Chapter 8
Collaborative Processes in Transdisciplinary Research

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> *The specialization, then, that has made possible the progress of experimental science during a century, is approaching a stage where it can no longer continue its advance unless a new generation undertakes to provide it with a more powerful form of turnspit . . .. For science needs from time to time, as a necessary regulator of its own advance, a labour of reconstitution, and as I have said, this demands an effort towards unification, which grows more and more difficult, involving, as it does, ever-vaster regions of the world of knowledge.*
>
> – José Ortega y Gasset (1930/1932) "The Barbarism of Specialization," *The Revolt of the Masses*

It has been widely acknowledged in recent years that if we are to achieve a coherent comprehension of the world and its enormous social, environmental, and public health problems we must make linkages between bodies of scientific knowledge and the social and political realities that generate them. Nearly eight decades after Spanish philosopher Ortega y Gasset noted the limits of specialization and the organization of knowledge into rigidly defined disciplinary boundaries, transdisciplinary (TD) collaboration is coming to be recognized as an essential strategy for understanding and resolving the complex urban public health challenges of our time (e.g., health disparities, AIDS, and heart disease). The past two decades have brought a surge of public and private investments in large-scale, multi-year TD research initiatives (Kahn, 1993; Kahn & Prager, 1994; Nass, Stillman, & Ebrary Inc., 2003; National Academy of Sciences, 2003; National Institutes of Health, 2003; Pellmar & Eisenberg, 2000; Stokols, Hall, Taylor, & Moser, 2008; Wuchty, Jones, & Uzzi, 2007). At the same time, the importance of evaluating the intellectual and societal contributions of TD initiatives has become increasingly evident (Abrams, Leslie, Mermelstein, Kobus, & Clayton, 2003; Brainard, 2002; Rhoten & Parker, 2004), giving rise to a new field – the *science of team science* – uniquely concerned with understanding and enhancing the outcomes of TD research and training initiatives

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(Hall, Feng, Moser, Stokols, & Taylor, 2008; Kessel & Rosenfield, 2008; Klein, 2008; Nash, 2008; Stokols, Misra, Moser, Hall, & Taylor, 2008).

Within the rapidly emerging science of team science, a growing number of studies focusing on the processes and outcomes of TD collaboration suggest that the levels of effectiveness of team science initiatives are highly variable and depend greatly on contextual circumstances (see Stokols, Misra et al., 2008, for review) and *collaborative readiness and capacity* factors (e.g., Hall et al., 2008; National Academy of Sciences, 2005; Rhoten, 2003; Stokols, Harvey, Gress, Fuqua, & Phillips, 2005). This chapter presents a concise overview of the characteristics and scope of TD collaborations and discusses findings related to the collaborative processes necessary to facilitate and conduct TD research. We also propose strategies for enhancing collaborative effectiveness and directions for future research in the study of TD research.

Characteristics of TD Research Initiatives

The ensuing discussion employs Rosenfield's (1992) and others' (Klein, 2008; Lawrence & Despres, 2004; Nash, 2008) distinction between various forms of *cross-disciplinary* (CD) research, encompassing *multidisciplinary* (MD), *interdisciplinary* (ID), and *transdisciplinary* (TD) research, in which the least integrative form is MD collaboration and the most integrative is TD collaboration. Whereas participants in MD and ID collaboration remain conceptually and methodologically anchored in their respective fields (though there is some exchange of diverse perspectives in these forms of collaboration as well), TD collaboration is characterized by the development of shared conceptual frameworks that integrate and transcend the individual disciplinary perspectives represented by the team members. Therefore, although many of the concepts discussed in this chapter apply across the CD spectrum, the degree to which these collaborative factors are salient to the success of a TD project or center is intensified due to the increased complexities associated with conducting TD research.

In addition to the distinction between various forms of CD research, collaborations can be compared along three dimensions of *integrative scope* (Stokols, 2006): *organizational, geographic, and analytic*, ranging from narrow to broad. In terms of their *organizational scope*, TD collaborations can be *intra-organizational* alliances whose members work within a single organization; *inter-organizational* collaborations, which span multiple organizations; or *inter-sectoral* partnerships, which include participants spanning multiple municipalities, regions, or nations. Similarly, TD collaborations can vary based on the *geographic scope* of the initiative ranging from local groups to community, regional, and national/global contexts. Across the various levels of organizational and geographic scope, participants in TD teams may be co-located at a single university or research institute or they may collaborate across several spatially and temporally dispersed locations.

