A Case Study Approach to Train Early-Stage Investigators in Transdisciplinary Research

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Transdisciplinary (TD) research is a collaboration in which investigators from diverse backgrounds co-generate ideas. Few successful examples of TD research outcomes have been reported, possibly due to a training barrier. Here, TD trainees present a case study methodology that augmented classic training exercises by removing hierarchical barriers and allowing the practice of TD methodologies. A 30-minute development period was critical for the team to enter the conceptualization phase of TD research, making 90-minute sessions preferable for these exercises. Six sessions over an academic year were necessary for optimum idea formation. Generating buy-in was a challenge, as pressuring potential team members to participate would alter viewpoint equitability. Internal and external enthusiasm grew over the time period. Participation led to sustained collaborations and provided a marketable skillset. This method was low-cost and, likely, generalizable to other institutions. Thus, case study approaches may be effective tools to train researchers in TD interactions.

Keywords: transdisciplinary research, postdoctoral fellows, training, case studies.

1 Introduction

Transdisciplinary (TD) research is a mode of collaboration in which investigators operate outside their disciplines to generate shared research aims [1]. The overarching goal of TD research is to re-

duce latency periods between discovery of potential therapeutic tools and their implementation in the larger population [2]. The National Institutes of Health have identified the need for TD research and projects such as the Washington University in St. Louis Transdisciplinary Research on Energetics and Cancer program (WUSTL-TREC) and the Program for the Elimination of Cancer Disparities (PECaD) have been funded to build infrastructures to support these efforts [3-6]. TD research is valuable because it allows a group to collectively: 1) identify complex public health concerns that would benefit from the expertise of a cross-disciplinary team, 2) systematically elucidate causative agents, 3) design multi-level effective interventions/treatments, 4) determine how best to implement such efforts in affected communities, and 5) implement them in a timely manner, while working within the framework of government, business, and advocacy groups [6]. The TD process requires that team members understand and exercise skill sets from other disciplines in which they lack formal training, thus trust must be built among team members across disciplines. Because collaborations across divergent disciplines (e.g. anthropology and molecular biology) are unusual, training scientists in the skills required for TD science is critical.

As observed in a classic reference on organizational change, *The Heart of Change*: "People will think of themselves or of their subgroups first and be protective and suspicious (of others) [7]." For this and other reasons, such as hiring and tenure and promotion, TD research is neither intuitive nor easy. Barriers to TD have been expertly reviewed and include: high labor intensity, lack of interdisciplinary understanding and subsequent conflicts, difficulty for team members to learn a common language, need for shared infrastructure, and the expense of associated costs [8]. Traditional training does not equip scientists with skill sets to mitigate these challenges. These have made examples of effective TD research relatively rare [2], and have highlighted the need to augment traditional training methods [8, 9].

Traditional TD training is based on a multi-mentor apprenticeship model that provides trainees with the following resources: exposure to the process of TD thinking, an expanded scientific lexicon, preparation for career advancement challenges, and protective measures to prevent regression to single disciplinary methodologies [9]. WUSTL-TREC and others have established training programs that achieve these goals. These programs use classical training methodologies such as formal seminars, journal clubs, didactic classes, and individual-project presentations [8, 9]. The training garnered by WUSTL-TREC introduced our team to a knowledge-base and comfort that supported team members' interactions with others' disciplines, began to establish a shared lexicon, provided career development preparation, and fostered small collaborations. However, we observed a disconnect between gaining knowledge of the TD process and developing the ability to effectively participate in or lead TD research independently of WUSTL-TREC.

We argue here that a critical gap in TD training is often missing: *the practice of TD research methodologies by assessing public health issues and brainstorming research approaches in a bias-free environment with a team of engaged peers from diverse disciplinary backgrounds.* We suggest that a case study approach using team-based language and mentality is an effective method to practice and train in this skill set. In our initial training, our team of seven postdoctoral fellows and one early career investigator experienced a formality and overlying power structure inherent in a traditional didactic training style that granted authority to the discipline of that session's leader. This led to disciplinary-specific discussions and inhibited the creative process required for genuine TD idea generation. For example, if the leader was an epidemiologist, then the training session was taught in and flowed from an epidemiological mindset. Additionally, we encountered some aforementioned TD barriers, such as problems with communication across disciplines. We found that with traditional training methods, the leading discipline was often the final word in conflict resolution, potentially biasing a discussion.

