Chapter in O'Rourke, M.O., Crowley, S., Eigenbrode, S.D., & Wulfhorst, J.D. (Eds), Enhancing communication & collaboration in interdisciplinary research. Los Angeles, CA: Sage Publications, 2014.

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Training the Next Generation of Transdisciplinarians

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Team members' capacity for cross-disciplinary communication and collaboration can be enhanced through a variety of training strategies, ranging from short-term, project-specific approaches (e.g., team science training workshops, collaborative readiness audits) to longer term modalities (e.g., college curricula, experiential learning, graduate and postgraduate internships incorporating multiple mentors from different fields) that are designed to cultivate an enduring transdisciplinary (TD) intellectual orientation that occurs over the course of an individual's career development. This chapter addresses the developmental phases and core attitudes, beliefs, values, cognitive skills, and behaviors underlying the cultivation of a scholar's TD orientation. Differences between the proposed conceptualization of a TD orientation and related theoretical constructs are considered. Examples are presented of curricular strategies designed to promote a TD orientation among undergraduate and graduate students within the School of Social Ecology at University of California, Irvine, and to enable them to communicate and collaborate more effectively as members of TD research teams. Efforts to evaluate the effectiveness of these training strategies also are discussed.

The author thanks Julie Thompson Klein and the editors of this volume for their helpful comments on earlier versions of the manuscript.

Introduction

The chapters in this volume reflect the surge of interest in cross-disciplinary approaches to a wide range of scientific and community problems that have emerged over the past few decades (cf., Frodeman, Klein, & Mitcham, 2010; Hirsch Hadorn et al., 2008; Kessel, Rosenfield, & Anderson, 2008; Klein, 1996; Repko, 2008; td-net, 2010; Whitfield, 2008). Cross-disciplinary teams have become increasingly prevalent across many research domains, owing to the growing recognition in academia and society at large that the world's most complex and intractable problems—including global climate change, poverty, war, famine, and disease—can be better understood and ameliorated from a broad interdisciplinary perspective than from the narrower vantage points of separate fields (Berkes, Colding, & Folke, 2003; Crow, 2010; Esparza & Yamada, 2007; Fry, 2001; Laszlo, 2001; Wuchty, Jones, & Uzzi, 2007).

The presumed benefits of cross-disciplinary approaches to scientific and community problems are widely touted, especially the potential for achieving a more comprehensive understanding of those problems when viewed from multiple rather than singular conceptual and methodological perspectives (Abrams, 2006; Higginbotham, Albrecht, & Connor, 2001; Naveh, 2001; Rosenfield, 1992; Weingart & Stehr, 2000). Yet it is also apparent that cross-disciplinary research programs and teams are not uniformly successful and occasionally falter due to the linguistic divides and interpersonal tensions that may arise among proponents of divergent scientific worldviews, and the labor intensity of collaborative ventures (Fiore, 2008; Morse, Nielsen-Pincus, Force, & Wulfhorst, 2007; Pickett, Burch, & Grove, 1999; Stokols, Misra, Hall, Taylor, & Moser, 2008). Confronted by the conceptual, logistical, and interpersonal challenges inherent in cross-disciplinary projects, research teams that successfully compete for large interdisciplinary grants (e.g., to support interdisciplinary centers) often shift toward a more "silo-ed" and less integrative work style once their collaborative grant application has been funded (cf., Cummings & Kiesler, 2007; Eigenbrode et al., 2007; Stokols, Harvey, Gress, Fuqua, & Phillips, 2005).

The burgeoning interest and investment in cross-disciplinary research, as well as the need to better understand the circumstances that facilitate or constrain collaborative success, have given rise to a rapidly growing field—the *science of team science,* or SciTS (Börner et al., 2010; Croyle, 2008; Stokols, Hall, Taylor, & Moser, 2008). One goal of SciTS scholarship is to evaluate the scientific and societal returns on investments in team-based research. Another important goal of the SciTS field is to translate lessons learned from prior cross-disciplinary research projects into practical tools and guidelines for improving the effectiveness of future collaborations among academicians, government officials, corporate leaders, and community stakeholders (Falk-Krzesinski et al., 2010; Hall, Feng, Moser, Stokols, & Taylor, 2008; Shen, 2008).

Examples of translational team science innovations include the Toolbox for Philosophical Dialogue described in Chapter 11 in this volume

(cf., Eigenbrode et al., 2007) and the training modules, "prenuptial agreements," and guidebooks for facilitating successful cross-disciplinary collaborations that are available online (COALESCE, 2012; National Cancer Institute [NCI], 2008, 2011; National Institutes of Health, 2010; NUCATS, 2010; ResearchToolkit.org, 2010; Science of Collaboratories, 2011). A key assumption underlying the development of these tools is that they can enhance communication and collaborative processes in team research. Preliminary efforts to evaluate the impacts of some of these resources (e.g., the Toolbox workshops) suggest that they do, in fact, facilitate more effective collaboration among team members (Eigenbrode et al., 2007; Schnapp, Rotschy, O'Rourke, & Crowley, 2012).

