TRANSDISCIPLINARY COMMUNICATION: INTRODUCTION TO THE SPECIAL SERIES

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OVERVIEW TO THE SERIES

What is transdisciplinary communication? We start with this question because it is the central focus of this Special Series on Transdisciplinary Communications; one that various authors grapple with in different ways. However, we also start with it because there is no clear definition of transdisciplinary communication. Communication problems are cited as one of the most significant impediments to effective cross-disciplinary collaboration (Hinds & Kiesler, 1995; Javenpaa & Leidner, 1999; Lievens & Moenaert, 2000; Ross et al., 2010; Stokols, 2014). Yet the systematic empirical study of communicative processes in transdisciplinary collaborative settings is rare. The purpose of this Special Series is threefold: (1) to problematize communication in transdisciplinary team contexts; (2) to confront the principal issues that face practitioners and scholars of transdisciplinary collaborations; and (3) to suggest frameworks and cases that move the discussion closer to constructing definitions of transdisciplinary communication.

In this introductory piece, as is customary, we will offer a synoptic account of contents of this Special Series and summaries of the material contained within. We will go a step further, however, to reflect on the initial question we posed and construct a working definition of transdisciplinary communication by identifying common threads in these contributions and weaving them together to come to an understanding of the key dimensions and goals of transdisciplinary communication.

TOWARD A WORKING DEFINITION OF TRANSDISCIPLINARY COMMUNICATION

Defining transdisciplinary communication (TDC) must necessarily start with a definition of transdisciplinarity. Scholars, including the authors of this Special Series, differ in their definitions and understandings of transdisciplinarity. In line with a significant body of scholarly work (Brown, Harris, &

Russell, 2010; Hirsch Hadorn et al., 2007; Jones, Wuchty, & Uzzi, 2008; Klein, 1996, 2014; Nicolescu, 2002), in the opening article of this Special Series, *Transdisciplinary Knowledge Producing Teams: Toward a Complex Systems Perspective* (Lotrecchiano & Misra, 2018), we define transdisciplinarity as *knowledge production* through *integration* and *collaboration* in the *pursuit of addressing complex societal problems*. Transdisciplinarity, therefore, is *team-based*, including a variety of academic, non-academic, and community members. Transdisciplinary (TD) teams address *issues that have far-reaching societal implications* (e.g., environmental denudation, climate change, health disparities). Finally, TD work must *result in the production of knowledge* that *integrates* perspectives, worldviews, theories, methods, or tools and *translates* to resolutions to the problem. Using Complex Adaptive Systems as a meta-theoretical framework, we develop a typology of the features of TD knowledge producing teams. In understanding the barriers to integrative knowledge production, we distinguish between *interactive systemic complexities* (interpersonal challenges to integrative knowledge production) and *structural systemic complexities* (structural or systemic barriers to integrative knowledge production).

Integrative knowledge production is the primary outcome of TDC. Communication is, therefore, not merely a component or factor in the structure and functioning of TD settings, but the essence of these endeavors. The distinction between interactive and structural systemic complexities in TD settings also points to two other characteristic features of TDC. First, the emergence of integrative knowledge through TDC results in both *individual and team level cognitive shifts in understanding the problem*. Second, this shift unfolds through an *iterative process of interpersonal interaction, observation, and reflection*.

Two articles study the nature of this cognitive shift in different settings, contexts, scales, and using different methodologies, but they underscore a common critical feature of TDC --- *thinking collectively*. In *What is Collaborative, Interdisciplinary Reasoning? The Heart of Interdisciplinary Team Science*, Bethany Laursen (2018) scrutinizes this cognitive shift at the individual and team level by analyzing the conversational transcript of a multidisciplinary team of researchers addressing a scientific problem. She develops an operational definition of *collaborative interdisciplinary reasoning* as a process of synthesizing disciplinary perspectives through assertions, evaluations and exchanges of claims at the individual level, which enables *shared understanding and action at the team level*. She also demonstrates a method for analyzing communicative processes in cross-disciplinary collaborative settings through what she calls pragma-dialectic argument reconstruction.

