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Review Article

The Science-of-Team-Science, Transdisciplinary Capacity, and Shifting Paradigms for Translational Professionals

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Abstract

The Science-of-Team-Science (SciTS) has become an important area of study as collaborative research becomes more normative throughout science inquiry and especially in medical and healthcare sectors. Team science aims for higher and collaborative levels of inquiry that operate within economies of knowledge similar to transdisciplinarity that strive to synthesize knowledge and innovate as a result of newly developed and hybridized methods of approach. This newly becoming and normalizing mode of science will require professionals to be aware of and embrace the shifting realities which have been the consequence of this new economy of knowledge. The next century of inquiry will require new generations of translational professionals that are keenly aware of their role as part of the translational process no matter what role they presently play in the continuum of bench to bedside to storefront healthcare. This paper reviews the SciTS landscape and theories of transdisciplinarity. It also provides insights about the shifting paradigms currently occurring in the discourse and identifies challenges for translational professionals.

INTRODUCTION

Translational biomedical interests in transdisciplinary team science stem from growing expectations that through team collaborations outcomes otherwise unrealizable will result. "Efforts to foster greater collaboration among scientists trained in different fields are not only useful but also an essential strategy for ameliorating social, environmental, and public health problems" [1]. These multilevel concerns require a greater understanding and the employment of integration strategies so that transdisciplinary capacity can become more common amongst researchers and healthcare providers in their attempts at solving complex problems. Team science focuses on the functional aspects of this collaborative process, uncovering the social, political, functional, individual and organizational patterns that can inform more efficient and effective cross-disciplinary collaborations. It is this collaboration between different disciplines that requires interpersonal, inter-organizational and inter-network skill building as basic, medical, and health sciences focus on crossing disciplinary boundaries [1].

Transdisciplinary capacity is grounded within several important considerations of the Science-of-team-science (SciTS) like readiness about the social-ecological perspectives that go beyond traditional scientific hierarchies [2,3], the sustainability of teams [4], the training of transdisciplinary researchers [5-8], new team science models and methods [9-11] and the forging of new transdisciplinary partnerships across sectors [12]. All of these concerns and those continuing to emerge in the discourse are critical to effective translational medicine. In addition to the psycho-social and cognitive boundary crossings that these concerns entice, methods for research and practice must be retooled to measure the emerging complexity of collaborating teams so that the essence and dynamical elements embedded in team and translational enterprises can be further developed [13-15].

As scientists and practitioners begin to go beyond their own communities to include adjacent stakeholders like patients, advocacy groups, politicians, policy makers, philanthropists and the like, greater complexity emerges. Amidst the complicating factors that are inherent to this enterprise, new ones emerge that are the result of diversities of agendas, different world views, divergent timelines and urgencies, multiple methodologies, and a wider variety of reasons for collaborations. The science-of-team-science, transdisciplinary capacity, and the professional development needed for effective scholarship and leadership in this expanding field must be continually considered along these

factors if positive team outcomes and innovation are expected.

This paper will review some of the more salient theories from the science-of-team-science and explore transdisciplinarity as an avenue for building collaboration capacity. Shifting paradigms for translational professionals will also be presented.

The Science-of-Team-Science (SciTS)

While the team science terrain is vast, two main conceptual and methodological preoccupations emerge in the literature by which all others can be consolidated. First, team science *initiatives* are attempts to create collaborative and sometimes cross-disciplinary opportunities otherwise underrepresented in a scientific community or sector. The intent of these initiatives is for groups of scientists and project stakeholders to test the boundaries of a particular scientific community either through the bringing together of like-trained professionals who might not otherwise interface with each other or by the introduction of a broad range of stakeholders from multiple disciplines and social perspectives. Their goal is to consider complex problems utilizing multiple methodologies operating from different worldviews.

The evaluation of such teams is usually conducted through organizational, geographic, and/or analytic lenses attempting to isolate the achievements associated with novelty in dealing with certain problem solving barriers. The organizational scope is preoccupied with defining and encouraging intra-organizational and inter-sectoral partnerships as well as inter-organizational alliances. The geographic scope focuses on the community diaspora trying to understand how disparate and/or disconnected entities should be networked together to form a more consistent and efficient body. The focus of the analytic lens ranges from the *"molecular to the molar"* levels of analysis striving to understand better the broad context of the specific scientific community in question [16]. Each shares a concern for understanding the structures of the community while individually concerned with different measures of successful collaboration suggesting that the mechanisms of team science itself, devoid of any specific context, is a subject worthy of scientific study [16]. The team science diaspora can therefore be observed as pertaining to a number of concerns each contributing to different levels of inquiry as the concept map below illustrates (Figure 1).