A common feature of the training resources cited above is that they are usually implemented on a project-specific, short-term basis—for example, when a research team is first funded to establish a cross-disciplinary center and during the early stages of participant collaboration. Whereas these short-term tools and strategies can be used effectively in many settings to improve cross-disciplinary communication, they cannot be relied on in all situations to ensure collaborative success. In some settings, certain individuals may persist in expressing unfavorable attitudes toward the disciplinary perspectives of their partners, thereby undermining interpersonal trust and the team's effectiveness in meeting its goals (cf., Sonnenwald, 2003). In other situations, a leader's inexperience may unnecessarily complicate collaborative processes (Gray, 2008). Also, some members may decide that they prefer to work individually, anchored in their own theoretical perspectives, rather than invest substantial time in cross-disciplinary exchanges with colleagues even after they've begun working as part of a research team or center (Austin, Park, & Goble, 2008; Campbell, 2005; Paletz & Schunn, 2010; Stokols et al., 2003). These examples of circumstances (including personal values, attitudes, and interpersonal styles) that can undermine cross-disciplinary collaboration highlight the importance of supplementing short-term, project-specific training strategies for improving team communication with longer term modalities (e.g., college curricula, experiential learning programs, and graduate or postgraduate internships incorporating multiple mentors from different fields) designed to cultivate an enduring intellectual orientation among students and scholars—one that is conducive to and supportive of their engagement in cross-disciplinary collaborative research.

A scholar's intellectual orientation and inclination to engage in cross-disciplinary research are cumulatively influenced by the educational environments, multiple mentors, and collaborative opportunities she or he encounters over the course of his or her career (Bammer, 2005; Barker, 1979; Callahan, 2010; Kessel et al., 2008; Klein, 2010a; National Academy of Sciences [NAS], 2005; Rhoten & Parker, 2004). Yet, to be most effective, educational efforts to instill a TD intellectual outlook among students and scholars (and to assess its influence on the processes and outcomes of cross-disciplinary collaboration) must be guided by a clear conception of what this orientation entails (Borrego & Newswander, 2010).

The ensuing discussion identifies distinctive facets of a TD intellectual orientation, including the core values, attitudes, beliefs, knowledge, and behaviors encompassed by this scholarly perspective (Fuqua, Stokols, Gress, Phillips, & Harvey, 2004; Hall, Stokols, et al., 2008; Klein, 2008; Stokols, 1998). Alternative approaches for nurturing a TD intellectual orientation also are discussed, including training programs that promote disciplinary specialization as a prerequisite for engaging in cross-disciplinary research as well as those that emphasize cross-disciplinary education and curricula at the outset of a student's career (Campbell, 1969; Heemskerk, Wilson, & Pavao-Zuckerman, 2003; Nash, 2008). Finally, examples of curricular strategies aimed at promoting a TD orientation among undergraduate, graduate, and postdoctoral trainees within an interdisciplinary academic program (the School of Social Ecology at the University of California, Irvine) will be presented, including a graduate seminar on Strategies of Theory Development that encourages students to develop their conceptual skills as cross-disciplinary theorists (Stokols, 2012).

Cultivating a TD Intellectual Orientation

Before discussing the core facets of a TD intellectual orientation, it is useful to consider different forms of cross-disciplinary research, including *multidisciplinarity*, *interdisciplinarity*, and *transdisciplinarity*, and their implications for designing training strategies that nurture student and scholar predilection for engaging in cross-disciplinary inquiry. Rosenfield (1992) and Kessel et al. (2008) define three forms of cross-disciplinary collaboration in contrast to *unidisciplinarity* (UD), whereby scholars from a single field work together to address a common research problem. In *multidisciplinary* (MD) collaborations, scholars from different fields work independently or sequentially, each from his or her disciplinary perspective, with the goal of eventually combining their perspectives to address a common research question. In *interdisciplinary* (ID) collaborations, team members work jointly, each drawing on his or her discipline-specific perspective, to address a common research problem. In TD teams, partners work jointly to develop shared conceptual frameworks and novel methodologies that ultimately synthesize and extend research on a particular topic across the boundaries of two or more fields.[1]

[1]Transdisciplinarity is conceptualized by some scholars as always involving, by definition, close collaboration between researchers and community stakeholders who work together to understand and ultimately resolve societal problems (td-net, 2010). In this chapter, TD research that bridges both academic and nonacademic perspectives as a basis for redressing societal problems is referred to as *transdisciplinary action research* (Stokols, 2006). At the same time, it is recognized that TD collaborations can occur among partners who represent primarily academic (discipline-based) rather than nonacademic epistemologies, and whose collaborative goals focus more on intellectual discovery rather than on the development of translational solutions to community problems.

These alternative forms of collaborative research reflect a continuum extending from the least amount of interchange among team members from different fields (UD) to the greatest degree of cross-disciplinary dialogue, integration, and innovation (TD).

As noted by Nash (2008), the distinctions between MD, ID, and TD research suggest corresponding approaches for training cross-disciplinary students and scholars. In MD training programs, students are taught a single disciplinary approach but also learn to work collaboratively with researchers from other fields. In ID settings, trainees are provided a working knowledge of the conceptual and methodological approaches of different disciplines. In TD programs, the major goal is to produce scholars capable of synthesizing concepts and methods from different fields that pertain to a particular research topic. Each of these approaches can be implemented to strengthen student receptiveness to and capacity for engaging in cross-disciplinary research. It seems reasonable to assume, however, that owing to their particular emphasis on conceptual synthesis, TD training programs have the greatest capacity to foster student abilities to frame research questions broadly and to integrate theoretical, philosophical, and methodological perspectives drawn from diverse fields.

It is important to note that the definitions and practice of UD, MD, ID, and TD research and training strategies are not mutually exclusive. In fact, many research and training programs involve mixtures of these orientations, whereby scholars and students emphasize different orientations over the course of their time in the program (cf., Klein, 2010b). Moreover, certain values, attitudes, and behaviors associated with a TD intellectual orientation are shared by and overlap with other collaborative perspectives, such as MD and ID research. Nonetheless, the conceptualization of a TD intellectual orientation proposed in this chapter is based on the assumption that it is the particular combination and synergy among certain collaborative values, beliefs, attitudes, and behaviors, in combination with certain conceptual strategies that emphasize multilevel theorizing and contextual analyses of research and societal problems, that distinguish a TD orientation from UD, MD, and ID perspectives.