In our case study experience, we initially observed significant challenges to buy-in and idea generation during a case study. Thirty minutes of an introduction period, herein described as "The Thirty Minute Rule", occurred before true collaborative idea generation. This required that case study sessions last at least 90 minutes. Team members: 1) were fully involved, from case study topic selection to post-discussion reflection, 2) solved problems together and generated TD ideas for future work, 3) developed a shared lexicon, 4) mediated arguments in an open forum, and 5) applied TD-related concepts outside of the allotted discussion times. The re-

sults were open communication around a given topic, long-term interdisciplinary collaborations, and development of a valuable skill set. Furthermore, our method was low-cost. Thus, we offer that case study approaches are effective tools to train researchers in TD interactions and may be applicable to other institutions.

2 Developing the TD Team and Lessons Learned

Here we describe a framework for a trainee-run case study TD training approach, including the steps underwent to launch it, barriers we experienced, and lessons learned.

1) Assessing institutional preparedness for a TD effort – Stokols and colleagues succinctly and thoroughly defined characteristics of institutional collaborative-readiness including: institutional support, a wide breadth of disciplines housing trainees, a high degree of prior team cooperation, the availability of convenient meeting places and/or close spatial proximity between collaborators, and the availability of electronic communication tools [8]. Because of WUSTL-TREC, our institution was highly collaborative-ready.

2) Recruiting advisors – Organizing members (ECB and LEL) first approached supportive mentors (KHM, GC, SG), who provided ideas and infrastructure. We also sought topical expertise. Dr. Julie Turner (Van Andel Institute) provided insight on leveraging case studies for TD training, structuring the team, and establishing language to foster trust and openness. Dr. Doug Larsen (Washington University) made suggestions on general team structure and training evaluation.

3) Generating buy-in – Team members were faced with expending time to an endeavor that might not yield immediate career-building results. Departmental, mentor-based, or other compulsive pressures threatened to negate efforts to build a foundation in which the power structure was equalized. Therefore, buy-in had to be generated at the outset.

Generating initial buy-in was difficult. Fifteen potential postdoctoral fellows and early stage investigators were asked to participate and only five initially accepted. Although we do not know why some declined, opinions expressed included concern about the need for great time and effort, that it was messy with an undefined endpoint, and could potentially expose individual gaps in knowledge. Initial reticence to participate was also attributed to a lack of clarity about outcomes of the process, difficult travel considerations, and being more distantly related to the existing TREC infrastructure. Trainees who chose not to participate likely also had a range of concern related to career stage, home life, and timing. Our case study team grew from a strong existing WUSTL-TREC infrastructure that supported the time spent on this endeavor, yet we still experienced this barrier. Thus, we suggest that generating buy-in is a challenge that might be experienced by many initiate teams. Interestingly, the testament of the early adopting members fostered increased recruitment; members assured others that use of the TD methodology was being achieved and our final team included eight members. Once a team member participated in one TD discussion session any hesitancies lessened, and no attrition was experienced. Validation of the importance of this effort was given by WUSTL-TREC leadership and outside support (e.g. the external advisory board). Thus, non-compulsory buy-in can occur both through initial and secondary recruitment. Conversely, buy-in could not be coerced from uninterested participants. An academic year was required to achieve a well-represented, cohesive team.

4) Team Composition and Career Stage – Our final team was composed of seven postdoctoral fellows and one investigator in her first year as assistant professor. Effort was made to minimize overrepresentation of one discipline over others although team members were self-selected. Most initial recruits were trained in the basic sciences (developmental biology, cancer biology, and molecular biology with public health training) or clinical sciences (gynecological oncology). Also, one initial member was a social epidemiologist. As successful discussions occurred, three additional social scientists asked to join (specializing in anthropology, behavioral health, and implementation science). None of the members withdrew from the team during the training.

