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Review Article

Interdisciplinarity and Transdisciplinarity: Keyword Meanings for Collaboration Science and Translational Medicine

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Abstract

The keywords of this special issue–collaboration science and translational medicine–appear frequently in conjunction with two other terms–"Interdisciplinarity" (ID) and "Transdisciplinarity" (TD). Interdisciplinarity is linked with collaboration and translational medicine because both integrate insights from multiple disciplines. Transdisciplinarity, in turn, is linked with new frameworks for health and wellness that transcend disciplinary and interdisciplinary inputs, involvement of stakeholders outside the academy in team-based research, and translation of scientific findings into new protocols and treatments. ID and TD, however, are too often buzzwords. Even when authoritative definitions are cited, their relationship to other terms is often unclear. Understanding the relationship of the four keywords is complicated by the growing complexity of boundary crossing today, involving not only disciplines but also occupational professions, interdisciplinary fields, and expertise outside the academy in civil society and the private and public sectors. The research community in translational medicine and epidemiology is well aware of this complexity, since its members work in contexts of basic science as well as preclinical, clinical, and epidemiological settings and in health outcomes. This investigation is aimed at more informed use of the terms ID and TD in collaboration science and translational medicine. It tracks the history of their intersections, overlaps and differences, and roles in the emerging areas of team science, convergence, and applied integrative research. Four major implications follow for translational medicine: benchmarking the heightened importance of the field in the history of interdisciplinarity, philosophical differences in the goals of ID and TD, etymological shifts in keywords, and recommendations for institutional change.

ABBREVIATIONS

ID: Interdisciplinarity; TD: Transdisciplinarity; SciTS: Science of Team Science; I2S: Integration and Implementation Sciences

INTRODUCTION

This special issue on collaboration science and translational medicine is an occasion for defining the intersection of not two but four widely used terms: collaboration, translation, interdisciplinarity, and transdisciplinarity. Interdisciplinarity (ID) is linked with collaboration and translational medicine because both integrate insights from multiple disciplines. Transdisciplinarity (TD), in turn, is linked with new frameworks for health and wellness that transcend disciplinary and interdisciplinary inputs, involvement of stakeholders outside the academy in team-based research, and translation of scientific findings into new protocols and treatments. ID and TD, however, are too often buzzwords. Even when authoritative definitions are cited, their relationship to other terms is still unclear. This investigation is aimed at more informed use of the terms ID and TD in collaboration science and translational medicine. It tracks the history of their intersections, overlaps and differences, and roles in the emerging areas of team science, convergence, and applied integrative research.

The first step in the investigation is to define Interdisciplinarity and Transdisciplinarity. Table 1 depicts their defining characteristics in a continuum of degrees of integration based on authoritative typologies [1]. It is not a hierarchy that moves deterministically from a lower to a higher level. Points on the continuum mark different purposes and varied forms of integration and collaboration.

Even Table 1, though, is inadequate to account for the complexity of boundary crossing today. The research community in translational medicine and epidemiology is keenly aware of this complexity, since its members work in contexts of basic science as well as preclinical, clinical, and epidemiological settings and in health outcomes. In doing so, they cross the boundaries of not only disciplines but also occupational professions, interdisciplinary fields, and expertise outside the academy in civil society and the private and public sectors. Yet, *interdisciplinarity* and *transdisciplinarity* continue to be common placeholders. Their persistence is not unusual. Over time connotations of keywords expand in response to new needs and interests, but we retain older labels out of habit. New terms signal the complex intersections of the four keywords in this study, depicted in Figure 1 in a timeline of historical benchmarks and descriptive language. It is not a comprehensive representation of either ID or TD, but it does account for major events and terminology pertinent to this research community.

COLLABORATION AND INTERDISCIPLINARITY

The first intersection of keywords–between interdisciplinarity and collaboration–stems from the popular assumption that interdisciplinarity is synonymous with teamwork. It is not. Individuals engage in a wide range of solo activities, from incorporating a method, tool or concept from another discipline into their personal research repetoires to teaching courses and modules by themselves on interdisciplinary topics and themes. Individuals from different disciplines also contibute to projects. They supply insights from their disciplinary perspectives, but the relationship of the parts is serial at best. Collaboration becomes *interdisciplinary* when representatives of different disciplines interact by crossing the boundaries of expertise. In the language of Table 1, they engage in linking, blending, integrating, and synthesizing different insights around a common question, problem, topic, or theme.