Several scholars (cf., Bunderson & Sutcliffe, 2003; Cannella, Park, & Lee, 2008; Fiore et al., 2010; Keyton, Beck, & Asbury, 2010; Van der Vegt & Bunderson, 2005) have suggested that collaborative orientations are emergent states of teams learned by their members over the course of their working together. A team's collaborative orientation can be fostered either by recruiting a diversity of members, each of whom brings unique disciplinary expertise to the team, or by recruiting individuals who are each familiar with multiple fields and predisposed toward cross-disciplinary integration prior to joining the team. Presumably, a team collaborative orientation can emerge from either of these team composition strategies, though the relative effectiveness of these approaches likely depends on the particular types of research and societal problems addressed by the team.

Recognizing that *collaborative orientations can be defined either as individual- or group-level constructs*, the present chapter focuses on the intrapersonal rather than the emergent team-based qualities of a TD orientation for the following reasons. First, organizational scholars have given considerable attention to the development of team-based collaborative orientations, yet the personal qualities that constitute an individual's TD orientation have received relatively little attention in prior research. Second, because the communicative and collaborative success of cross-disciplinary teams depends at least in part on their members and the intellectual styles that each brings to the group, it seems plausible that identifying core attributes associated with a TD orientation and developing educational programs to nurture those personal qualities may improve the prospects for effective cross-disciplinary communication and collaboration. More specifically, cultivating an individual's TD orientation may enable him or her to communicate more effectively with fellow team members who represent diverse disciplinary and philosophical perspectives, and to identify more readily with the collaborative and integrative goals of the team—activities that are crucial for effective team cognition and interpersonal coordination (cf., Fiore et al., 2010; Keyton et al., 2010).

Considering the unique features of MD, ID, and TD forms of cross-disciplinarity and acknowledging that these orientations are at least partly overlapping in regard to their identifying characteristics, the ensuing discussion focuses primarily on the distinctive qualities and developmental trajectory of a TD orientation among students and scholars. Clearly, significant and innovative discoveries can be achieved through UD, MD, and ID research, as well as through TD scholarship (cf., Klein, 2010b). At the same time, multiple lines of earlier research suggest that scholars who possess diverse knowledge sets drawn from multiple fields, as well as the inclination to integrate multiple analytic levels in their work, are more likely to generate highly radical innovations as compared with those whose knowledge and conceptual strategies are more narrowly circumscribed (Cohen & Levinthal, 1990; Leung, Maddux, Galinsky, & Chiu, 2008; Root-Bernstein, Bernstein, & Garnier, 1995; Simonton, 2009). Accordingly, a TD orientation may be more conducive to achieving highly novel scientific and societal advances at the boundaries of multiple fields than may those associated with MD or ID approaches. The present analysis suggests that to the extent scholars aspire to study and help mitigate complex societal problems that are inherently multifaceted and (often) seemingly intractable, they will be more likely to arrive at a comprehensive and novel understanding of those problems when they approach them from a broadly integrative, TD perspective than if they approach from the narrower vantage points of particular fields (Association of American Colleges and Universities [AACU], 2007; Bammer, 2005; Brown, Harris, & Russell, 2010; Fuller, 2003; Holley, 2009; Laszlo, 2001; Naveh, 2001).

Finally, it is useful to note that all four research orientations (UD, ID, MD, TD) can be pursued either by a single scholar working independently or by members of a research team who decide to work collaboratively (Abrams,

2006; Stokols et al., 2003). Thus, a TD intellectual orientation can be expressed both through independent as well as collaborative scholarship. To the extent that students and established scholars prefer to work collaboratively as members of a TD research team, their training should foster the development of interpersonal skills conducive to effective collaboration. We turn now to a consideration of the core facets of a TD intellectual orientation, which is the intended outcome of TD training.

Core Facets of an Individual's TD Orientation

An individual's *TD orientation* is a constellation of personal attributes that emerges developmentally over the course of a scholar's career and is shaped through exposure to multiple learning environments, mentors, and research settings. Whereas each stage of an individual's development (including kindergarten through high school, college, graduate school, and continuing education later in one's career) contributes to his or her overall intellectual orientation, the present discussion highlights the formative impact of university and postgraduate training experiences. For most individuals, it is during these life stages that one's intellectual orientation emerges most clearly (cf., Bammer, 2005; Chang, Hursting, Perkins, Dores, & Weed, 2005; Golde & Gallagher, 1999; IGERT, 2010; Jantsch, 1970; Klein, 2010a; Misra, Stokols, Hall, & Feng, 2010; NAS, 2005).

The TD intellectual orientation as conceptualized here encompasses at least five categories of personal attributes: (1) *TD values* that predispose one toward acquiring a broad understanding of complex research and societal problems and translating integrative insights about them into practical solutions; these values are closely linked to (2) a set of *attitudes* favorable toward engaging in integrative scholarship bridging multiple disciplines; (3) *beliefs* that integrating concepts and methods from diverse fields is essential for achieving important scientific and societal advances; (4) *conceptual skills and knowledge* that enable scholars to traverse multiple levels of analysis, synthesize disparate disciplinary and philosophical perspectives, and develop novel conceptualizations that transcend preexisting constructs and theories; and (5) *TD behaviors* that are conducive to learning about and synthesizing concepts and methods from disparate fields and collaborating effectively as a research team member.