Chitvan Trivedi and Shalini Misra's paper (2018), *Dialogue and The Creation of Transformative Social Change: The Case of Social Enterprises* examines the role and nature of TDC in trans-sector TD collaborations through a grounded theory methodology. Aligned with Lotrecchiano and Misra's (2018) definition of TD knowledge producing teams, trans-sector TD problem-solving collaborations include stakeholders from a variety of societal sectors (non-profits, NGOs, community members, academics) and focus on solutions to complex social problems through deliberative democratic practices. Social enterprises are one such type of trans-sector TD problem-solving collaboration. This multi-level and contextual analysis finds that two conditions are necessary for integrative knowledge production leading to the creation of positive social change. The first is an *organic organizational structure*, which promotes unencumbered intra-organizational information exchange, high level of decisional autonomy, and the ability for organizations to adapt quickly to environmental changes. The second condition is *dialogue*, or open, deep and continuous interpersonal communication among all members of the problem-solving team. This study finds that these two conditions in combination result in the emergence of *organizational learning*, or the collective capacity of the organization to make sense of and respond to internal and external changes (Crossan, Lane, & White, 1999; March, 1991; Yukl, 2009).

Specific communication practices, like the use of metaphorical language, the activation of organizational values and norms, and the free flow of meaning in settings designed to encourage open interpersonal exchanges to promote *sensemaking or the process of collective thinking* lead to insights that could not be attained individually (Trivedi & Misra, 2018). *Sensemaking could be considered a form of cognitive shifting in which one's own tacit knowledge, assumptions, and beliefs become explicit through dialogue and reflection.*

This individual-level cognitive shift, in turn, leads to changes in organizational routines and the emergence of collective or organizational knowledge or wisdom. Thus, we make further progress toward our working definition of TDC by developing further understanding of the nature of the cognitive shift involved in this process. *Transdisciplinary communication entails collective thinking or sensemaking, resulting in the transformation of tacit knowledge to explicit knowledge, which in turn leads to organizational learning.*

The next two articles consider the role of leadership in communication within TD scientific settings. Using complex adaptive systems as the meta-theoretical framework and ethnography as the method, Elina Mäkinen's (2018) study of a newly formed TD medical research center, *Complexity Leadership Theory and the Leaders of Transdisciplinary Science*, found that leadership orientations, roles, and practices are key to *collective thinking* and *organizational learning*. She concludes that the *entanglement*, or the creative and situationally defined combination, of different types of leadership roles and practices to foster interdependency among team members are critical for the emergence of *shared adaptive dynamics*. Shared adaptive dynamics are feedback loops of information and knowledge that flow through individuals and units across multiple levels of the organization. Supporting Trivedi & Misra's (2018) conclusion that non-hierarchical and fluid organizational structure that promotes interdependency between individuals and units and the free flow of information is a fundamental contextual factor for TD complex problem solving, Mäkinen's study found that the inability of leaders to foster interdependencies between members of multidisciplinary teams impeded collective thinking. If leaders become the primary knowledge translators and brokers in newly formed cross-disciplinary science teams, they tend to become the focus of integrative knowledge creation, hindering the creation of collective knowledge across all levels of the organization. A hypothesis that arises from this study is whether the inclusion of knowledge brokers, translators, or connectors at different levels of the organization, especially during the early stages of a collaboration can promote TD communication and collective learning instead of the sole reliance on one leader.

Maritza Salazar and Teresa Lant's (2018) research examined another aspect of leadership in enabling TDC – the intrapersonal qualities of the leaders. In the article, *Facilitating Innovation in Interdisciplinary Teams: The Role of Leaders and Integrative Communication*, they studied leadership qualities in 52 multidisciplinary medical research teams. They found that leaders who are moderately experienced and well versed in a variety of areas other than their own discipline and have a breadth of research and practice-based experience are best able to manage interactions in cross-disciplinary team settings. In team settings characterized by a diversity of disciplinary expertise, no history of collaboration with each other, and little overlapping expertise, leaders who possess a *multidisciplinary breadth of experience* can enable TDC. They are better able to promote interdependencies among team members by choosing cross-disciplinary research topics, drawing attention to the expertise of team members, stimulating information sharing among team members, and summarizing and synthesizing different ideas during interactions. Indeed, teams with leaders with just the right amount of multidisciplinary breadth of experience created more innovative outcomes compared to leaders of teams who had too little or too much multidisciplinary breadth.

