Gregor TORKAR,[*] Sue L. T. McGREGOR[**]

EMERGING TRANSDISCIPLINARY THINKING IN SCIENCE: LESSONS TO BE LEARNED AS WE STRIVE FOR SOCIETAL TRANSFORMATION

Abstract: This paper focuses on the transdisciplinary methodology in scientific communities and aspires to synthesize the common ground ideas that might facilitate the present need for transformation to a new (not yet fully defined, agreed or envisioned) society. The intent here is not to discuss the fundamentals of a new society, although this will clearly contribute to the discussion. The main goal is to dialogue about how to create a fertile ground for the growth of human knowledge and wisdom contributing to a cultural (re)evolution. The first part provides a brief tour through histories of societies from different continents, which were following different courses because of differences in their physical environments. The goal here is to reveal the main downsides which emerged in human evolution and history, leading to the present ecological crisis. This attempt is not meant to pinpoint the blameworthy, but rather to show the value of human–nature co-evolution. Building on this discussion, the second part of the paper shares the new idea of stakesharing in societies. Almost everyone is familiar with the term stakeholder, referring to someone who can affect, or can be affected by others and their decisions. To have a stake in something means people share or have an involvement in it. The term stakesharer was coined to reflect the idea that, within transdisciplinary work, people with a stake in the outcome share information as they try to stake out a collective response to human–nature interface problems. The last part of the paper introduces some examples of transdisciplinary methodology that are being used in scientific communities (e. g., Directory of open access journals, bisociations, the all results journals). Described transdisciplinary discourse provides a permanent possibility for the evolution of scientific knowledge which is of great importance in order to tackle the complexus of interrelated global issues around human living and survival (=sustainability).

Key words: *transdisciplinary, science, stakesharer, knowledge, sustainability, society, transformation*

[*] University of Nova Gorica, Laboratory for Environmental Research, Nova Gorica, and University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

[**] Mount Saint Vincent University, Nova Scotia, Canada

INTRODUCTION

The global community is nowadays confronted with many complex environmental challenges and people need directions on where to go and how to get there; the same is true for the science community. This paper focuses on the transdisciplinary methodology in scientific communities and aspires to synthesize the common ground ideas that might facilitate the present need for transformation to a new (not yet fully defined, agreed or envisioned) society. The natural sciences, the social sciences, medical and engineering sciences, and the humanities all provide knowledge about causes, effects and mitigation of environmental problems [1]. Despite that, the substantial capacity of the scientific world is, to certain extent, paralyzed and often a hostage of external pressures or influences, financial dependency, exclusivity or even self-censorship. Science and scientists are losing their position in public as trustees of reason. In order to regain this necessary role in present society, science must tackle new global challenges differently. Einstein pointed out that "we can't solve problems by using the same kind of thinking we used when we created them." Transdisciplinarity or transdisciplinary methodology can complement traditional disciplinary approaches in science in order to tackle the complexus of interrelated global issues around human living and survival.

The intent here is not to discuss the fundamentals of a new society, although this will clearly contribute to the discussion. The main goal is to dialogue about how to create a fertile ground for the growth of integral scientific knowledge and consequently contributing to a cultural (re)evolution, informed by a transdisciplinary methodology (and related philosophical axioms: ontology, logic and epistemology).

1. GLOBAL EXISTENTIAL CHALLENGES

Natural capital (natural resources and services) has always been the physical basis for the existence of societies and their economies. In general, the amount of natural resources extracted is increasing; in just the last 30 years, humans have extracted and used 50% more resources than in the past. The level of resource consumption per capita has also grown substantially in human history: from hunters and gatherers to agrarian to industrial society (e. g., hunter/gatherer 3 kg/day per capita, agrarian society 11 kg/day per capita, industrial society 44 kg/day per capita, a 1,360 percent increase). Natural resources are also unevenly consumed around the world; ranging from 10 kg/day per person in Africa to 100 kg/day per person in Oceania [2]. The global human population is 7 + billion at the moment and growing. This basic information about human–nature co-evolution can already induce a discussion about regularly asked question by journalists to environmental scientists about the human future: "Do you imply humans should go back and live in the caves?" Starting from the numbers presented above, prehistoric societies of hunters and gatherers had a substantially lower impact on the environment than representatives of the industrial societies. However, this fact doesn't imply we should all go back and become hunters and gatherers.