Depending on the nature of the scientific or community problem being addressed by the team, the *analytic scope* of TD collaboration ranges from *molecular* (e.g.,

neuroscience) to *molar* (e.g., public policy) levels of analysis. A wider range of disciplinary perspectives and professional viewpoints must be integrated to achieve a TD approach to a particular problem as the analytic scope of the project moves from molecular to community levels. Collaborations that have broader organizational, geographic, and analytic scope are likely to encounter a larger and more complex array of constraints and challenges as they pursue their scientific and community problem-solving goals (Stokols, 2006; Stokols, Misra et al., 2008).

Team science programs are often undertaken to address certain priorities among the multiple potential outcomes of TD collaboration. Some of these priority goals include scientific discovery, the training of TD scholars, and the development of clinical, public health, and policy interventions. For instance, collaborative initiatives such as the NIH Clinical Translational Research Centers (CTRC) and the Centers for Population Health and Health Disparities (CPHHD) emphasize community-based participatory research in addition to basic medical and behavioral research as a criterion for effective collaboration among university researchers and community-based health practitioners as they work together to develop and implement evidence-based disease prevention programs (Minkler & Wallerstein, 2003; National Institutes of Health, 2002; Zerhouni, 2005). Other team science programs, by contrast, devote little time and resources to the translation of scientific research into clinical practices and, instead, place greater priority on scientific discovery and intellectual integration.

The content and relative importance of the collaborative goals of TD projects may be *phase specific* (Stokols, Misra et al., 2008) and, thereby, change over the course of an initiative. For example, greater emphasis may be given to training and basic research during the initial stages of a team science project, whereas the intermediate and longer term phases of collaboration may assign greater priority to translating scientific knowledge into community interventions and policies aimed at improving public health.

Since the mid-1990s, a growing number of studies (Gray, 1999; Kessel, Rosenfield, & Anderson, 2008; Klein, 1996; Morgan et al., 2003; Stokols et al., 2003, 2005) have assessed the processes and outcomes of TD research centers as their members collaborated on a variety of scientific topics (e.g., reducing cancer incidence, morbidity, and mortality associated with obesity and low levels of physical activity; the genetic and dispositional bases of nicotine addiction and tobacco use) over a period of several years. The next section identifies broad themes that emerged from a review of research examining factors found to facilitate or constrain team science programs across a variety of community and institutional settings.

Processes of TD Research Initiatives: Collaborative Readiness and Capacity Factors

One of the broad themes that has emerged from earlier studies of TD research initiatives is the influence of certain *collaborative readiness* factors (Fuqua, Stokols, Gress, Phillips, & Harvey, 2004; Hall, Stokols et al., 2008; Kessel et al., 2008; Olson

& Olson, 2000; Stokols, 2006; Stokols et al., 2003, 2005; Stokols, Misra et al., 2008) on the success of the team science program. *Collaborative readiness* factors refer to antecedent conditions that exert a disproportionately high influence on the success of TD collaborations, especially during their initial stages (e.g., during proposal development, preparations for project launch once funding is received, and the initial months of the project once it has commenced). However, it is important to note that these factors are not only influential at the outset of collaboration but are dynamic and malleable and continue to play a critical role across the duration of the project. Specifically, these factors, as they become enhanced or diminished over the course of a project, are referred to as *collaborative capacity* factors (Hall et al., 2008). Stokols, Misra, et al.'s (2008) review of the contextual factors that influence the effectiveness of TD collaboration suggested that collaborative effectiveness encompasses multiple dimensions including intrapersonal, interpersonal, organizational, structural, societal, and scientific domains (see Hall et al., 2008; Hays, 2008).