TD Values

Certain values are highly consistent with participation in collaborative research spanning multiple fields. Human values are the guiding principles that a person aspires or adheres to across the various spheres of his or her life (cf., Rokeach, 2000; Schwartz & Bilsky, 1990). Examples of these are *integrity* and *fairness*, which motivate individuals to behave honestly and equitably in their interactions with others. Values especially conducive to a

scholar's participation in TD research include *open-mindedness*, *tolerance, and respect* toward other points of view; an *inclusive rather than exclusionary stance* toward perspectives that are unfamiliar or different from one's own; and an emphasis on *pluralism rather than determinism* when considering the causal structure of scientific and societal problems. As well, individual desire to promote *social justice* and *environmental sustainability* may fuel their efforts to engage with community partners in translational TD action research aimed at ameliorating societal and ecological problems (AACU, 2007; Brown & Jennings, 2003; Schor, 1992; Stokols, 2006). The principles and ideals mentioned above are a representative but not exhaustive set of the value commitments associated with a TD orientation. These values enable members of cross-disciplinary teams to resist certain constraints, such as in-group versus out-group biases, parochialism, and the tendency to associate with and feel attracted to similar others (cf., Byrne, 1971; Lau & Murningham, 2005; Raskas & Hambrick, 1992; Tajfel, 1982), that commonly arise among collaborators who have been trained in different fields and have inculcated discipline-centric worldviews. TD value commitments are the *motivational* core that supports and sustains a variety of attitudes, beliefs, conceptual approaches, and behaviors that are mutually consistent with one another and jointly constitute the TD intellectual orientation.

TD Attitudes

A person's attitudes reflect his or her positive, negative, or neutral feelings toward particular topics, ideas, people, or things (cf., Rosenberg, 1956). Individuals who embrace values of openness to new ideas and plural perspectives on science and society are likely to be more favorable toward opportunities to collaborate with others in cross-disciplinary research than are those who are less receptive to unfamiliar points of view. Similarly, they may be more willing to invest additional time in learning the subject matter of diverse fields because they regard cross-disciplinary studies and the societal outcomes of such research as highly valuable. At a more general level, positive attitudes toward persisting on complex tasks, even when confronted by logistical, interpersonal, or conceptual challenges, may be a prerequisite for achieving successful outcomes in collaborative research. Favorable attitudes toward the processes and outcomes of cross-disciplinary inquiry may be rooted in more general and enduring personal dispositions, such as psychological hardiness, optimism, perseverance, stamina, adaptability, intellectual curiosity, tolerance for uncertainty, and willingness to take risks (cf., Kruglanski, Pierro, Manetti, & Grada, 2006; Maddi, 2001; Nash, 2008).

TD Beliefs

Beliefs reflect an individual's cognitions about the relationships between two or more attitude objects, such as beliefs about the causes of a particular

phenomenon or opinions about another person's distinctive qualities (Fishbein & Ajzen, 1975). In studies of cross-disciplinary scientific collaboration, scholars' beliefs about the favorable and/or negative outcomes of participating as members of research centers and teams have been identified and measured. For example, the NCI Research Orientation Scale measures the degree to which individuals believe that the benefits of collaborating with other scientists outweigh the costs of such work or that they tend to be more productive working on their own rather than as members of a collaborative research team (Hall, Stokols, et al., 2008). The Toolbox research project queries participants about their *philosophical beliefs* (including their ontological and epistemological assumptions) concerning the kinds of evidentiary support required for validating scientific measurements and findings and the extent to which the value of research stems from its applicability to community problem solving or its potential for producing basic discoveries (Eigenbrode et al., 2007). Other studies of scientific teams have assessed participants' beliefs that their efforts to work collaboratively with fellow scholars across disciplinary and geographic boundaries will result in *innovative theoretical insights*, *significant empirical discoveries*, and *translations of research findings into societal improvements* (Olson et al., 2008). Interestingly, an *individual's belief in his or her ability to be creative* as a theorist and researcher may be one of the most important prerequisites for scholarly success (Sternberg, 2002), especially in the context of cross-disciplinary studies where innovative efforts to forge new linkages across the boundaries of multiple fields are essential. These examples, though limited in number and scope, reflect the kinds of beliefs that are central to an individual's initial engagement and sustained participation in TD research.

TD Conceptual Skills and Knowledge

An individual's capacity to participate effectively in TD research projects depends in part on his or her acquisition of certain conceptual skills and types of knowledge. The ability to view research and societal problems reflexively and critically from multiple levels of analysis and to achieve an integrative and holistic understanding of their causes and consequences are essential ingredients of a TD orientation (Boix Mansilla, 2010; Pohl & Hirsch Hadorn, 2008; Wickson, Carew, & Russell, 2006). One's capacity to create novel conceptual frameworks that transcend the constructs and methods of particular fields is greater to the extent that she or he is able to think broadly and contextually about the multiple underpinnings of complex problems (Klein, 2008; Stokols, 1987; Suedfeld & Tetlock, 1977).

Graduate and undergraduate students increasingly are being taught skills that align with these attributes in a growing number of university programs that focus on the integration of diverse disciplinary perspectives and strategies of creative theorizing spanning multiple levels of analysis (Bammer, 2005; Borrego & Newswander, 2010; Klein, 2010a; Misra et al., 2009,

2010; Nash, 2008). For instance, Bammer (2005) developed a university program focusing on *integration and implementation sciences*. Bammer contends that certain categories of knowledge are required to facilitate a scholar's ability to learn and implement these conceptual skills, especially *systems thinking*, *participatory methods*, and *knowledge management* strategies. Additional knowledge sets emphasized in other TD training programs include methods and tools (e.g., stakeholder analysis, anticipatory governance, and conflict resolution strategies) that can enable students to prepare for community-based TD research (Bergmann et al., 2012; Pohl & Hirsch Hadorn, 2008; Wiek, Withycombe, & Redman, 2011).