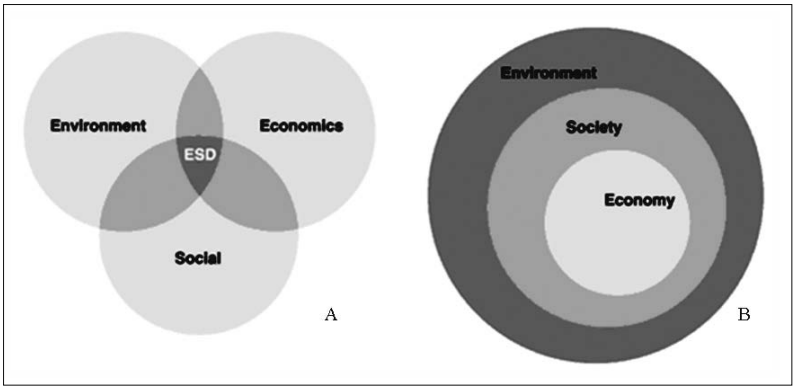

Figure 1. Two interpretations of sustainability dimension

The human history of the last 13,000 years was convincingly described by Pulitzer Prize winning author Jared Diamond in the book *Guns, Germs and Steel* [3]. Diamond explained that histories of societies from different continents followed different courses, because of differences in their physical environments. Physical environment is the limiting factor shaping the society (i. e., some societies remained hunters-gatherers and others transformed into industrial societies). This finiteness of natural capacity forces us all to think about the limits of our societal and economic development. It also explains the main downsides, which emerged in the last centuries of human history, leading to the present ecological crisis. Neglecting traditional environmental knowledge and wisdom of sustainable human (co)existence within the local physical environment, and embracing blind faith in technological developments, lead to the unsustainable use of natural resources and services.

Sustainable use or sustainability should always be conceptualized within the framework of time and space. The meaning of sustainable use is often not clearly defined even by environmentalists, because it is a difficult concept [4]. It is useful to think about sustainability as concept with three main components – biological, social and financial (economical) [5]. Biological (environmental or ecological) sustainability implies that the activity does not compromise the integrity of biological systems. Social sustainability requires cultural appropriateness, as well as social and institutional long-term support. Financial (economical) sustainability implies that activity outcompetes unsustainable alternative activities in profit-making [6].

Sustainability is most commonly interpreted as each of the three sustainability components with equal weight whereas others perceive that economy and society are only subsets of the environment (i. e., ecological system). Regarding the former, Strachan [7] noticed that people perceive three system circles of the same size (i. e., a Venn diagram) (Figure 1, example A) as balanced or trade-offs between social, economical and ecological systems. He explained that the concept of so called "nested systems", where there is a hierarchy of interconnected systems (Figure 1, example B), is also an aspect of systems thinking, which is important for concep-

tualising sustainability from a systems perspective. From the point of our discussion, this differentiation not only plays an important role in understanding human dependence on natural resources (ecological limits) but also in suggesting decision-making processes and providing guidance for sciences in our striving for societal transformation.

2. EMERGING TRANSDISCIPLINARY THINKING IN SCIENCE

Transdisciplinarity thinking is gradually emerging in science. In the process of showing examples and outcomes of transdisciplinarity in the world of science, the three pillars (axioms) of Nicolescuian transdisciplinary methodology will be explained: ontology (Multiple Layers of Reality mediated by the Hidden Third), inclusive logic (the Logic of the Included Middle), and epistemology (knowledge as emergent and complex) [8, 9].

Almost everyone is familiar with the term stakeholder, referring to someone who can affect, or can be affected by, others and their decisions. Stakeholders often do not share a unified view and therefore do not always or readily see the need for peacefully linking multiple interests. What is taken to be "true" depends on the framework of knowledge and assumptions brought in by individual and his or her personal context. Knowledge, including scientific, is configured into the practices of individual subjects [10]. In the process of identifying stakeholders, those affecting or affected by a project, issue or event are identified. Apart from rare radical ecologists (e. g. deep ecology), stakeholders in decision-making process are representatives of socio-economic interests; however, as described above (Figure 1), the environmental (ecological) dimension is a fundamental limit, which defines and is limited to the development of socio-economic systems. Each stakeholder in the community stands on its own position (ground) and holding (perceiving) about the environment, land, resources or knowledge as appropriation in the service of individual (group) interests (e. g. profit making).

Gomez Salzar [10] argued that decisions made in the political, social, technoscientific and economic spheres do not usually consider the complexity of the interactions among the elements that constitute existence conditions. Nowadays, the dominant understanding of the world is as mere property in comparison to past indigenous understandings of it as a living space. We have "to re-orientate and re-educate ourselves as beings *in*, and *of*, the world, as embodied fields of consciousness participating in an indeterminate flux of chemical, biological and cultural interactions" [11, p. 185]. Danvers argued that we need to move away from the seventeenth century world perception of Descartes, who emphasized the separateness of things and the ultimate importance of rational thought as a way of understanding the world, an analytical and 'objective' form of understanding. We need to move towards inclusiveness, connections and interdependence as well as (inter)subjective forms of understanding the world.