A pair of articles, written by Megan Potterbusch and Gaetano R. Lotrecchiano (2018) and by David Lebow (2018), explores the potential of digital technologies for promoting TDC and research on communicative processes within multidisciplinary teams. Potterbusch and Lotrecchiano's concept article entitled *Shifting Paradigms in Information Flow: An Open Science Framework (OSF) for Knowledge Sharing Teams* challenges the traditional, linear, and opaque scholarly information workflow and outlines the potential of Open Science as a new paradigm for communication and collaboration. They contend that open science-based digital tools and technologies can facilitate knowledge integration by promoting workflow transparency. Digital records of online interactions and digital artifacts created during the course of collaboration have the potential to open new avenues of communication, ease information flow across disciplinary lines, promote information exchange, and enhance trust among team members because of the increased transparency afforded by such tools. Further, these digital records present a new way of gathering evidence about the commu-

nicative processes and outcomes of team interactions over time. Certainly, acceptance of new technologies and readiness and competence in using them, attitudes toward transparency and sharing information, and access to the human and material infrastructure needed to support open science technologies are critical contextual factors that can constrain or facilitate the effectiveness of open machine-assisted technologies in enabling TDC.

While the Open Science Framework and associated tools and technologies focus on macro-level team interactions and workflow, David Lebow's (2018) social machine, called HyLighter, to aims facilitate knowledge integration in micro-level contexts, such as writing an integrative literature review. This tool, described in *A Social Machine for Transdisciplinary Research* is designed for collaborative sensemaking through offloading some of the cognitive effort that needs to be expended in integrating information, onto intelligent machines. According to Lebow, social machines have the potential to reduce cognitive overload inherent in TD collaborative efforts. Social machines can assist individuals and teams in their sense-making efforts by facilitating the identification of points of overlap or synthesis when dealing with large amounts of disparate pieces and types of digital information, typical of our digital ecology.

The Open Science Framework (Potterbusch & Lotrecchiano, 2018) and Social Machines (Lebow, 2018) introduce novel approaches to communication in cross-disciplinary settings, beyond face-to-face interpersonal interactions, which are commensurate with the realities of our increasingly digitally mediated socio-physical worlds. The utility, efficacy, consequences, as well as unintended positive and negative consequences of human-machine interactions in collaborative settings, is yet to be systematically explored and understood, but these articles challenge current paradigms to consider the potential of intelligent machines in encouraging collective thinking, sensemaking, and learning.

The final set of articles in this series are cases that examine processes that led to the creation of a TD curriculum in regulatory affairs (Drago, McDonald, & Lotrecchiano, 2018) and a university-based TD research initiative (Medina, Báez, & Méndez, 2018). Daniela Drago, Paige McDonald, and Gaetano Lotrecchiano describe how the process of mapping the global competencies required for students of regulatory affairs, a health sciences field, with the features of a TD knowledge producing team, as described in Lotrecchiano and Misra (2018), illuminated the need for training students in transnational competencies. Their paper, *Communicating Transdisciplinary Characteristics in Global Regulatory Affairs: An Example from Health Professions Education*, describes transnational competencies, including complex problem solving, information exchange across cultural, sectoral, national, and disciplinary boundaries, praxis or the interaction between theory and application, deconstructing and reconstructing interactions, and wide stakeholder involvement --- all features of TD knowledge producing teams from a complexity perspective.

Collaborative Transdisciplinary Research in a Small Institution: Challenges and Opportunities written by Nilda Medina, Loggina Báez, & Loyda Mèndez (2018) emphasizes the importance of continuous capacity building and collaborative readiness in their case study of the process of implementing a TD research initiative in a small, resource scarce, minority-serving, teaching intensive institution in Puerto Rico. Capacity building, meaning systemic institutional efforts to promote shifts in the power structure, providing the human, physical, and administrative infrastructure to promote TDC and collaboration, and settings and events that are designed to promote cross-disciplinary interaction and knowledge sharing are the most decisive aspects for the success and sustainability of TD research initiatives, according to this case analysis. The article highlights the macro-level principles, institutional environment, and practices needed to promote TDC and collaboration and outlines some of the barriers and challenges faced in this process. Some of these challenges correspond with TD collaborative efforts in other settings and contexts and others are unique to small institutions or severely exacerbated because of resource shortages. For example, small teaching intensive institutions do not have the critical mass of faculty members or the time for cross-disciplinary research collaborations, which are extremely time intensive. Medina, Báez and Méndez wrote this paper during the height of the crisis in Puerto Rico caused by Hurricane Maria in 2017. Their extraordinary determi-

nation and herculean efforts to complete this paper on time despite the insurmountable obstacles is a testament to their commitment to TD collaboration and communication.