This second evaluative consideration in the SciTS is a focus of inquiry that shifts away from the intentionality of collaboration, *the why*, to concerns about the effectiveness, antecedent conditions, and outcomes associated with team scientific collaboration—*how teams collaborate*. This line of inquiry focuses more so on the *dynamics* of the team science enterprise in the hopes of understanding more about the ecology of the endeavor and its most successful characteristics for further and future replication. "Identifying the most appropriate criteria for judging the effectiveness of transdisciplinary team science initiatives depends on the ways in which key dimensions of team performance and the essential qualities of transdisciplinary collaborations are defined" [16].

This level of team evaluation hosts a number of interests that not only point to the task of working effectively in teams but also focus on central tenants of team working [18-20]. Social psychology and management effectiveness has moved away

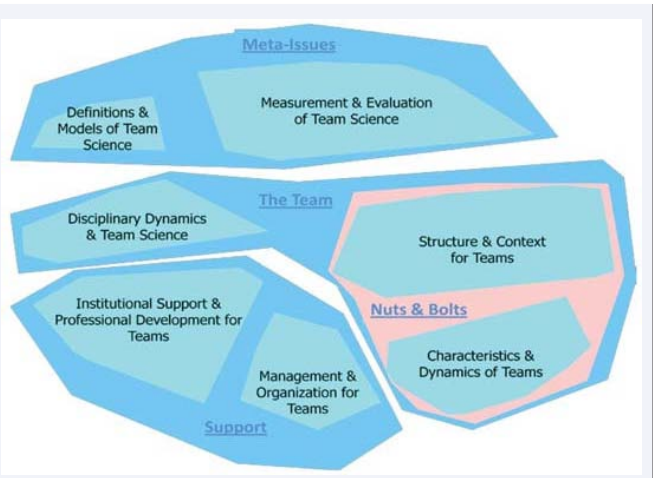

Figure 1 Science of Team Science Concept Map [17]. Science of Team Science Concept Map. This map summarizes clusters and regions of topics identified as important parts of a comprehensive research agenda for the SciTS.

from quasi-experimental approaches to include issues of team familiarity and social cohesiveness [21,22] highlighting that "good" or desirous performance reciprocates cohesion. Others report that team successes are less likely to be successful in some tasks as heterogeneous groups [23-25]. Some studies have found that this is partially due to emergent social behaviors that are bred through familiarity like social loafing, and "groupthink" [26,27] that may be deterrents to high performance.

Researchers have also focused on team size and physical environmental conditions in the hope of understanding team effectiveness. Teams require coordination for effectiveness without a causal connection between size and actual success rate. "As the work group gets larger, the leader is more likely to engage in initiating structure behaviors but no more likely to engage in consideration behaviors, and subordinates are more likely to be dissatisfied; as the leader engages in more leadership behaviors (of either type), subordinates are more likely to be satisfied" [28]. Others have suggested that major predictors to team effectiveness are grounded in variables like the degree of openness a team has to information, the degree of heterogeneity, and the team's size. They conclude that employee involvement programs (EIPs) can be instrumental in patching knowledge gaps between employees and managers, gaining greater heterogeneity and producing greater positivity toward EIPs, and that EIPs in themselves were useful predictors to how team members perceive effectiveness [29].

Leadership traits and behaviors have always been part of the team development discourse. This is mainly due to the multiplicity of definitions of leadership and the multiple layers of analysis that are possible and utilized in inquiry. Though leader-centric traits and behaviors and the primacy of their influencing role in sustaining interdisciplinary collaborations continues to be supported in contemporary literature [30-34] no direct linkages convincingly derive that leader-centric characteristics impact successful teaming [16]. This is mainly because of the shift in inquiry from individual-centric behavior and trait analysis to more systemic concerns that include the individual as part of

the collective mechanism. Shared vocabularies, metaphors, story-lines, intermediaries, and negotiation all serve as tools for assisting in collaboration and are useful to managers responsible for engaging collaboration. Leadership as a function of both interdisciplinary and transdisciplinary team dynamics is in need of further and future development.