Descartes-informed methods of decision-making in societies are no longer satisfactory in addressing important ecological (conservational) issues, because they lead

to a constant trade-offs and, inevitably, to depletion of natural capital. Recognizing this reality, the term *stakesharer* was coined to reflect the idea that, within transdisciplinary work, people with a stake in the outcome share information and perspectives as they try to stake out a collective response to human–nature interface problems (see [12]). This approach assumes that humans can endogenously adopt norms of trustworthiness and reciprocity in contexts where there is a higher probability that they can share something [13].

The essential contribution of transdisciplinary methodology to decision-making processes is the assumption that there are multiple layers of reality that interact with each other [14, 8]; therefore, reality depends on how we configure knowledge. Cicovacki [15, 16] pointed out that traditional theories of truth are onesided and inadequate. It is not that they completely miss the nature of truth; rather, they capture only a few relevant aspects and disregard all others. To gain a more holistic notion of truth, scientists, dealing with complexus of interrelated global issues around human living and survival, should embrace the role of being stakesharers – balancing different logics, values, ways of knowing and functioning on many different levels of reality (e. g., political, economic, social, ecological, spiritual, cultural) (Axiom 1, ontology) [8].

By embracing different logics as legitimate (e. g., deductive, inductive, abductive, exclusive, inclusive), our basic assumptions about the nature of reality come under question and are shared with others to overcome a fragmented approach to the problem. Axiom 2 in a transdisciplinary methodology deals with the Logic of the Included Middle. Those stakesharers engaged in collectively addressing complex problems come together in the fertile middle ground where their energies and perspectives meet. With a willingness to remain open to others' perspectives and viewpoints, synergy can evolve and complex new, transdisciplinary knowledge can emerge, thanks in part to the use of inclusive logic (nothing is excluded because it may be necessary to solve the problem). Disparate ideas are woven together, thanks to intellectual fusion and a deep respect for the tensions that arise during chaos (new order emerging, just not predictably) [14, 17].

Axiom 3 pertains to epistemology, with transdisciplinary knowledge characterised as complex, emergent and alive, always in-formation [8]. The recognition that there is no single form of rational behaviour or approach to obtain valid knowledge is based on a pluralistic understanding of knowledge, which rejects absolute rationality and extreme relativism [10]. Sharing and creating knowledge and understandings are vital for the sustainable use of natural resources. All actors have uniquely different perspectives as to what is a problem and what constitutes improvement. Fragmented disciplinary research, and even multi and interdisciplinary inquiry, remains fixed on a few aspects of reality and does not attempt to understand it as a whole [16]. In transdisciplinary research, people from a variety of disciplines and from diverse sectors of society meet and exchange information and knowledge [8, 1]. This exchange includes dialogue amongst scientists from different disciplines and actors from civil society where the problems of the world are challenged.

3. TRANSDISCIPLINARITY IN ACTION

From a very pragmatic stance, what might this transdisciplinary knowledge creation look like in academic research and knowledge dissemination? First, in the last two decades, several high quality directories of open access journals have arisen and have accomplished the sharing of knowledge in science without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself [18]. The Internet is a powerful new technology for instantly sharing information thus enabling the formation and sharing of new knowledge. There are of course some disadvantages to open-access venues, which can be overcome with efficient peer review systems. In this spirit of forward thinking, the *Directory of Open Access Journals* (DOAJ) aims to be comprehensive and cover all open access scientific and scholarly journals that use a quality control system to guarantee the rigour of the content. The DOAJ team select scientific or scholarly periodicals that give access to full text, of all languages, free to use exercising peer review or editorial quality control and use a funding model that does not charge readers or their institutions for access [19], although authors often have to pay to get published. From a transdisciplinary perspective, open access models have the potential to contribute to the emergence new knowledge that is at once in between, across and beyond different individuals, disciplines and societies [9].

Second, transdisciplinary thinking is embedded in recent initiatives in science to pay more attention to the research studies that allegedly failed to produce 'useful' results. At present, more than 60% of experiments fail to produce results or expected discoveries. This high percentage of 'failed' research generates high level knowledge. But generally, all these experiments have not been published anywhere as they have been considered as useless for research targets. Ironically (but so transdisciplinarian), failures *can* be viewed as valuable pieces of information in science and a vital key for development in science. The main objective of the *All Results Journals* (ARJ) is recovering and publishing those experiments that either failed or led to "unexpected" results [20]. They also have an open access policy. These journals provide immediate open access to their contents on the principle that making research freely available to the public supports a greater global exchange of knowledge; the true spirit of transdisciplinarity.