While our methodology may provide value-added TD training for researchers at all career stages, our experience suggested that three criteria are needed:

1) expertise and confidence in one's own field;
2) time for additional training activities; and
3) an openness to the value and limits of any singular discipline that may be intrinsic or taught from previous training experiences (as was done for our members by the existing WUSTL-TREC and PECaD infrastructures).

Postdoctoral fellows may be particularly amenable to the transformations intended to occur during TD training because of their transitional status. They are at a career stage in which they are determining specific questions and career paths for future work. We found that this transitional state opened our behaviors to new disciplinary perspectives rather than operating from preset rules of thinking; a characteristic necessary for effective TD research. Also, some team members were considering TD research as a potential *de facto* career option. Postdoctoral fellows in the middle of their training had the most flexibility in time and effort and, thus, willingness to dedicate time to the TD training exercises. While this timing-related "sweet spot" may differ from one TD group to the next, it is worth considering in the planning stages in order to maximize the success of TD training groups.

5) Civility and conflict management – A commonly cited challenge to TD research is the need for mediation when disciplinary perspectives come into conflict [8, 10]. We addressed this by generating civility guidelines at the outset, which included: 1) respect for all disciplines, 2) sincerity in all comments, 3) allowing respectful requests to table vignettes, and 4) time management. Because the rules were self-developed and enforced, no power structure alterations seemed to be introduced. Importantly, we encountered little need to mediate arguments as trust was built. Regular solicited feedback provided the members opportunity to voice concerns.

Authorship of publications was discussed in advance. It was agreed that the co-first authors had contributed most to the generation of ideas and would retain the major responsibility for synthesizing the paper; a coin-toss determined their order. Middle authors were ranked alphabetically and the last three authors were the established mentors who supported the effort. This largely reflects the convention of basic science, where the senior author comes last, as opposed to social sciences, where authors are ranked in order of effort.

These characteristics might be best embodied in an early career pool of members (e.g. postdoctoral fellows and early career investigators). When adequately supported by their mentoring teams, postdoctoral fellows may have more freedom to undertake TD training than more senior researchers, who face additional pressures.

6) Case study approach – We chose a case study approach to address the critical gap in TD training (i.e. trainees must practice doing TD). Case study training programs are team-building exercises that allow members to negotiate different problem-solving skills in new ways, while retaining focus within a specific context [11]. As such, case studies allowed our members to apply their expertise to novel concepts and work across disciplines to design approaches and generate solutions within a given study. The initiators of the team brainstormed examples of potential topics for the first two sessions; the team brainstormed the subsequent topics. Our team worked through six case studies that were intentionally broad-based and arose from a common research interest in cancer. Topics ranged from known to unknown etiology (Table 1). It was critical to work through several case studies because particular topics organically focused discussions toward certain disciplinary mindsets and methodologies.

Discussions were held monthly for 90 minutes over a period of eight months. Related articles were offered prior to meetings. During the discussion, team members were asked to form hypotheses and design methods to address specific questions, but the conversation was intentionally free flowing with minimal mediation (general discussion flow outlined in Fig. 1a). The last five minutes were spent summarizing the discussion.

Throughout the process, the team's communication, trust, and ability to generate ideas increased markedly. For example, the second case study involved prostate cancer disparities in African American men. Few TD ideas emerged from this early discussion. Rather, the team learned to discuss sensitive topics, perform *ad hoc* research during the meeting, and overcome unfamiliarity with working as a team. We also determined points at which external experts were required (outlined in Fig. 1a). By the last meeting, many of these initial teamwork

Table 1: Case Study Topics Ranging from Known to Unknown Etiologies

Case Study Topic Types	**Specific Discussion Topics**
Examples of collaborative efforts to determine etiology and interventions	Lung cancer and smoking
Existing databases on disease clusters and risk factors	African American disparities in prostate cancer in Michigan
Mechanisms of widespread diseases	Transmission of Human Papilloma Virus (HPV) and cervical cancer
Potential causal agents and disease risk in populations	(1) Social barriers to HPV vaccination rates (2) Substance use and adolescent delinquency
Local public health concerns of interest shared by group members	Local waste fire near nuclear waste dumping ground