Participatory goal setting ensures an awareness of group structure, belief, and simultaneous collective efficacy [21,27,35]. Communication patterns and their effect on group dynamics have been shown to be critical. The lack of adequate feedback has been shown to severely restrict team performance [27,36] while sustained communication between team members has been shown to encourage feelings of trust and safety [37] and to better equip teams to manage issues associated with size and cohesion [27]. These types of communication are not only internal (within group) but also across groups. Common vocabularies, cross-disciplinary activities, group research over individual endeavors, and debate about theory, methodology, and technique are in themselves maintenance variables to the team enterprise [33]. Factors like the relationship between homogeneity and group process and social integration are linked to the ability to set goals and "are likely to increase the frequency of communication among members and the attraction the members have for one another" [38].

Interdependence is shown to be a strong indicator of transdisciplinary team success. The interdependence of team members is directly related to successful outcomes of teams in achieving collective goals and rewards. When team goals are the product of both individual and collective performance separately, the team is understood as being a hybridized, participating with both individual and collective goal and reward systems [39]. As teams of scientists expand beyond traditional constructs of collaboration, technology-mediated collaboration precipitates certain standards of functionality. The need to attain and transfer data, maintain uninterrupted communication, address security, integrity and privacy concerns, and to market all become major issues in environments where standards vary greatly. In addition to the technology needs themselves, certain individual factors become important as diversity increases from the intersection of generations, genders, ethnicities and skill sets. While these barriers may seem incidental at times they are critical for crossing major ideological boundaries of technologically enhanced science.

The barriers that individuals encounter in teams are often the result of a lack of cohesion and common goals and outcomes. It is the result of several factors. The first is competition between partners as different groups that comprise community, practice, political, and science interests are brought together into an arena where competition is a factor in the partnership [40]. These can range from different time pressures from stakeholders, different distance capacities, or even socioeconomic barriers. In community health arenas this is often manifest by the different expectations over pragmatic and long-term outlooks and goals. Often, these are at the heart of the problem as scientists become more comfortable with the latter and practitioners, patients and advocates are more concerned with the former. The conflicts that may immerge from these affiliations are numerous and contribute to an organizational climate within itself as coalitions forge and form these alliances. "In relationship to coalitions, organizational climate may be characterized by relationships among members, member-staff relationships, communication patterns among members and with staff, and a coalition's decision-making, problem solving and conflict resolution processes" [32]. A wide range of ethics and outlooks may contribute to these barriers and simultaneously may be useful in problem solving. Within the literature there is a suggestion that agreed upon principles and goals can be useful in diminishing these collaborative challenges [40-42].

The conflicts that immerge from building coalitions and inter-team alliances are often the result of less tangible factors but more over directly associated with the status of individuals and groups and how this status may affect access and control in teams. The power differentials that these types of conflicts breed can promote inequality of resources between members and groups. These may be as simplistic as availability of funding, community access, language barriers, and any other factor that may restrict an individual or group from obtaining resources necessary for collaborations [16]. These can sometimes be long standing differences between the status of health professionals versus physicians, scientists, and/or universities compared to community or international partners. In one sense these can be purely semantic concerns but at other times they can become some of the most stubborn barriers impeding collaboration amongst needed partnerships [43]. Researchers suggest that operating norms can assist in overcoming these barriers [40,42] and to establish trust amongst otherwise historically mistrusting entities [1].

While some strides have been made in the science-of-team-science to produce adequate and generalizable research constructs, the field is still in a state of emergence with relatively few studies that allow for a consensus of research on the subject. Of those studies that do exist, many are an amalgamation of conceptual frames and methodologies without out any real conceptual cohesion. However, as a result of both the empirical evidence and also the conceptual literature it is reasonable to construct characteristics of team science that assist in understanding the main variable for possible further research. The translational paradigm *requires* an intimate relationship with the SciTS if it is to succeed in its research, discovery, and population impact goals.