Intrapersonal Factors

Intrapersonal collaborative readiness and capacity factors, essential for the success of team science initiatives, include members' preparedness for the complexities and uncertainties of TD work (Stokols, 2006); their openness toward new disciplinary and methodological perspectives and worldviews (Israel, Schulz, Parker, & Becker, 1998); their willingness to devote substantial amounts of time to learning about others' expertise; valuing collaboration and embracing a TD ethic (i.e., a strongly held commitment to engaging in collaborative research and an openness to integrating diverse disciplinary perspectives and levels of analysis) (Stokols, 1998; Stokols et al., 2003; Wray, 2002). Another important intrapersonal factor found to increase members' readiness for effective teamwork is the extent and quality of team members' past collaborative experiences with each other and their experience with TD collaboration in general. Team members who have had positive collaborative experiences with each other in the past may not have to spend as much time establishing and sustaining trust as compared to teams whose members begin collaborating with little or no history of working together on prior projects (Cummings & Kiesler, 2008); Hall, Stokols et al., 2008; Israel et al., 1998; Lantz, Viruell-Fuentes, Israel, Softley, & Guzman, 2001; Stokols, 2006; Stokols et al., 2005).

Finally, a number of studies suggest that collaborative versus non-collaborative leadership styles play a crucial role in determining the success of TD initiatives (Gray, 2008). Leaders who are transformational in their style, inclusive, empowering, adept at negotiating and resolving conflicts, and offer constructive feedback and encouragement to colleagues are able to augment trust and cohesiveness among team members and achieve high levels of performance (Bennis, 1997; Israel et al., 1998; Kumpfer, Turner, Hopkins, & Librett, 1993; Stokols, 2006). Similarly, *dynamic leadership* styles in which members share authority and responsibility according to the shifting requirements of their tasks have been found to lessen

pressures felt by individual leaders and foster inclusiveness in collaborative settings (Kayes, Kayes, & Kolb, 2005).

Interpersonal Factors

Earlier studies have found that one of the most critical *interpersonal* determinants of collaborative effectiveness is mutually respectful and constructive interpersonal communication (Fiore, 2008; Kahn, 1993; Stokols et al., 2003, 2005). Regular and constructive intellectual and social communication fosters trust and cohesion and is necessary to strengthen collaborative processes and ease TD tensions. Moreover, ongoing communication is essential for conducting effective TD research in that it allows for the refinement and clarification of goals, roles, and task requirements and helps build a shared vision and identity (Stokols et al., 2008). Through this interaction, members have the opportunity to understand and appreciate their colleagues' perspectives and worldviews and eventually integrate and transcend disciplinary boundaries to develop novel conceptual frameworks for understanding and solving complex problems.

Organizational Factors

It is important that participating organizations recognize and reward members for engaging in collaborative activities by providing organizational, environmental, and technological support. There are a number of areas where supportive institutional policies and activities can impact the ease, productivity, and effectiveness of collaboration. Examples include division of overhead and cost sharing across entities or departments and providing administrative support for the increased coordination and maintenance of budgets and subcontracts that come with conducting multi-departmental or multi-institutional research.

The presence of strong organizational incentives is another important factor in TD research (Butterfoss, Goodman, & Wandersman, 1993; Israel et al., 1998). Team science projects require members to devote substantial amounts of start-up as well as on-going time for meetings and brainstorming sessions, to engage in multi-authorship publications, and to develop written products that reach journals across disciplines and perhaps even beyond scientific venues (e.g., policy briefs) in order to maximize the impact of the research endeavor. Traditional academic criteria for promotion and tenure typically emphasize high levels of productivity early in an investigator's career, as evidenced by single or first authorship on articles that appear in prestigious, discipline-specific journals. Therefore, providing greater recognition for collaborative work through changes in university tenure and promotion policies can be an important incentive for enabling junior researchers to participate actively in TD research and training activities (National Academy of Sciences, 2005; Rhoten & Parker, 2004). Similarly, non-hierarchical organizational structures and routines that encourage participatory goal setting and decision

making can foster inclusiveness among team members thereby increasing institutional support for intradepartmental and inter-university collaboration (Morgan et al., 2003).