Scientists typically date the relationship of collaboration and interdisciplinarity to World War II. In an etymology of *interdisciplinarity*, though, Roberta Frank recalled the term was shorthand in the early 1920s for research that crossed divisions of the seven disciplinary societies of the Social Science Research Council, focused on social problems such as poverty, crime, and war. Between 1925 and 1930, the terms *co-operative research*, *mutual interdependence*, and *intercommunication* also appeared in books on the social sciences [2]. World War II, though, was a watershed in this history, highlighted by the Manhattan Project to build an atomic bomb and the beginnings of operations research. The formation of institutes and laboratories to solve military problems accustomed academic administrators to having large-scale collaborative projects on campus. By 1944, Brozek and Keys even claimed an interdisciplinary approach was already a prominent characteristic of science, marked by *cooperative research* [3]. After the war many projects were dismantled, but some influential laboratories continued to operate and, Lawrence Bass recalled in a manual on the operation of interdisciplinary teams, *interdisciplinary task force management* was a feature of civilian affairs, engineering projects, feasibility studies, and industrial research and development [4].

Over the latter half of the century, the profile of ID expanded. By the 1960s interdisciplinary teamwork was a recognized approach in space research and, Bass added, during the 1970s *interdisciplinary attack* was a tag phrase for combining talents to solve problems such as urban decay and environmental pollution [4]. Further into the 1980s, international economic competition created pressure for a renewed technology initiative that blurred boundaries of not only disciplines but also the academy, government, and industry. This trend was especially apparent in science-based areas of manufacturing, high technology, computer sciences, pharmaceuticals, and biomedicine. Sites of collaboration expanded beyond the familiar matrix structures of centers and institutes on campuses to include offices of technology transfer, contract research, and the hybrid communities of industrial liaison programs, joint mergers and ventures, and entrepreneurial firms. The work in these organizational enclaves was as much inter-institutional as it was interdisciplinary, prompting Rustum Roy to propose the more accurate term is *interactive research* across university, government, and industry and across research sectors from basic research through engineering to manufacturing [5].

The descriptor *interactive* could apply to any type of interaction, and *interdisciplinarity* continued to be a standard reference. Yet, Roy's proposal was an important signal of

Table 1

DEGREE OF INTEGRATION →

DISCIPLINARY	MULTIDISCIPLINARY	INTERDISCIPLINARY	TRANSDISCIPLINARY
Specializing Concentrating Analyzing Segmenting	Juxtaposing Sequencing Coordinating	Interacting Linking Blending Integrating Synthesizing	Transcending Overarching Transforming Transgressing

Early History: 1920s	WWII & Postwar Era: 1940s	Expansion in 1960s & 1970s	1980s & 1990s	2000 Forward
Social Science Research Council	Manhattan Project beginnings of operations research	space program "revolution" of molecular biology	"revolution" in genomics escalation of interdisciplinary problem-focused research increased funding for interdisciplinary research	ascendency of "transdisciplinarity" "transcendent interdisciplinary research" expansion of "translational" science and medicine (T1, T2)
"interdisciplinary" research & problem-solving "co-operative research" "mutual interdependence" "intercommunication"	"co-operative research" "interdisciplinary task force management"	"interdisciplinary attack" typology of "multidisciplinarity," "interdisciplinarity," and "transdisciplinarity"	escalation of "interactive research"	emergence of science of team science (SciTS) emergence of "integration & implementation sciences" (I2S) for "integrative applied research" "revolution" of convergence as an "enhanced form of interdisciplinary research"

Figure 1 Key Benchmarks and Descriptors. Copyright: Kendall Soucie, 2014

expanding meaning beyond disciplines to include professions and other sectors of society. When a major report on *Facilitating Interdisciplinary Research* appeared in 2004 from the National Academy of Sciences (NAS) in the US, its authors even defined government-university-industry collaborations as a major type of research [6]. Roy's exemplar was materials science. Yet, the greater complexity of boundary crossing also became a feature of the emerging field of clinical and translational science. Moreover, proliferation of teamwork propelled a belief that research in general has become not only increasingly interdisciplinary but collaborative as well.