The last example is bisociations (not mere associations). Bisociation refers to the mixture of concepts from two contexts, categories of objects or frames of thought that are *normally* considered separate by the literal processes of the mind [21]. According to Koestler [21], bisociation means to join unrelated, often conflicting, information in a new way. He coined the term in order to make a distinction between the routine skills of thinking of a single 'plane' (Figure 2, rigidity) and a creative act that always operates on more than one plane (Figure 2, resourcefulness). Bisociations, *or context-crossing associations*, are used in nonstandard text mining tasks of cross-context link discovery [e. g. 22, 23, 24]. Petrič at al. [24] showed that detecting interesting outliers, which appear in the literature on a given medi-

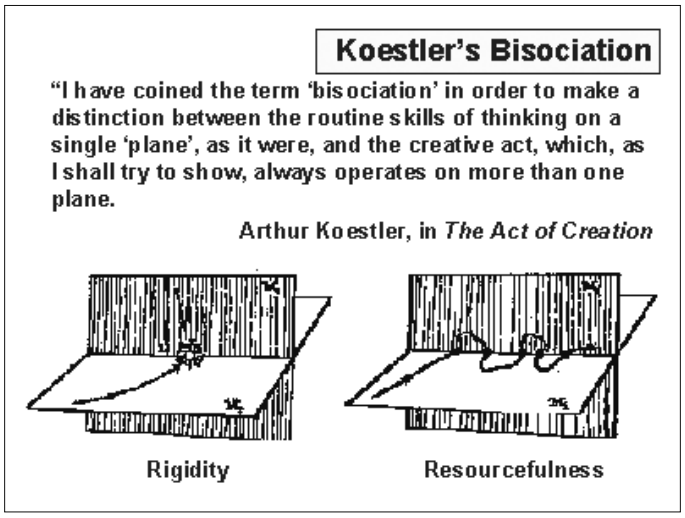

Figure 2. Koestler's bisociation [21]

cal phenomenon, can help the expert to find implicit relationships among concepts of different domains.

To explain, consider that the majority of articles in a given scientific domain describe matters related to a common understanding of that domain. Exploration of outliers leads to the detection of scientifically interesting *bridging concepts* amongst disjoint sets of scientific articles. This bridging allows the emergence of new transdisciplinary knowledge. *Trans* means zigzagging back and forth, moving across, going beyond existing boundaries [12]. In transdisciplinary research, members of different cultures interact to co-create knowledge. Co-creation of knowledge in this context is a collaborative process of knowledge generation and/or production that involves two or more scientific disciplines [1] and societal sectors [8]. The term co-production in this context stands for "simultaneous production of knowledge and social order" [25, p. 401].

In order to be able to join unrelated, often conflicting, information in a new way [21], people must accept the existence of multiple realities that interact with each other. By accepting multiple realities, scientists addressing sustainability issues can communicate more efficiently to each other and produce alive, dynamic, in flux, moving and perpetually changing middle ground knowledge using the Logic of the Included middle (Axiom 2) [9]. This logic holds that there is a middle ground if people accept that different actors have different perceptions of things. This logic can be applied in cross-context link discovery. By detecting interesting outliers, which appeared in the text mining Petrič et al. [24] showed how this fertile shared space, that transdisciplinarity manifested, generated new complex knowledge – Axiom 3, knowledge as complex and emergent [9].

If we accept that the world and everything in it is dynamic, evolving and always in-formation, our knowledge, explanations and definitions gain nonpermanent status [12]. The word 'information' changes to the hyphenated version of 'in-formation' (=in the process of formation), revealing the nature of nonpermanent (evolutionary) status of knowledge in transdisciplinarity. Transdisciplinary discourse provides a permanent possibility for the co-evolution of scientific knowledge, which is paramount for transformation to a sustainable global society.

CONCLUSION

The intent of "taking the hold away" from stake*holders* is to enable new types of scientific knowledge to emerge through complex and integrated, mutually-learned insights of researchers in science sharing knowledge (i. e., stake*sharers*). Some examples of transdisciplinary methodology, which are gaining ground in scientific communities, were presented in this paper (e. g., directory of open access journals, bisociations, the all-results journals) and we hope that there will be more to report in the future years. By applying a transdisciplinary methodology, all theories at any given Level of reality have the potential to become *transitory theories*, which are open to change when confronted with contradictions from other, even new, Levels of Reality [14, 17]. The transdisciplinary approach in science can help us tackle the complexus of interrelated global issues around human living and survival (=sustainability).

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