Transdisciplinarity capacity

Developing and nurturing transdisciplinary and translational environments requires a basic understanding of the nuanced differences and the impact of unidisciplinarity, interdisciplinarity, multidisciplinarity, and transdisciplinarity. Unidisciplinarity can be easily defined as *of one discipline*; it is important to note that in certain arenas it can also represent a denial of other disciplines as well and take the form of an elitism or siloed environment [44]. In the latter cases, certain sectors may possess certain biases or hierarchical continua that value some disciplines over others in problem solving discourses. The impact of this state of knowledge is a restricted approach to knowledge sharing. Multidisciplinarity is defined as an economy of knowledge [45] that involves two or more disciplines working in collaboration on a common problem

[46]. This approach supersedes a unidisciplinary approach in that it stresses the value of utilizing more than one epistemological lens. Healthcare specialty and subspecialty systems value this approach as practitioners contribute their own individual disciplinary perspective to health problems in the hopes of a collective contribution. However, multidisciplinary often lacks the ingenuity to put forth new techniques, modify approaches, or construct new frameworks that by their integration might positively affect outcomes. It attempts to achieve greater understanding and knowledge through the multiplication of methods and not through hybridization of approaches [47]. Interdisciplinarity, a more integrated economy of knowledge, is a mode that governs science "directed toward solving complex issues and addressing scientific knowledge production proper, promising to circumvent the schism between scientific expertise and policy-making by… the involvement of stakeholders [that] make sure the 'right problem' gets addressed 'in the right way'" [48-50] rather than the 'right problem' being addressed by the 'right discipline'.

While interdisciplinarity and multidisciplinarity focus on the function of exchange between disciplines (a capacity critical to translational enterprises), a transdisciplinarity capacity responds more fundamentally to the complex paradigm that works across and synthesizes disciplines. The functions differ slightly by order of degree. "As the prefix "trans" indicates, transdisciplinarity involves going between, across, and beyond different disciplines suggesting innovation through synthesis. While transdisciplinarity refers to the links between knowledge and models available in different disciplines, transdisciplinarity moves beyond this to develop both a new vision and a new experience of learning" [51]. The challenge of integrating different knowledge and epistemologies, as well as theory and practice, the [participant] is inevitably faced with the problem of paradox…relating to different levels of reality" [52]. Transdisciplinary knowledge is therefore coined, *in vivo* knowledge. It "corresponds between the external world of the object [individual] and the internal world of the subject [team]…including a system of values" [53]. It moves us from a consideration of science as bound by disciplines and gravitates to a more holistic schema that considers the dynamics of entire systems of actors and concepts [47,54]. This notion is helpful in charting the relationship between multi-, inter-, and transdisciplinary economies in comparison to each other (Figure 2).

Transdisciplinarity presumes an integration of disciplines that provides a "synthetic reconfiguration of available knowledge regarding the social, economic, and ecological conditions" [56]. Here the tension between "simplicity" and "complexity", "insulation" and "hybridity", "consensus" and "agreement", and "universality" and the "dialogue of the local-regional-global" are highlighted to illustrate the shift in dynamics and a need for investigation of the culture for which knowledge resides [57]. These dichotomies are "risk producing" rather than "risk reducing", focused on "extending expertise", and not only "legitimation through participation or knowledge possession" [50].

The movement to a transdisciplinary economy is subject

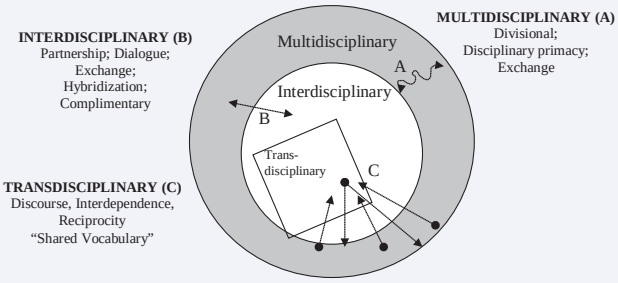

Figure 2 Disciplinary economies of knowledge [55]. Individual economies as part of a greater systematic whole. Multi- and interdisciplinary economies are shown as similar entities (large circles) differing to the central task of a transdisciplinary economy (interior square). They generally operate in similar ways (A&B), making connections from within or from without of their respective economy, in comparison to a transdisciplinary economy (C) that is intrinsically different from the other two as it is continually oscillating between the economies. Individuals (arrows) interact with each other within or across boundaries. While multi- and interdisciplinary economies maintain a certain disciplinary driven character through exchange or dialogue, transdisciplinarity economies assumes novel approaches through discourse, shared vocabularies, and reciprocity with other disciplines.

to unfavorable conditions that make it difficult to transition from an interdisciplinary mode to this more novel one. The transfers of power, reinterpretations of service delivery, training and education requirements, and questions of legitimacy all contribute to a general resistance to transdisciplinarity [48]. These barriers affect the sociological structures and goals that "dictate authority and specialization of roles that limit the sphere of activity and the orientation of groups of individuals to various sub-goals associated with these specialized interests" [58].