Stephen M. Fiore, for one, claims that "Interdisciplinary research is *team* research," treating the two terms as "essentially overlapping concepts." He also contends the complexity and quantity of knowledge within disciplines today means no individual is capable of maintaining the deep understanding necessary to conduct "truly interdisciplinary research." Citing the classic example of Leonardo DaVinci, Fiore associates solo ID with a small number of erudite scholars of rare breadth and depth [7]. The spectrum of solo interdisciplinary work is wider, and the Leonardesque ambition largely discounted today. Yet, Fiore signals escalation of health sciences to the forefront of interdisciplinary research, a development stemming from the ascendancy of biology in the hierarchy of sciences and heightened momentum for health science research. Private foundations and major public agencies such as the National Institutes of Health (NIH) supported this effort with increased funding for collaborative research that addressed the multi-causal complexity of health problems. And, NIH promoted a new conceptual vocabulary for research around the keywords *translation* and *transdisciplinarity*.

Translation and transdisciplinarity

The intersection of *translation* and *transdisciplinarity* is a major event in the history of interdisciplinarity that also requires careful distinctions between terms. In a ground-breaking book on the art of translation, *After Babel*, George Steiner argued that all communication is a form of translation. "To hear significance," Steiner wrote, "is to translate." Original meaning, though, is lost in the process of translation [8]. Whether moving from one language or discipline to another, translation is not a rote transfer of meaning. The metaphor of harnessing in translational medicine signifies the difference between "transfer" and "translation." The noun harness is associated with a device, such as a strap, that holds something in place. The verb, though, emphasizes channeling the power of something–whether solar energy or scientific discoveries–into new contexts with their own defining conditions. Harnessing, in short, goes beyond mechanical transfer. The challenge for translational medicine, however, is great because the problems being addressed have multiple levels and stakeholder values.

Two major connotations of *translational* research underscore the complexity of the challenge and the different kinds of boundary crossing that are involved. In 2003, the Clinical Research Roundtable at the Institute of Medicine identified two "translational blocks." The first, dubbed T1, impedes "transfer" of scientific discoveries in the laboratory into development of new methods for diagnosis, therapy, and testing in human studies. The second, T2, impedes "translation" of clinical studies into everyday clinical practices and decision making in health care [9]. Commenting on the distinction, Steven H. Woolf reported that many consider translational medicine to be synonymous with the slogan "bench-to-bedside." Yet, the two blocks have differing goals, settings, study designs, investigators, and knowledge bases. Woolf explained the differences.

T1 requires mastery of molecular biology, genetics, and other basic sciences. In contrast, "the 'laboratory' for T2 research is the community and care settings, where population-based interventions and practice-based research networks bring the results of T1 research to the public." Consequently, T2 requires different skills, including "mastery of the 'implementation science' of fielding and evaluating interventions in real-world settings and of the disciplines that form the design of those interventions." The list of disciplines expands to include clinical epidemiology, communication theory, behavioral science, public policy, financing, organizational theory, system redesign, informatics, and mixed methods research. The challenges also differ. T1 grapples with biological and technological concerns, recruitment for clinical trials, and regulatory matters. T2 grapples with human behavior and organizational inertia, constraints of infrastructure and resources, and changing conditions that cannot be fully controlled [10].

In the US, Woolf added, the record of research funding suggests that T1 overshadows T2. The Clinical and Translational Science Award program, for example, encouraged "community engagement." Yet, he admonished, a stronger commitment to T2 requires expanding further beyond the basic science bench research of T1, adding psychology, cognition, social marketing, economics, and political science to the mix of expertise. The expansions of T2 are not simply additive. They are transformative, with the aim of creating a new transdisciplinary paradigm of health and wellness. The term *transdisciplinarity* is dated conventionally to the first international meeting on interdisciplinarity in 1970TD was defined as "a common system of axioms" that transcends the narrow scope of disciplinary worldviews through an overarching synthesis. The exemplar was anthropology conceived as a broad science of humans, though participants added two connotations. Jean Piaget associated TD with the epistemological quest for unity in the form of general structures and patterns of thought, while Erich Jantsch highlighted social purpose in a model of science, education, and innovation informed by systems theory and design science [11]. Subsequently, new synthetic frameworks gained traction, including feminist theory and sustainability. The transgressive imperative in Table 1 gained favor in humanities and fields grounded in cultural critique. And, in the late 20^{th} and early 21^{st} centuries, two connotations expanded the profile of TD on both national and international scales.