Taken together, these nine articles illuminate the following about TDC:

(1) Integrative knowledge production, or the creative synthesis of theories, concepts, or methods toward the resolution of complex societal problems, is the primary outcome of TDC.

(2) TDC, therefore, has a central and constitutive place in TD collaborative endeavors and is not merely a component of it. TDC needs to be studied as a part of the ecology of TD collaborative settings since it is inextricably linked to leadership, organizational structures and routines, and institutional structures and practices and individual's dispositions to cross-disciplinary collaboration.

(3) TDC entails transformational cognitive shifts at both the individual and organizational levels. One feature of this cognitive shift is collective thinking or sensemaking, where one becomes aware of one's own tacit knowledge, assumptions, and beliefs and makes them explicit through assertions and claims, questioning of these assertions and claims, and providing explanations for one's claims. Open, deep, and continuous interpersonal interaction and reflection are essential for cognitive shifting to occur at the individual and organizational level.

(4) Integrative knowledge production is stifled if individual level cognitive shifts do not lead to shifts in organizational routines leading to the emergence of organizational learning or collective knowledge and wisdom. Organizational structure plays a decisive role in promoting collective thinking, sensemaking, and organizational learning. Organizational structures that facilitate shared adaptive dynamics or the free flow of knowledge and information through individuals and units across the organization promote TDC. Similarly, institutional capacity and readiness are macro-level features can promote effective TD collaboration and communication.

(5) Leaders play a critical role in promoting collective thinking and sensemaking. Leadership qualities, such their multidisciplinary breadth, and practices such as the ability to foster interdependencies between team members, their use of metaphorical language to make tacit knowledge explicit, their fostering of settings that encourage open interaction that activate organizational values are key to collective sensemaking.

(6) Finally, intelligent and democratic digital technologies have the potential to facilitate knowledge integration in cross-disciplinary collaborative settings by reducing the cognitive burden on individuals and making the information exchange between team members more transparent and equitable. The next generation of digital technologies also offers promising methods for the study of TDC and collaboration.

THE FUTURE OF THE STUDY OF TD COMMUNICATION

The implications of these conclusions are of no small consequence for they emphasize a holistic conceptualization of TDand an effort to reconcile prior relational and cognitive theories of communication in cross-disciplinary collaborative settings (Craig, 1999; Hall & O'Rourke, 2014; Keyton, 1999; Keyton & Beck, 2010; Keyton, Beck, & Ashbury, 2010; Klein, 2013). While relational theories of communication emphasize interactions that foster the social fabric of the team, cognitive theories focus on the generation of collective knowledge. The research reported in this Special Series indicates that TDC is the heart of TD collaboration and can be more completely understood within its ecological context. *Integrative knowledge production requires cognitive shifts at both the individual and organizational level and this process is dependent on coordinated acts of interaction, observation, and reflection across all levels of the organization.* Put in another way, and perhaps more provocatively, *transdisciplinary interactions open up third spaces of hybrid understanding and meaning as opposed to creating spaces of sameness in the minds of people* (Akkerman & Bakker, 2011; Gutiérrez, Rymes, & Larson, 1995; Soja, 1996). As is the case with all

human understanding and symbolic activity, this hybrid understanding emerges through reflexive dialogic processes (Bakhtin, 1981).

The articles in this Special Series contribute to the study of TDC in the following ways. They illuminate the content and quality of what is conveyed in these interactions; understand how they affect interpersonal relationships and organizational learning; explore the epistemic and interpersonal demands it places on leaders and members of TD collaborations; identify the institutional and organizational context for effective TDC; and consider the potential contributions of novel digital technologies in promoting knowledge integration.