In the Strategies of Theory Development course described in a later section (Stokols, 2012), students also are introduced to principles of *human and social ecology*, *contextual and transformational theorizing*, and ways of *incorporating diverse analytic perspectives* into their conceptual frameworks (e.g., objectivism and subjectivism, determinism and pluralism, individual and aggregate analysis, grand and middle-range theorizing, inductive-grounded and deductive-a priori modeling, analogical and visual reasoning). Scholars possessing these kinds of conceptual skills and knowledge sets should be better prepared to comprehend and manage the integrative complexities inherent in multilevel, cross-disciplinary research projects.

TD Behaviors

Several behaviors are reflective and supportive of a TD intellectual orientation. Some personal practices and routines increase a scholar's exposure to diverse disciplinary perspectives and knowledge—for instance, reading articles and books, taking courses, attending conferences and presentations outside of one's primary field, and engaging in frequent meetings with colleagues from different disciplines to share and integrate ideas (Hall, Stokols, et al., 2008; Klein, 2010b; NAS, 2005; Stokols et al., 2005). Other behaviors facilitate effective communication and collaboration in team settings, such as communicating with colleagues respectfully, maintaining proper etiquette when sending electronic messages, and gaining extensive experience working collaboratively in TD research projects and centers, initially as a student and later as an established scholar. The more collaborative experience one acquires in TD research settings, the better prepared she or he will be to lead and manage future team-based projects. Thus, certain behaviors enable a scholar to facilitate TD collaboration with and among one's colleagues—especially, acting in ways that enable them to cooperatively develop and openly share their ideas, as well as negotiate and resolve intellectual or interpersonal disagreements (Gray, 2008; Klein, 2010b; Morgan et al., 2003; Obstfeld, 2005).

The TD values, attitudes, beliefs, conceptual skills, and behaviors mentioned above constitute a partial but illustrative sample of the personal attributes associated with a TD orientation. As mentioned earlier, each of

these values, attitudes, beliefs, behaviors, and conceptual orientations may share some commonality with other collaborative styles, such as MD and ID perspectives. However, it is *composite synergy* among TD attitudes, beliefs, and values, in combination with highly integrative conceptual and behavioral skills, that accounts for the distinctive capacity of the TD intellectual orientation (even as compared with ID research) to generate exceptionally novel scientific and societal innovations. Having identified certain core facets of this intellectual perspective, we next consider the structure of educational programs designed to cultivate a TD orientation among undergraduate, graduate, and postdoctoral students, as well as among scholars previously trained in specific fields.

Educational Strategies for Nurturing a TD Intellectual Orientation

The interrelated facets of a TD outlook suggest specific criteria for designing and evaluating educational programs aimed at nurturing this orientation among students and scholars. Ideally, these programs should be organized to include curricular and didactic elements that foster TD attributes and skills. Accordingly, the efficacy of a TD program can be evaluated by measuring the extent to which it promotes intended developmental changes in student value commitments, attitudes, beliefs, conceptual skills, and behavior both during and after training.

Whereas many ID and TD proponents would agree on the broad goals and intended consequences of cross-disciplinary training (e.g., the development of an individual's ability to synthesize concepts and methods from diverse fields), there has been some divergence of opinion about the best curricular strategies and institutional designs for achieving those goals. Scholars have expressed contrasting views about various pedagogical issues, such as whether or not specialized disciplinary training is an essential prerequisite for, and should always precede, one's efforts to cultivate TD competencies. For instance, Campbell (1969) asserts that students should be encouraged to engage in problem-focused cross-disciplinary inquiry during the earliest stages of their educational careers. As an alternative to trying to master the subject matter of one or more fields before engaging in cross-disciplinary scholarship, Campbell exhorts students to pursue "fish-scale" research topics that overlap the boundaries of two or more fields. With sufficient encouragement from mentors to acquire and synthesize information from multiple disciplines pertinent to topics lying at the interface of those fields, students become proficient in conducting cross-disciplinary research. Also, by embracing problem-focused rather than discipline-centric research at the outset of their careers, they are better able to avoid the conceptual biases associated with *disciplinary chauvinism* and the *ethnocentrism* of traditional academic departments (cf., Heemskerk et al., 2003).

Klein (2010a) offers an alternative and more sanguine view of the educational benefits that students derive through their exposure, often concurrently, to UD, MD, ID, and TD training cultures and programs. She observes that these diverse forms of scholarship, rather than being antithetical to one another, often coexist comfortably and constructively within the same educational settings—and within the same scholars, who may shift between UD, MD, ID, and TD modes of inquiry depending on the particular research project (or phase of research) in which they are engaged at a given time. Klein (2008) specifically emphasizes the educational benefits that derive from a "quadrangulation" of UD *depth*, MD *breadth*, ID *integration*, and development of TD *competencies* within baccalaureate, doctoral, and postgraduate training programs.

A related concern is whether or not entire universities and educational systems should be restructured to facilitate TD training and problem-oriented rather than discipline-centric education (cf., Jantsch, 1970). At many universities, cross-disciplinary training is provided by research institutes and degree-granting programs that exist alongside (yet often peripheral and marginal to) the more traditional and prevalent disciplinary departments on campus. Some suggest that university students be encouraged to participate in these adjunct cross-disciplinary programs to supplement their discipline-based training (Klein, 2008; Lattuca, 2001; NAS, 2005; Weingart & Stehr, 2000), and to apply for postdoctoral fellowships that afford opportunities to work with multiple mentors representing diverse fields (Chang et al., 2005; Robert Wood Johnson Foundation, 2008).

On the other hand, Michael Crow (2010), president of Arizona State University, offers a radically different vision of higher education—one that emphasizes TD training, community engagement, and problem-focused research at all levels of the institution. According to Crow, TD scholarship and solutions to the epochal problems of our time (e.g., planetary sustainability, human rights, poverty alleviation) can best be advanced through a comprehensive redesign of the New American University that replaces traditional academic departments organized around arbitrary (and increasingly "ossified") disciplinary boundaries with problem-oriented, TD schools and institutes focusing on broad topics such as global sustainability and human evolution and social change. A fundamental restructuring of American universities around core themes such as integrative learning, community engagement, and societal relevance also is envisioned by the AACU (2007), though it often works within existing university structures while supporting efforts to promote more enduring institutional changes.