Team science and convergence

Elevation of TD in the US is due in no small part to the effort of a public agency, the National Cancer Institute (NCI), to align *transdisciplinarity* with "team science." The claim to one of the key descriptors in Table 1–transcendence–lies in the stated goal of generating a new methodological and conceptual framework for analyzing social, economic, political, environmental, and institutional factors in health and well-being. In a series of state-of-the-art articles in 2008, authors called this initiative a form of "transcendent interdisciplinary research." The emphasis is on scientific discoveries, educational outcomes, translation of findings into new clinical practices, and public policies [12]. Collaboration is so central to this initiative that a new field emerged, the Science of Team Science (SciTS). Its formation reflects a widely shared belief that collaboration is essential to both the acceleration of scientific discovery and innovation and the translation of findings into more effective policies and practices. The SciTS network supports both goals by advancing processes and outcomes of team-based research. A forthcoming report on the science of team science, commissioned by NAS, brings current wisdom of practice together with recommendations for improving the effectiveness of collaboration [13].

A recent compilation of work in one particular area – transdisciplinary public heath–also presents a synthesis of definitions, core characteristics, and strategies. Stokols, Hall, and Vogel identify four phases in transdisciplinary research and practice: development, conceptualization, implementation, and translation. They describe the implementation phase as a period of executing a research plan, prior to a translation phase when findings are applied toward development of an innovative solution to a real-world problem. Developmental processes, they suggest, are "likely to benefit" when members include a wider range of professionals and local stakeholder groups such as practitioners, policymakers, and citizens. They are not treated as necessary partners, although "sustained participation" of collaborators is considered key to the long-term success of translation [14].

Another recently released report from NAS takes a further step by linking *team science, translation* and *transdisciplinarity* in a new concept of "convergence." Although not framed in terms of T1 and T2, it bridges the translational blocks of discovery and *translation*. The report describes convergence as an initiative aimed at generating ideas, discoveries, conceptual and methodological approaches, and tools that lead to new inventions, innovations, treatment protocols, and approaches to education and training. The report also positions convergence historically by contrasting it to two earlier "interdisciplinary" revolutions: the emergence of molecular and cellular biology in the 1950s through 1970s and emergence of genomics in the late 1980s and 1990s. The third revolution of convergence is "an expanded form of interdisciplinarity" in which bodies of specialized knowledge comprise macro domains of research activity that cross sector boundaries by forming academic, clinical, and industrial partnerships. The knowledge base is also wide, crossing boundaries of life sciences as well as physical sciences and engineering. The term "translational application" appears throughout the report, exemplified by new products emanating from nanoscience, biodesign, tissue and molecular engineering, and biomedical uses of 3D printing [15]. Yet, convergence goes beyond older linear transfers from basic science to a new generative "convergence-divergence" process. Components can be combined and recombined to create new products and services.

The emergence of new terms and related movements of team science and convergence is another signal of the need for something more than interdisciplinary combinations of existing approaches. SciTS adopts *transdisciplinarity* in the name of a new framework anchored by empirical approaches to best practices for collaboration in health sciences. Convergence is more of a call to action with stronger orientation to the marketplace of innovation. Two final movements take an added step by broadening the role of stakeholder and developing a comparative approach to the methodologies needed for problem solving.

BROADENING STAKEHOLDER INVOLVEMENT AND METHODOLOGIES

In stipulating mastery of implementation science as one of the required skills for T2, Woolf cautioned that T2 and even a proposed T3 model of "practice-based research" are both incomplete. Other practitioners also translate research into practice settings, including patients, public health administrators, employers, school officials, regulators, product designers, the food industry, and other consumers of evidence [10]. NCI and the SciTS initiative engage a range of stakeholders, including scientists, trainees, funders, policymakers, and clinical and community partners. Yet, patients are not involved directly in the actual research process comparable to their level of involvement in a European-based network for *transdisciplinarity* that emphasizes co-production of knowledge. Its roots were evident in the late 1980s and early 1990s in Swiss and German contexts of environmental research and by the year 2000, at a benchmark international conference on *transdisciplinarity* in Zurich, case studies were reported in all fields of human interaction with natural systems and technical innovations. The cornerstone of this new connotation of TD is the combined premise that problems of the *Lebenswelt*–the lifeworld–ought to form the basis of research, not disciplines, and that stakeholders in public and private sectors should be partners in research and implementation of solutions. The Swiss-based Network for Transdisciplinary Research, known as td-net, has centered its work on this dual premise [16].