Structural Factors

Among the *physical-environmental* and *technological* collaborative readiness and capacity factors that have been found to encourage communication, trust, and integration of intellectual ideas is the spatial proximity of team members' offices and laboratories (Miller, 2008; Stokols, 2006). In fact, one early study found that beyond distances of 30–50 m collaboration among coworkers working in the same facility decreased markedly (Allen, 1984). In the case of remote collaborations, where such an arrangement is not feasible, it is especially critical that participating sites have access to the necessary electronic infrastructure such as broadband electronic networking capabilities, linkages between sites, and other technical support. Additionally, data security, privacy provisions, rapid retrieval and long-term archival access to data, and technologies that facilitate the formation of knowledge and social networks have been found to enhance remote scientific collaborations. Another factor found to be directly related to the collaborative success of remote TD teams is team members' *technological readiness*, including their familiarity with various electronic information and communication tools, protocols, and codes of conduct, and the effectiveness of their communication styles (Cummings & Kiesler, 2008); Lipnack & Stamps, 1997; Miller, 2008; Olson & Olson, 2000; Sonnenwald, 2007).

The availability of opportunities to meet and communicate, especially at the outset of a collaborative initiative as well as at regular intervals through face-to-face meetings, social gatherings, and retreats has been found to facilitate interpersonal trust and reduce conflict and social fragmentation among the members of distance collaborations (Rocco, 1998; Stokols, 2006). Furthermore, studies of team environments suggest the importance of providing participants access to distraction-free workspaces and comfortable meeting areas to facilitate participation in both individualized tasks requiring high levels of concentration or confidentiality and group activities requiring high levels of coordination (e.g., discussions and brainstorming sessions) (Brill & Weidemann, 2001; Steele, 1986; Sundstrom, DeMeuse, & Futrell, 1990).

Societal and Scientific Factors

At the state/provincial, national, and international policy-making levels, easing of political barriers and the reduction of tensions between nations, enactment of protocols for ensuring ethical scientific conduct, adjudicating claims to intellectual property ownership and licensing, and protecting animal and human subjects' rights provide the social, political, and legal foundations for initiating and sustaining effective large-scale TD collaborations (Cohen & Linton, 2003; David & Spence, 2003; Havemann, 2001; Klein, 2004; Sonnenwald, 2007). Moreover, various scientific

fields may differ in terms of the extent to which they are ready for integration with other disciplines, depending on the depth and maturity of prior basic research efforts within each field (see Hays, 2008). Specifically, if particular areas of science are not compatible in terms of ideology, conceptualization, and support structures (e.g., methodology, terminology), then TD collaboration may not be feasible.

Whereas many contextual factors contribute to collaborative readiness, the capacity of a TD team to sustain effective collaboration over extended periods depends to a large extent on how well team members are able to manage the substantial amounts of new information and communications they are exposed to as they work with colleagues trained in multiple fields, many of whom may be dispersed across several geographic locations. Little research attention has been given to the challenges of managing information and communication overload in TD team science initiatives despite the fact that it has been shown to adversely affect productivity, effectiveness, decision making, health, and personal relationships in many organizational and occupational settings (e.g., Bawden, Holtham, & Courtney, 1999; Farhoomand & Druiy, 2002). Some important facets of this problem are considered below.

Information and Communication Overload in TD Research

Conducting TD research requires a willingness to consume and manage large amounts of new information. In addition to keeping up with the growth of information in their own respective fields, it is also necessary to master and bridge often unfamiliar fields of research. While information overload also occurs in unidisciplinary research (Wilson, 1996), the scope and the intensity of the amount of new information are distinct in TD research. This constant barrage of information is associated with a number of negative outcomes including suboptimal decision making and decreased productivity, difficulties in identifying and selecting relevant information, ignoring information and being too selective in processing information and communications, experiencing perceived loss of control over information and communication, and increased errors, stress, confusion, and cognitive strain (Bawden et al., 1999; Eppler & Mengis, 2004; Farhoomand & Druiy, 2002; Mark, Gudith, & Klocke, 2008; Misra, 2010).