Whereas some university-based programs emphasize TD training at the outset of a student's undergraduate or graduate studies as envisioned by Campbell and Crow, most efforts to promote cross-disciplinary training incorporate a blend of UD, MD, ID, and TD experiences as described by Klein. In many of these programs, students are required to specialize within a particular field and then supplement their disciplinary coursework with cross-disciplinary fellowships and apprenticeships supervised by multiple

mentors. Excellent examples of these programs are the National Science Foundation–funded Integrative Graduate Education and Research Traineeships (IGERTs) offered at many U.S. universities (Borrego & Newswander, 2010; IGERT, 2010) and NCI's Cancer Prevention Fellowship Program (Chang et al., 2005).

An extensive review of curricular innovations and training programs that cultivate a TD intellectual perspective is beyond the scope of this chapter. A comprehensive, internationally oriented review of educational programs designed to instill ID and TD competencies is provided by Klein (2010a). The ensuing discussion focuses instead on an academic unit at the University of California, Irvine (UCI)—namely, the School of Social Ecology (UCI, 2012)—and its predecessor, the Program in Social Ecology (hereafter, "the School" and "the Program"). The Program was established at UCI in 1970 with the explicit mission of training students to analyze research and policy questions from a broad ecological perspective that integrates multiple disciplines and links basic theory and research with community problem solving. Social Ecology evolved from a program for a school on the Irvine campus in 1992, following a 3-year review by the UC Regents, Administration, and Academic Senate. Social Ecology at UCI is one of the longest standing, cross-disciplinary degree-granting units within a major research university.

UCI's School of Social Ecology

From its inception, the Program incorporated certain innovative features, including (1) required core courses for the BA, MA, and PhD degrees in social ecology that introduce students to the integrative conceptual and methodological themes (e.g., the ecological paradigm, systems theory, problem-oriented research and practice, principles of TD inquiry) bridging the multiple disciplines represented within the Program; (2) an undergraduate field study curriculum that requires all Social Ecology BA students to complete internships at local government agencies, NGOs, or private firms for the purpose of encouraging experiential learning and community-engaged scholarship; (3) recruitment of faculty members and graduate students trained in a variety of different fields, such as urban and regional planning, psychology and social behavior, criminology and law, demography, environmental sciences, and public health; (4) cultivation of several problem-oriented action research programs focusing on complex social and environmental problems; and (5) participation of Social Ecology faculty members in local community decision-making groups, such as the Irvine City Council and Planning Commission.

The Program grew rapidly during the 1970s and 1980s, attracting scores of doctoral students and more than 1,500 BA majors by 1985. Student enrollments and faculty recruitments continued to climb during the 1990s, fueling additional expansion of the School's degree programs and facilities.

With more than 3,500 BA students by 1998, social ecology became the second largest undergraduate major on the Irvine campus. Not surprisingly, the rapid growth of the School and its occupancy of additional space in multiple buildings precipitated certain tensions between the original cross-disciplinary mission and organization of the School, on the one hand, and its increasingly departmentalized and decentralized structure by the late 1990s, on the other. For instance, the number of schoolwide required core courses was reduced over the years to accommodate the curricular requirements of newly established, department-based graduate and undergraduate degree programs. These organizational developments are described in greater detail elsewhere (cf., Binder, 1972; Stokols, 1998).

Despite the inevitable tensions prompted by the School's rapid growth and departmentalization, it has continued over four decades to offer a series of core courses that introduce its annual cohorts of incoming students to the integrative themes associated with ecologically oriented TD action research. The School's faculty members also offer elective courses and serve as mentors in fellowship programs that afford graduate and undergraduate students opportunities to participate in team-based TD research teams. Moreover, they have established several institutes and centers to engage faculty and students from across the entire campus in problem-focused TD research (UCI, 2012).

Social Ecology Curricula Designed to Nurture a TD Intellectual Orientation

In this section, three specific courses designed to foster a TD intellectual stance among UCI students are described. The results of evaluative studies to assess the educational outcomes associated with two of these courses also are noted. First, the Interdisciplinary Summer Undergraduate Research Experience (ID-SURE) was established in 2004 with funding from the National Institutes of Health to provide junior and senior students with training in the principles and strategies of team-based TD research. ID-SURE fellows complete a one-quarter course in the Social Ecology of Health Promotion that focuses on multilevel systems analyses of public health problems and disease prevention strategies (UCI, 2004). One of the course requirements is that participants work on team-based research projects with fellow students representing two or more BA majors at UCI.

A 3-year study undertaken to assess the educational processes and outcomes generated by the ID-SURE curriculum found that the components of this program bolstered students' TD orientation in terms of the extent to which they gained appreciation for the value of collaborative scholarship and became more knowledgeable about TD research concepts and methods. Moreover, the extent to which students engaged in behaviors associated with a TD orientation (e.g., reading journal articles and attending lectures outside of their primary academic major) was found to increase over the course of the training program (Misra et al., 2009).