In combination, these articles also raise a number of questions for the theory and empirical study of TDC. For example, **are there clearly distinguishable stages of communication in TD settings?** What challenges are specific to each stage of communication and what are the leverage points for interventions to address these communication challenges? Hall and O'Rourke (2014) distinguish between the stages in a TD project: *framing*, *launching*, *integrating*, *generating*, *deciding*, and *evaluating*. Decisions about who will be involved in the project and the scope of the problem are identified in the framing stage, followed by the launching stage when the project is initiated and the team is equipped to work together. The integration phase involves the crucial work of synthesis, which, if successful, leads to the generation of multiple problem-solving alternatives and decisions about directions to pursue. The decisions are evaluated to address project limitations or conclude the project. Communication features in each stage of TD collaboration are expected to be different and unique. For example, cognitive shifts from tacit to explicit knowledge may be most evident in the integrating and generating stages. However, what types of communication practices and routines support the synthesis stage? Are there certain types of framing and launching communication practices that better enable the integrative communication in the later stages of the collaboration?

Another related question ripe for theoretical exploration is whether different types of cognitive shifts are entailed in TDC and what types of tools, technologies, routines, and practices can facilitate transformative cognitive shifts. The literature on knowledge flow and boundary crossing between and within organizations may be useful in illuminating the nature of cognitive shifts in TD communication in the collaborative settings. *Syntactic knowledge boundary* refers to obstacles in the communication arising from the lack of shared language or terminology, the amount and nature of the knowledge held by individuals and units, and the relationship and interdependencies between different individuals and units (Carlile, 2002, 2004). All these features are characteristic of TD knowledge producing teams. Crossing *semantic knowledge boundaries* in this body of work refers to the creation of shared meanings by making tacit knowledge explicit, including previously unknown interdependencies between individuals and units. *Pragmatic knowledge boundaries* concern differences in the interests of individuals and units. Pragmatic boundaries can impede sharing and evaluation of knowledge and crossing them requires dialogue coupled with integrative processes or mechanisms. A taxonomy of communication boundaries in TD settings and the associated cognitive shifts would be helpful in the understanding and supporting TDC, including training the next generation of TD scholars and practitioners. Some initial ideas toward building a taxonomy of communication boundaries in TD settings, in addition to syntactic, semantic, and pragmatic boundaries, include the following:

(1) *Experiential boundaries*: differences emerging from experiences and understanding of the problem under consideration, including whether one has first-hand experience of the problem or is merely studying the problem from a distance, and whether one has experience in cross-disciplinary collaboration

(2) *Methodological boundaries*: differences epistemological commitments and methodological orientations of team members

(3) **Spatial-temporal boundaries***:* communication barriers arising from the geographic dispersion of teams

(4) **Technological boundaries***:* communication challenges emerging from the lack of adequate and appropriate technological tools, human and physical infrastructure to support collaborative efforts

(5) **Institutional and organizational boundaries***:* communication challenges arising from the lack of the appropriate organizational structure and institutional framework and governance structures to support integrative knowledge production

(6) **Social and interpersonal boundaries:** communication problems resulting from different values, beliefs, attitudes, and conceptual knowledge and skills as well as different levels of cross-disciplinary communication competence

(7) **Political and ethical boundaries:** communication obstacles arising from differences in political and ethical questions related to the problem under consideration, the relationship between those questions, and the relative importance and prioritization of ethical and political questions

Such theory development efforts might also consider the synergistic impacts of these communication boundaries. Another topic for investigation is **the impact of the disciplinary, professional, cultural, and geographic breadth of the problem solving team and the scope of the problem being addressed have on TDC.** This preliminary list of communication boundaries can initiate exploration on the forms and processes of cognitive shifting needed for successful TDC. For example, it is possible that some types of cognitive shifting are more instrumental and pragmatic, such as understanding what a particular term or concept means in a certain discipline and being able to employ it in another disciplinary domain. Other types of cognitive shifting are emancipatory or transformative, such as feeling empathy for the experiences and perspectives of community members, thereby transforming the way one understands a particular question or problem.

A final related set of questions concerns **the conditions and specific mechanisms that can support TD communication.** For example, skillful intellectual leadership can promote inclusive communication and synthesis (Mäkinen, 2018; Salazar & Lant, 2018; Trivedi & Misra, 2018). The types of workflows, tools, and technologies that foster TDC is another potent area of research.

In sum, individual and organizational transformation and learning are the heart of TDC. The cognitive, interpersonal, organizational, and institutional dimensions of TDC are closely interlinked, and, therefore, TDC can be most completely understood in its ecological context through multi-level, multi-scalar analyses. We hope that this Informing Science Special Series on Communication in Transdisciplinary Teams stimulates more theory development and better and more relevant empirical research on communicative processes in TD collaborations. Much remains to be learned about this very important topic.

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