Social dynamism and conflict plays an important part in the discourse on transdisciplinarity, specifically role and discipline interactions. This integrative sociology chiefly affected by Karl Marx, ascribed to a 'conflict' or 'coercion' school of social emphasis that seeks to uncover the operations of change, conflict, disintegration, and coercion as normative mechanisms within societies. Conflict is a phenomenon of "exchange" [59]. Exchange, as a unit of measurement, is useful in analysis to measure emergence. For example, disagreements about methodologies and strategies are not only exchanges of conflict; they are indicators of the barriers within the system that communicate the inability to transcend beyond boundaries to achieve new orders of consideration. It clarifies the meaning of relationships, the "sewing together" [60] of society "by a variety of cross-cutting conflicts between its component parts" [58]. Conflicts arise as social structures pressuring individuals to eventual engagement in non-conforming behavior [61]. These episodes identify characteristics of reference groups and place them into two categories: those with a normative function and those with a comparative function [62]. Each works to activate the interactive discourse in a society by either affecting conformity or non-conformity with regards to social values and traditional norms. Though counter intuitive, perpetually "dysfunctional" societies possess greater functionality to generate new norms and new institutions. Conflict, in his theory, is the catalyst that harbors technological innovation as its byproduct [63]. Parts of systems (disciplines) can remain fully intact [64,65] by virtue

of their innate independence while contributing to change in society. This conversation includes the possibility that while conflict entices change and innovation, different parts of a social system retain their individual interests separate from the society as a whole. Sub-groups (disciplines) can have individual interests specific to their own point of reference while parallel (and possibly contrary) interests abound with regards to the entire system.

The challenge for team members is "how to maintain some distance [from the enterprise] while working as an embedded [stakeholder]" [52]. Transdisciplinarity values the abilities of learners to disembody themselves from the disciplinary tenets that at times serve as barriers to crossing disciplinary boundaries while simultaneously serving as the means by which dialogue can occur. Cognitive, behavioral, and environmental factors are in tension or "reciprocal" relationship and affect each other bi-directionally [66]. Though studies that provide empirical evidence of this phenomenon are rare, characteristics of transdisciplinary settings can be arrived at using a complexus of theory from multiple sources which are all identifiable aspects of these environments: complex problem solving as multidimensional, human and natural system interfaces which are both actual and conceptual [46,52], praxis as a theory and application interface [52,53,56,57,67-70], interpenetration of epistemologies and the dissolution of disciplinary boundaries [52,71-73], methodological pluralism [52], collaborative deconstructing and developing of interfacing partners [50,52,71,74,75], stakeholder involvement as a means of investing in outcomes [48,50,52,76], open systems as means for exchanges across boundaries [47,53,54,77-84], and different (shifting) levels of reality suggesting disunity in perspectives [53,57,66,68-70,85,86].

Transdisciplinarity requires a reappraisal of integration of knowledge resources and a reconsideration of the systems that it brings together. This is its contribution to translational science inquiry. It must be internally differentiated to achieve integrative properties making it able to respond to medical and healthcare environments [86]. We have recognized that dysfunction and tension are typified by the discourses between disciplines. They are commonplace within societies where these economies reside. This dynamic tension or conflict between order and stability strive to either establish equilibria of knowledge or to highlight tension as the heart of the discussion. For these reasons it is important that the shifting realities of the translational discourse are identified and explored for future professionals.

Shifting Realities for Translational Team Science

Specialization > Integration: One of the major barriers to achieving transdisciplinary translational science in healthcare is the dominance of specialty-based medicine. While biomedical science and the mechanisms that support it are slowly coming online, to secure the important resources to encourage cross-disciplinary engagement, medicine continues, due a number of factors like educational culture and the healthcare system itself, work against these scientific research trends. Healthcare continues to grow closer to its service population but simultaneously stretches its relationship with basic research. In addition, though evidence-based medicine has become a hallmark of care excellence, medical specialization works against the transdisciplinary economy of knowledge. This is a problem for the translational enterprise that not only relies on ties between researchers and healthcare providers, but also the providers and community action and policy makers that they strive to work with. The adage that translational research is the 'bench to bedside' paradigm now includes the 'storefront' as discoveries and their application rely on stakeholders of all types to inform the direction of science and healthcare policy for high impact innovation and positive social outcomes.