At the doctoral level, the Seminar in Social Ecology (SE200) is a core course taken by all first-year PhD students in the School during their initial quarter of graduate studies. This foundational seminar, established in 1973, introduces graduate students to principles of human and social ecology, systems theory, multilevel contextual analyses of scientific and societal problems, and strategies of community-engaged action research. The course readings and lectures examine the history of the ecological paradigm and the challenges posed by efforts to translate research findings into evidence-based community interventions and public policies (cf., Altman, 1995; Catalano, 1979; Stokols, ~~2009~~). These issues are addressed from the perspectives of the School's diverse academic departments and research centers. Stokols, 2013)

An evaluation of the educational outcomes of the schoolwide TD doctoral training program in social ecology, including the introductory SE200 seminar, was conducted by Mitrany and Stokols (2005). Based on a content analysis of each dissertation written by PhD candidates from the various doctoral training programs in the School, independent reviewers rated the TD qualities of the dissertations, including the degree to which they reflected broad gauged integration of concepts and methods from different fields and incorporated multiple levels of analysis and diverse research methods. On the whole, Mitrany and Stokols's data suggested that the School's core training program has been moderately successful in nurturing a cross-disciplinary orientation among its graduates. Although relatively few dissertations presented conceptual frameworks transcending the boundaries of multiple fields, many of them demonstrated strong ID attributes, such as the establishment of links between concepts and methods from different disciplines and multilevel contextual analyses of research questions and societal problems. These results offer encouraging evidence for the short-term impacts of ID and TD training programs, but the longer term educational outcomes of these curricula (including graduates' career trajectories and cumulative scholarly accomplishments) remain to be evaluated in future studies.

One other course in the School designed to promote a strong TD orientation in students' current and future work is the graduate seminar on Strategies of Theory Development, SE261 (Stokols, 2012). This seminar is not required for all PhD students in the School but is typically taken by all social ecology degree candidates and by many enrolled in other doctoral programs at UCI. A fundamental purpose of the course is to encourage students to develop their skills as creative theorists. Another goal of the seminar is to introduce them to key issues and controversies facing the development of multilevel TD theories—for example, the conceptual challenges that arise when scholars attempt to integrate the contrasting epistemologies and worldviews associated with distinctly different disciplines. Because the ability to creatively synthesize conceptual and methodological perspectives from diverse fields is so fundamental to the cultivation of a TD intellectual orientation, the remaining discussion focuses on the principal assumptions and

didactic approaches emphasized in Social Ecology's Strategies of Theory Development seminar as it has been taught over the past 30 years.

Cultivating a TD Orientation Through Strategies of Cross-Disciplinary Theorizing

Graduate curricula in the behavioral and natural sciences typically emphasize the development of methodological skills for testing hypotheses. All too often, however, graduate training gives short shrift to the hypothesis-formation phase of research. A key assumption of the Strategies of Theory Development seminar is that TD theorizing can be enhanced by encouraging students and scholars to develop their skills as creative theoreticians. The development of novel hypotheses is essential for progress in any type of scholarship, including UD, MD, ID, and TD research. Yet the capacity to create novel conceptual frameworks bridging multiple levels of analysis is absolutely fundamental to TD inquiry. Moreover, the challenges inherent in TD theorizing are especially daunting when formulating new theories that integrate the perspectives of highly divergent fields—for instance, creating broad gauged frameworks spanning environmental, biomedical, psychological, organizational, and sociological levels of analysis, as compared with narrower models linking disciplines whose analytic levels and conceptual/methodological perspectives are relatively similar, such as molecular biology, pharmacology, and neuroscience (cf., Klein, 2010b; Misra et al., 2010; Stokols et al., 2003).

As noted earlier in this chapter and in Chapter 11 in this volume, the Toolbox Project is designed to promote communication and understanding among team members about their disciplinary vantage points and dissimilar theoretical, philosophical, and methodological assumptions as they initiate and continue to work together on a cross-disciplinary research project (Eigenbrode et al., 2007). Similarly, Heemskerk et al. (2003) emphasize the value of conceptual discussions and efforts among research partners to create shared graphical models as strategies for bridging their disciplinary perspectives and enhancing collaborative success. The Strategies of Theory Development seminar at UCI is intended to introduce graduate students to the contrasting epistemologies and worldviews of multiple fields *at the outset of their careers* so that as they participate in subsequent TD projects they will be better prepared to understand, appreciate, and assimilate the alternative philosophical assumptions, constructs, and methods associated with disparate fields and levels of analysis.

Efforts to cultivate the conceptual skills and knowledge base needed for creative TD theorizing often confront major challenges. First, graduate students usually are advised to focus on their empirical research projects and postpone efforts to develop novel theories until they have completed their graduate studies and in some instances until they have achieved tenure at a

university. Creative theorizing is regarded by many faculty mentors as an ill-advised goal for PhD candidates, especially those who are just beginning their graduate careers. The Strategies of Theory Development seminar aims to disabuse students of these typical biases against encouraging theory development efforts among doctoral candidates. Efforts are made early in the course to demystify the processes of informal theorizing and formal theory development (Marx, 1976). Seminar participants are encouraged at the outset to make a staunch commitment to developing their skills as creative theorists (cf., Levy, 1968; Sternberg, 2002) and to draw on their personal experiences and intuitions as a basis for developing new theoretical insights (Mills, 1959).

Several features of the Theory Development Seminar are designed to bolster student motivation and capacity to generate novel ideas and provide ample opportunity for them to share their conceptual work with fellow students trained in a variety of different fields. First, course readings introduce strategies for enhancing creative problem solving and developing new ideas through techniques such as visual and analogical reasoning for avoiding "conceptual ruts" and analytical approaches that help alleviate conceptual, emotional, psychological, and interpersonal barriers to creative thinking (cf., Adams, 2001; Crovitz, 1970; Gordon, 1974; McKim, 1980; Weick, 1974; Wicker, 1985). Second, seminar participants prepare three short "idea papers" over the course of the 10-week quarter, in which they propose new concepts, gradually define and differentiate their constructs into a set of interrelated subtypes, and eventually articulate hypothesized relationships among subcategories in the form of a more structured theoretical statement. Third, students share and comment on one another's idea papers during three group tutorial sessions (each lasting 2–3 hours) that occur outside of the 10 weekly, 3-hour class sessions. Fourth, participants compile a journal of their own ideas and personal reactions to the assigned readings each week, which they turn in at the end of the quarter (cf., Mills, 1959).