TD collaboration is especially challenging for geographically dispersed teams. Individuals may be required to become proficient in new kinds of information and communication technologies (e.g., video conferencing, online meetings, and electronic discussion boards). Moreover, large-scale TD collaborations require team members to manage substantial volumes of e-mail; print and archive e-mail communications, and digitized attachments; pull and share information with other team members in a timely manner; deal with feelings of alienation when information is distributed unevenly among team members; cope with the depersonalizing qualities of computer-mediated communication; and resolve glitches in communications technologies as they occur over the course of a collaborative project (Finholt, Rocco,

Bree, Jain, & Herbsleb, 1998; Olson & Olson, 2000; Sonnenwald, 2007). This source of communication-based overload can have important implications. Recent studies of knowledge workers indicate that their workplace and organizational routines have become increasingly fragmented, in that they frequently switch among multiple tasks and encounter many interruptions owing to their dependence on the Internet and wireless communication strategies (Gonzales & Mark, 2005; Mark, 2002; Mark, Gonzalez, & Harris, 2005; Mark et al., 2008; Su & Mark, 2008). Even when participants work together within a single organization, members must participate in additional center-wide meetings, events, and working group sessions above and beyond their regular organizational responsibilities, which can heighten the sense of overload experienced by team members.

The preceding review of the collaborative processes of TD research and information and communication-based overload in TD research reveals that TD teams are often susceptible to intrapersonal, interpersonal, organizational, and structural barriers and are prone to interpersonal tensions, conflict, and social fragmentation across the duration of the collaborative process (Stokols, Misra et al., 2008). Examples of the challenges and constraints faced by TD research teams are described in further detail in Chapter 2. The next section reviews a variety of strategies to help mitigate these challenges and promote sustained and effective TD research.

Strategies for Encouraging and Sustaining Effective TD Collaborations

Intrapersonal Strategies

At the intrapersonal level, there are a variety of techniques individuals can implement to deal with information overload. Individual coping repertoires such as personal information management and organization styles (e.g., routines for "going off-line" at regular intervals, strategies for sorting and responding to e-mail messages, taking regular breaks from computer or digital communication-related activities) have been found to mediate the effect of cyber-based sources of overload on stress. That is, individuals reporting higher levels of coping capacity experienced lower levels of stress associated with cyber-based overload as compared to those who reported lower levels of coping capacity (Misra, 2010).

Interpersonal Strategies

There are a number of strategies to enhance effective communication and resolve interpersonal team conflict within TD teams. Appreciative inquiry (AI) is a process that aims to enhance collaborative effectiveness through an exploration of the strengths and successful experiences of the members. Therefore, rather than

focusing on the challenges of the collaboration, AI begins with an analysis of what is working within the group and then uses that information to engender change (Cooperrider & Srivastva, 1987). Appreciative inquiry approaches have been found to foster trust and build relationships among team members. Another method to build team unity and reduce conflict is the use of seminar programs aimed at facilitating knowledge transfer and shared language development. This can help reduce tensions related to opposing scientific perspectives and language and knowledge barriers that often exist when members from differing disciplines collaborate.

Oftentimes the source of interpersonal tensions originates from the lack of clearly defined expectations at the outset of collaboration. Delineating expectations through a scientific *prenuptial agreement* or *terms of reference* in the shape of a formal written contract or verbal discussion can help resolve issues such as authorships, roles, goals, and execution of the project before they become sources of conflict (Gadlin & Jessar, 2002). Expectations and policies can also be outlined at the outset through the creation of operation manuals and publication guidelines.

Organizational Strategies

Strategies to overcome organizational barriers to TD collaboration include *university-level* measures such as those recommended by the University of California (UCI), Irvine task force for identifying barriers to multidisciplinary research (Hamkalo et al., 2000). The UCI task force recommends that the personnel recruitment and review processes need to be sensitized to the issues participants encounter in TD research. Specifically, chairs and deans of departments should monitor faculty members' individual contributions to collaborative research projects and ensure that such contributions are fully acknowledged. It is also recommended that the administration be made more aware of the benefits and needs of TD research so that team science activities can be a priority on university and departmental agendas.

In addition to identifying funding sources for TD research projects, the UCI task force recommends stimulating interactions and discussions among faculty across departmental and disciplinary lines through regular meetings and retreats, arranging for dedicated resource persons to mediate discussions between potential collaborators and guide faculty through multi-investigator proposals and agency requirements, and negotiating agreements for cost sharing, space, and staff commitments between faculty and deans of departments.