To overcome the barriers that separate the research/provider from the provider/patient sectors, integration within medical research scholarship as well as beyond needs to occur. Simultaneously, integration across activities needs to be tempered with integration across structures [87]. Medical education needs to take seriously its role in preparing translational researchers critically assessing what interventions need to be included into traditional approaches so that medical research can become more translational by design [88]. Lastly, we can not underestimate the importance of structures that allow for those who have been grounded in their own field to explore and entertain the restructuring of their careers so that they can with more frequency crossover from research to care to policy making activities with greater ease allowing for multiple experiences to inform their professional philosophies and professional skill sets. "As individuals compare themselves to others, they may place themselves and others into categories characterized by certain traits, values, norms, or other defining attribute [89]. In doing so, individuals become defined within group-level social identities. Members of a group gain distinctiveness through their membership and are motivated to preserve the qualities of distinctiveness"[90].

Leader-centrism > Leadership: The transdisciplinary translational knowledge framework not only presents challenges, for existing leaders of teams, it also tests all team members abilities to consider leadership as an elastic processual concept. Over the last century, the shift from transactional characteristics of leadership to more transformational ones has deemphasized leader-centric perspectives like 'great man' and even group theories that rely on top-down management interventions, to those that embrace trait/behavior, distributed and complexity models of leadership [91]. This had led us to give far more attention to the concept of leadership and its impact within systems. A systemic approach assumes that complexity is a grounding force in the attempt to ensure information and knowledge sharing and synthesis [34].

While much of complexity science has been focused on complexity leadership theory and how it informs corporate workplace settings, educational and healthcare environments where internal and external demands are constantly at play are equally in need of such perspectives. Like industrial managers, educational and healthcare translational leadership is confronted with being both autonomous and interdependent and ensuring that the interchange of knowledge performs accordingly [92]. Leadership in these sectors is to ensure that the "application of new knowledge includes institutionalizing it in a way that ensures it is retained as long as it remains relevant [and] encourages, facilitates, and sustains a favorable level of innovation and collective learning" [93]. Individual leaders serve as *catalysts* that exercise abilities to affect organizational learning through social interactions in countless ways.

Some studies have suggested that innovation is a core element in organizational learning depended on the managerial leaders and their role as futurists, integrators, and strategists [94] or as a transformational agents operating within frameworks that focus on the role of the manager and their intuiting, interpreting, integrating, and institutionalizing skills [95]. However, others continue to propose that leadership theories that focus on the leader and their function and characteristics are too constricted to capture the necessary dynamics associated with the management of new knowledge. Complexity leadership in educational and healthcare environments "must be prepared to find new routes to agreed destinations, and not be afraid of getting lost, trusting that the edge of chaos is the grounds of real creativity and development for all" [96]. This element of chaos is the social environment that "encourages the use of procedures that increase creative ideas, nurturing promising ideas that are initially vague or controversial, obtaining resources needed to develop ideas, analyze team processes, and monitoring events that are relevant to innovative activities by the team" [93] encouraging exploration and exploitation [97]. While transformational leadership is instrumental in instilling exploratory innovations in workplace environments, it is limited in its ability to maintain both exploratory and exploitative mechanisms [98].

Interdisciplinary > Transdisciplinary: A major challenge while striving for higher level of knowledge synthesis is the transitioning from one economy of knowledge to another. For this reason, the definitions and characteristics of each have been previous described. We live in a world dedicated to teaming and translation as a normative function in healthcare science and policy. Though this is the case we often interchange the economies of knowledge in our speech and writing. Transdisciplinarity is not just an elevated economy of knowledge. It is an economy that breeds innovation and applications of technology and collective intelligence so as to solve more complex and troubling problems by drawing from the 'swarm' of stakeholders [99].

A major challenge for all teams of scientists is ongoing evaluation of the extent of 'swarm' involvement, the different and scaffolding relationships that make a community effective, and its ability to clearly self incorporate the opinions and contributions of these diverse team members. The practical implications may seem obvious but include both the need to expand stakeholder inclusion and the cultural lens in which they perceive problems and solutions [100]. This boundary spanning, the challenges and internal barriers that hamper the achievement of such self-evaluation and accomplishments is another aspect of the transdisciplinary landscape.