Whereas these strategies afford class members opportunities to develop and communicate novel ideas and obtain constructive feedback from the instructor and fellow students, they do not directly confront another fundamental challenge associated with nurturing student capacity for creative TD theorizing—namely, the disciplinary biases and worldviews that they have accumulated as BA majors in various fields during their college years, which are often reinforced by faculty mentors who themselves are strongly aligned with scholarly paradigms endorsed by particular fields (cf., Kuhn, 1970). To counter these biases against synthetic cross-paradigm theorizing, the Theory Development Seminar exposes participants to widely different epistemological assumptions, many of which are arrayed along bipolar continua such as rationalism versus empiricism, objectivist versus subjectivist representations of reality, reductionist versus contextualist analyses of research topics, qualitative and/or quantitative research methods, grand versus middle-range theorizing, and aggregate versus individual (or macro, meso, and micro) levels of analysis adopted when investigating particular phenomena. Seminar students are explicitly encouraged to learn about the contrasting

assumptions inherent in these metatheoretical continua and to become adept at transversing and integrating different points along each continuum rather than getting "stuck" at the extreme ends of the continua and thereby locked into a particular *disciplinary orthodoxy* (for instance, by embracing exclusively microlevel analyses of the biomedical or psychological antecedents of disease while neglecting macroeconomic or sociological facets of the problem; cf., Becker, 1993).

The seminar readings assigned each week are selected to highlight contrasting epistemological perspectives. For instance, Platt's (1964) essay on "strong inference" and Gergen's (1978) article on "generative theory" illustrate the divergent perspectives of positivist and relativist philosophies of science. Park, Burgess, and McKenzie's (1925) objectivist "Chicago School" perspective on human ecology is contrasted with Firey's (1945) subjectivist analysis of "sentiment and symbolism as ecological variables." Also, students read Marx and Engels's (1968) *Communist Manifesto* and Weber's (1958) *Protestant Ethic and the Spirit of Capitalism* as exemplars of materialist/deterministic versus rationalist/pluralistic interpretations of history; they compare Merton's (1968) writings on deductive middle-range and grand theories with Glaser and Strauss's (1967) inductive approach to creating grounded theories; and they discuss Lewin's (1936) microlevel analysis of psychological facts with Durkheim's (1938) macrosocietal conceptualization of social facts. Moreover, they are assigned readings that highlight the differences between reductionism and contextualism as metatheoretical approaches to theory development (Jessor, 1958; Stokols, 1987).

To date, no studies have been conducted to directly assess the effectiveness of the School's graduate seminar on Strategies of Theory Development in cultivating the core values, attitudes, beliefs, conceptual skills, and behaviors associated with a TD intellectual orientation. However, several students who participated in the seminar over the years developed doctoral dissertations based on the theoretical ideas initially outlined in their seminar papers and quarterly journal. And in some cases, seminar participants went on to publish elaborated versions of their theory development course papers as solo-authored theoretical articles in peer-reviewed scholarly journals (e.g., Alfonzo, 2005; Campbell, 1983).

Conclusion

The initial sections of this chapter traced the growing interest and investment in TD approaches to research, teaching, and community problem solving. As well, the core facets of a *TD intellectual orientation* were described, and alternative educational approaches for nurturing TD values, attitudes, beliefs, knowledge, and behaviors were discussed. The latter portions of the chapter summarized curricular strategies implemented in the School of Social Ecology at UCI for the purpose of cultivating a TD orientation among baccalaureate, graduate, and postgraduate trainees.

Take-Home Messages

- Intrapersonal facets of a TD intellectual orientation were emphasized, rather than viewing this orientation as a group-level construct that emerges through ongoing collaborations among team members.
- A key assumption underlying this chapter is that the cultivation of an intrapersonal TD orientation and scholarly identity can add substantial value to team science collaborations—especially by preparing team members representing diverse disciplinary backgrounds and scientific worldviews to communicate and coordinate with one another more effectively in both basic research and translational (i.e., practice-oriented) settings.
- Not all scholars will be equally amenable toward engaging in cross-disciplinary collaborative projects with others—even after exposure to TD training programs and curricula. Some individuals, because of their particular research interests, talents, and/or dispositional styles, will be more comfortable and productive by choosing to study discipline-centric problems in an individualized rather than collaborative fashion. One size or type of intellectual orientation does not fit all scholars and research topics equally well.
- Thus, it is important not to force broadly integrative TD values, attitudes, beliefs, behaviors, and cognitive styles on all students and scholars, and to recognize that after being introduced to alternative intellectual orientations (e.g., ranging from UD to MD, ID, and TD), some individuals will opt for UD and noncollaborative approaches in their future research.
- Developing educational strategies that identify students' unique intellectual talents and encouraging them to pursue the research settings and careers that are best suited to them (whether those be UD or TD, collaborative or noncollaborative) warrant further consideration in future studies of team science, training, and practice.
- Future expansion of educational programs designed to strengthen scholars' capacity for creative, multilevel theorizing is needed since most college and graduate training programs give insufficient attention to strategies of theory development and typically do little to encourage students' efforts to create novel ideas and conceptual frameworks—especially those that are of broad scope and integrate the diverse perspectives of multiple fields.
- It is now more important than ever to find ways of encouraging and supporting scholars' efforts to create broadly integrative TD theories and conceptual frameworks. The present analysis of curricular strategies for nurturing a TD orientation is intended to provide a useful starting point for designing new and improved educational initiatives to advance the goals of collaborative TD scholarship, teaching, and the translation of research findings into community-based practices and policies.

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