Since multi-investigator projects involving more than one academic unit pose special problems for ensuring fiscal responsibility, the task force recommends the development of campus policy statements concerning the management of such projects as well as written agreements about responsibilities, requirements, timelines for submission of data, and final reports among participating academic units.

Similar reforms to faculty appointments, tenure, and promotion policies at the *department level* have been made in the University of North Carolina (UNC), Chapel Hill School of Medicine (Orringer, 2008). Since it has been recognized that interdisciplinary research is increasingly important for the future of biomedical

science, committees are instructed to consider UNC faculty members' contributions to such collaborative projects in terms of their role in the project as well as the indispensability, originality, and creativity of their contributions. The policy states that as part of the review process, information about the faculty members' contributions to such projects should be solicited from principal investigators, project directors, and others who have first-hand knowledge about the faculty member's role. Such policies are vital since the extent of alignment between university-level and department-level policies to promote TD collaboration is an important factor influencing the effectiveness of such collaborations (Stokols et al., 2003).

Structural Strategies

Structural strategies for encouraging team science programs occur primarily at the technological and physical-environmental levels. State-of-the-art technology can enhance collaborative capacity, but maintaining up-to-date equipment and software is important for ensuring that collaborative groups (especially dispersed groups) are able to communicate and share data efficiently. This can be accomplished by leveraging institutional resources (e.g., software licenses available that may not be widely publicized) and using free or low-cost web tools such as social networking sites and wiki pages. Additionally, efforts should be made to maximize and strategically consider the use of space by reorganizing when possible to ensure sufficiently large, proximally located office and laboratory spaces for team members.

Societal/scientific strategies: Despite the challenges at the societal and scientific levels, efforts have been made to promote effective TD work (Gruman & Prager, 2002). Importantly, broader level changes have relied upon gradual but steady progress at intrapersonal strategies, interpersonal readiness, organizational reform, and a call from the scientific communities and public health at large. One strategy for systematic and broader level change is to institutionalize the stakeholders' role in setting research priorities and garnering funding support (Gruman & Prager, 2002; Hall, Feng, et al., 2008). Within this process it is imperative that all relevant parties are engaged in the decision-making process which includes not only scientists but also health-care personnel, clinicians, patient advocacy groups, the pharmaceutical industry, business, and the general public. The incorporation of different stakeholders' perspectives is inherently a collaborative process in its own right and can ultimately speed up the "discovery to application" and public health impact processes.

Another broader level strategy is to mandate coordination among the scientific community, health-care system, industry and business as well as cross-agency collaborations through government policies (Gruman & Prager, 2002; Shen, 2008). A systematic link within and across various agencies, scientific and non-scientific communities with shared resources, languages, and accountabilities will ensure that TD collaboration is being executed with a common vision, shared goals, and responsibilities. Finally, it is becoming ubiquitous to build cultural literacy and

capacity among different stakeholder groups in order to function effectively in an increasingly inter-connected global community.

Summary and Conclusions

This chapter provides a review of the research on collaborative processes (i.e., collaborative readiness and capacity factors) associated with TD research initiatives. A relatively neglected challenge associated with TD collaborative work – information and communication overload – was introduced and elaborated. Further, strategies for enhancing collaborative effectiveness and translating scientific knowledge into health-promotive community interventions were proposed.

In sum, the preceding review of collaborative processes of TD team work suggests that the contextual factors most crucial to collaborative effectiveness are highly variable and depend on the type (e.g., scientific versus translation aims, narrow versus broad geographical scope, and narrow versus broad disciplinary orientation) and phase (e.g., research, training, or translation of scientific knowledge into community-based interventions) of the collaborative activities. At the same time, certain contextual and situational factors such as empowering leadership, members' collaborative readiness, and regular and effective communication emerged as important factors influencing the collaborative success of TD teams across a broad array of collaborative settings. Moreover, these contextual factors may influence team processes and outcomes interactively or cumulatively (Altman, 1995; Stokols, 2006). These findings suggest the value of optimizing as many factors as applicable to particular TD initiatives by matching the specific goals and structure of the TD research program with targeted investments in those contextual resources that are deemed most essential to its effectiveness.

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