Evaluation Principles and Challenges for Professionals

To secure thoughtful and applied transitions to the upper tiers of this sort of knowledge economy, Julie Klein suggests a multi-level evaluation matrix useful in assessing the research, application, and policy characteristics of transdisciplinary knowledge integration. These principles do not only evaluate research and policy endeavors but also allow for a thoughtful consideration of the difference between inter- and transdisciplinary initiatives and the conceptual frames that these types of initiatives must develop, adopt, and maintain (Table 1).

For professionals focused on career trajectories that include transdisciplinary translational science initiatives, these principles may not only feel foreign but may cut across pillars of developmental training and unidisciplinary cultures. While challenging enough as principles to be applied, what is of equal if not more challenging is the thought of adopting new leadership and interactive qualities amidst the quest of practicing these principles for application. Collaboration, though a hallmark of modern science, still represents a contradictory condition for some translational scientists. Career challenges exists and are ongoing for professionals as they continue to commit to the transdisciplinary translational way of thinking and acting (Table 2).

Navigating the transdisciplinary and translational environment requires professionals to be reflective of their own career paths as they negotiate decision-making about which directions might lead them to their specific career goals. These will differ greatly for academics, scientists, practitioners, activists, patients and policymakers whom all play an important role in the translational process. The professional challenges associated with the economy of knowledge described here is in itself a constantly changing and dynamic environment. So in addition to reflections about career pathways, translational professionals

Table 1: Evaluation principles for transdisciplinary translational scientists [9].

Evaluative measure	Principle
Variability of Goals	• Interdisciplinary and transdisciplinary research are not driven by a single goal.
Variability of criteria indicators	• Quality, epistemic, credible, and variable indicators must co-exist.
Leveraging integration	• Engaging integration at all levels of the process.
Interactions of social and cognitive factors in collaboration	• Cognitive-epistemic and social factors must coexist and be hallmarks of the collaborative process.
Management, leadership and coaching	• Processes need structure and leadership that nurtures cognitive, structural, and process tasks.
Iteration in a comprehensive and transparent system	• Collaborative input, transparency, and common stakeholding.
Effectiveness and impact	• Effectiveness and impact occur on multiple levels and in multiple sectors across time, diverse fields, and subject to patterns of citation.

Table 2: Career Challenges of Interdisciplinary/Transdisciplinary Collaborations [101].

Challenges	Professional Realities
Acceptable Risk/Benefit Ratios	• Effort/Time imbalance • Uncertainty—options
Contribution and Credit	• Separating the "soup ingredients" • Keeping Track—Be proactive and prospective
Future Plans. What's Next?	• Developing your own identity • Developing transportable skills • Negotiating trajectories—leadership positions • Future resource use agreement
Promotion/Tenure	• Understanding the criteria, process, and players • Meeting the criteria
Finding Support	• Supportive home/institutional environment • Supportive mentors/colleagues
Finding Appropriate Reviewers	• Constructive input • Non-conflicted Review

most also be reflexive, conversing with a changing environment that requires new and emerging outcomes from its professionals as translational science takes hold and replaced more traditional approaches over time.

CONCLUSION

Throughout this paper several topics have been presented as a network for consideration. First is the concept of team science that is not new but as of late has a new scientific home in the science-of-team-science. Through this science we look to what works in teams, try to observe and collect data about them, and analyze the impact for future practical application. In essence, transdisciplinarity as a knowledge economy is also not new. It is a strong acknowledgement of the natural and physical complexity of our world. It represents sciences searching for methods and means so that the world's overlapping elements can be studied with more clarity and applied in ways that secure a synthesis of knowledge as a changing and dynamic variable. Together these two concepts make for a very jumbled and multilevel conversation most professionals would rather not have. Though the commitment to integrating and understanding the complexity that these represent in translational science has already begun we continue to embarked on the journey of understanding how the two relate.

This new way of reconsidering and redefining characteristic of individual and team success relies on the interjection of new theoretical and practical thought streams. It requires us to continue on the quest of developing new frames of evaluation that can manage not only the known but allow for the emergence of the unknown. All the while adjusted methods must achieve a greater individual sense of contribution while breeding teams of individuals that accept and strive to contribute to team knowledge and a new level of community and global impact. This entire process pushes us to refocus our research ideals and strive for impact in every aspect of the research process no matter which end of the continuum we gravitate toward the basic or applied side of inquiry.

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