdisciplinary studies. For the first time, Rittel and Webber (1973) invented the concept of tamed and wicked problems. Later on, the concept of real world problem, complex problem, and life-world problem received academic platform for research. These problems were studied by several scholars within the framework of public policy and policy research for problem solution through collaborative work. This study suggests carrying out further research on the same subject.

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