The underlying assumptions of this new connotation of TD are also evident in the concepts of "socially robust knowledge" and "integrative applied research." In 1994, Gibbons, et al. proposed that a new mode of knowledge production is fostering synthetic reconfiguration and recontextualization of knowledge. In contrast to discipline-based work in Mode 1, the defining traits of Mode 2 are complexity, non-linearity, heterogeneity, and transdisciplinarity. Gibbons and colleagues argued that new configurations of research work are being generated continuously and a new social distribution of knowledge is occurring as a wider range of organizations and stakeholders contribute their skills and expertise to problem solving. Mode 2 theory was faulted for overstating the novelty and degree of change and for uncritical acceptance of commercial imperatives in areas of implementation such as aircraft design, pharmaceutics, electronics, and other industrial interests [17]. In 2001, though, Nowotny, Gibbons, and Scott extended Mode 2 to argue that contextualization of problems requires participation in the agora of public debate. When this boundary is crossed, a shift occurs from solely "reliable scientific knowledge" to inclusion of "socially robust knowledge" that dismantles the expert/lay dichotomy while fostering new alliances between the academy and society [18].

The second related concept–"integrative applied research"–marks the limits of both *interdisciplinarity* and *transdisciplinarity.* The Australian-based network for Integration and Implementation Sciences, known as I2S, is advancing this concept as a means of solving problems that are not only complex but wicked. Like complex problems, "wicked problems" are marked by divergence of values and knowledge. However, they are also characterized by a higher degree of unknowns, uncertainty, and unwanted side effects. *Interdisciplinarity* and *transdisciplinarity* still appear in the discourse of wicked problems. However, they are not sufficient. Nor are other exemplars such as integrated assessment, systemic intervention, sustainability science, Mode 2, post-normal science, team science, and action research. I2S is building a repository of concepts, methods, and case studies for synthesizing both disciplinary and stakeholder knowledge [19]. The co-founder of I2S, Gabriel Bammer, retains the terms *interdisciplinarity* and "applied" research in her book *Disciplining Interdisciplinarity.* Yet, the underlying concept of "integrative applied research" goes beyond transfer. The relevance of approaches must be assessed and built upon as knowledge from multiple sources is situated in the context of particular problems [20].

The emphasis on comparative methodology in the I2S network is part of a growing turn beyond universal and linear models. The I2S affiliated book *Research Integration: Using Dialogue Methods* classifies 14 dialogue methods into two groups that include well-known approaches such as Delphi technique, systems methodology, and scenario planning as well as forums for stakeholder involvement with the potential to create socially robust knowledge, such as citizens' juries, consensus conferences, and consensus development panels [21]. Co-authored by German researchers, *Methods for Transdisciplinary Research* is a primer for "informed choice" from a repertoire of methods, instruments, tools, and strategies. Comparable to I2S, they include familiar approaches of integrative assessment and hypothesis and model building as well as stakeholder participation and mutual learning. The continuous process of making adjustments in the context of particular problems refigures TD research from transfer to generativity [22]. Edited by Finnish researchers, *Heuristics for Transdisciplinary Environmental Research* also links TD with generativity in a solution-oriented approach to problems. Established methods still play a role. Yet, rules of thumb, guidelines emanating from practice, and comparative weighing of possibilities in the context of a problem are of equal importance. Learning also develops *in situ*, through trial and error in a collaborative art of invention [23].

CONCLUSION

Stepping back from developments traced in this investigation, several implications follow for translational medicine. The first lesson is historical. *Interdisciplinarity* arose out of a need for broader approaches to problems of society, manifested in the Social Science Research Council, and a commitment to education of the whole person, manifested in the general education and core curriculum movements. War-related research centered on military needs heightened its visibility and over ensuing decades a plurality of new fields emerged that now span, to name only a few examples, American studies and women's studies, social psychology and criminal justice studies, molecular biology and clinical and translational science. New fields arise to serve new needs and priorities. Cultural and political revolutions in the 1960s, for example, were catalysts for the rise of Black/ethnic/ and women's studies, and environmental studies and urban studies emerged in the same era. In subsequent decades, the increased prominence of biology and medical research coupled with the growth of team-based research and heightened priority of problem focus brought translational research to the forefront of both ID and TD. The ascendancy of *transdisciplinarity* does not signal the end of either disciplinary or interdisciplinary expertise is still crucial to "scientifically reliable knowledge," and interdisciplinary integrations of methods, tools, and concepts play a productive role in T1 and T2, team science, convergence, and integrative applied research. Yet, harnessing the knowledge and skills needed for addressing complex problems requires new transformative frameworks and trans-sector collaborations with a broader range of stakeholders in order to produce "socially robust knowledge."

The second lesson is philosophical. All goals are not identical. One strand of transdisciplinary problem solving, for instance, centers on collaborations between academic researchers and industrial/private sectors for the purpose of product and technology development. A different type of *transdisciplinarity* occurs when academic experts and social actors cooperate in the name of democratic solutions to controversial problems such as sustainability and risks of technological modernizations such as nuclear power plants. Differing imperatives even occur in the same area. The *Convergence* report reflects a strong orientation to the marketplace of innovation, including production of new drugs and treatments for health care. A T2 conception of translational medicine, though, is grounded in an epistemological view of "the whole person" and the complex etiology of diseases that do not have a strictly biological origin. As Bryan Turner noted in an earlier study of interdisciplinarity and the medical curriculum, diseases such as cancer, heart-disease, cerosis, and arteriosclerosis are characterized by a multicausality of social, individual, biological and cultural factors [24].

The third lesson is etymological. Commenting on Bammer's proposal, Linda Neuhauser observed that public health efforts in the US aimed at integrating disciplines have tended to advocate *transdisciplinarity*. "Implementation" was usually aligned with "research translation," and *translation* was sometimes called "dissemination" in a strategically planned process that spreads new or existing interventions. Most models of translational health have tended to focus on either disciplinary integration or implementation/translation. Early models depicted knowledge as a "product" transferred passively from researchers to practitioners to users. Later models emphasized a form of interdisciplinary "integration" in which knowledge becomes interwoven with priorities, culture, and contexts. Orientation to a whole system requires that relationships be considered at all levels in order to ensure effective adoption of scientific findings. More recently, Neuhauser added, combined models have emerged [25]. Stokols, et al.'s matrix for "transdisciplinary action research" describes integration of transdisciplinary research in a collaboration action cycle (implementation) with three dimensions: "analytic scope (biological to policy), organizational scope (intra-organization to intersectoral), and geographic scope (local to global)" [26]. Sussman, et al. also propose ways that researchers and practitioners might collaborate during translational phases in order to transform science into action [27].

The fourth and final lesson centers on institutional change. *Interdisciplinarity* has been a recognized concept for nearly a hundred years, and *Transdisciplinarity* gained prominence over the past two decades. Even the latest accounts, though, are replete with reports of obstacles to change. They offer solutions. However, a handful of exemplars are offered, typically elite models. Even respected clinical and translational research centers confront the challenge of sustainability. The impediments and disincentives are hauntingly familiar. Recommendations for easing them span organizational structures, policies for hiring and tenure and promotion, long-term funding and infrastructure, education and training. Yet, changes remain unevenly institutionalized and the current system of education lags in preparing the next generation of scholars and practitioners. There is no major bullet. However, education is vital. When major reports on ID and TD appear, and pertinent accrediting agencies and professional organizations issue recommendations for change, they need to be disseminated in national meetings, local planning committees, and in courses that define the nature of disciplines, professions, and interdisciplinary fields with translational imperatives. The published wisdom of practice also needs to be transmitted in self-tutorials, workshops, and professional development materials.

Haire-Joshu and McBride's textbook *Transdisciplinary Public Health* is a model for not only the formal years of degree preparation but also career-long continuing education for veteran researchers who need to update their content knowledge and skills [28]. Wayne State University's Division of Research also provides a model for serving local needs through annotated bibliographies and training modules that anyone may access free online. The annotated bibliographies include a Beginning Bibliography on Interdisciplinarity and Resources for Interdisciplinary Education. The Training Modules highlight key resources with tips on how to use them in the areas of Barriers and Strategies, Education and Training, Evaluation, Tenure and Promotion, and Resources for Team Science [29]. In addition, several online forums guide users to a host of resources for collaborative research with emphasis on health-science contexts. The National Cancer Institute's *Team Science Tool Kit* is an repository of over 875 resources, applications, and instruments. It includes models, methods, and materials for evaluation [30]. The SciTS ListServ: Mendeley is another forum for cross-disciplinary and inter-professional exchange of information and resources on topics related to team science. Members can search resources in the database, create subgroups, and add references and comments [31]. The challenge now is to make use of the accumulated wisdom of theory and practice.

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