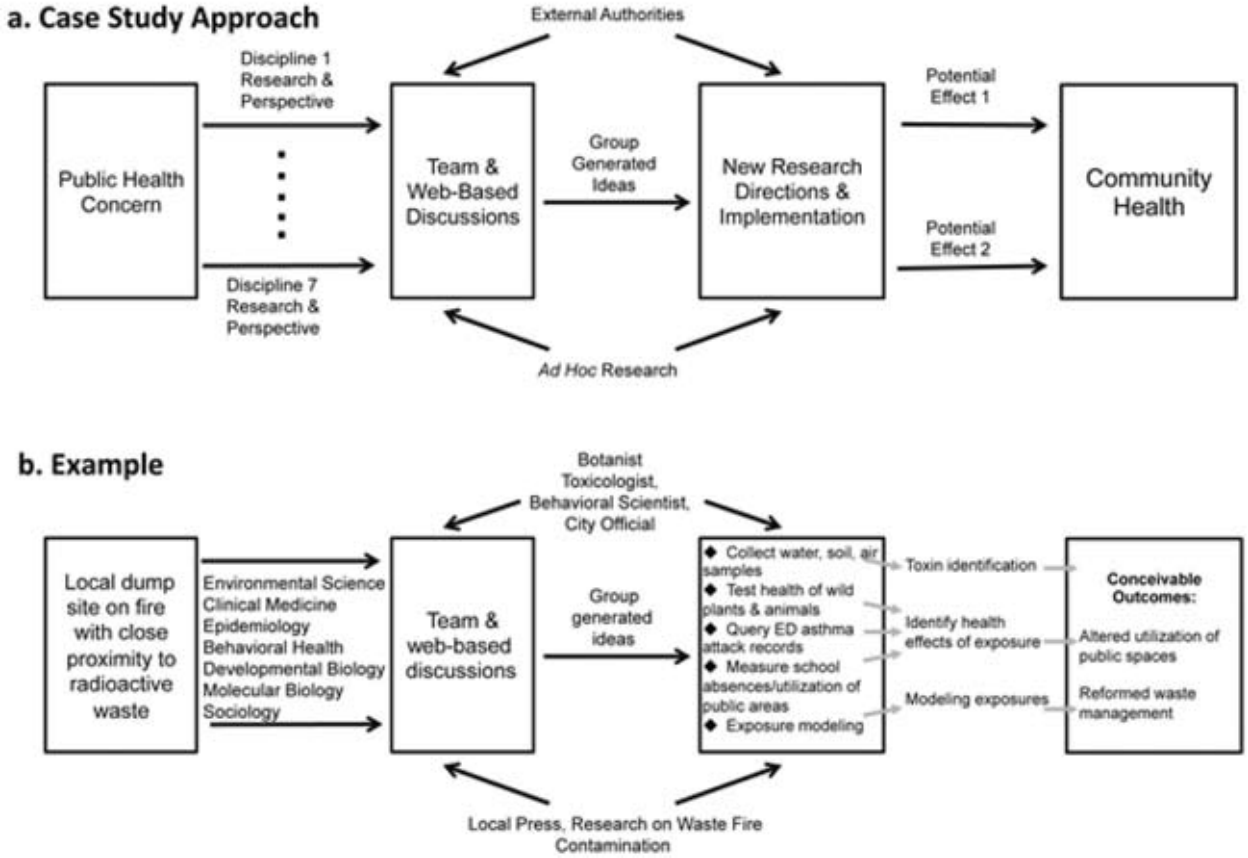

Figure 1: a) A diagram of the intended workflow of a transdisciplinary case study meeting. Team members choose a public health topic, perform discipline-specific research and bring their unique perspective to both in-person and follow-up web-based meetings. During these meetings and subsequent discussions, opinions are gathered from outside experts and additional research on topics is done as needed. Future discussions would determine a workflow for chosen research directions and implementation with the goal of affecting the community in need. This is not based on measurement. b) An example of outcomes from one case study experience.

based barriers had been resolved. Our final case study was on a local waste site on fire. During this discussion, the team developed several approaches to investigating whether the fire had adverse health effects in the surrounding community. Fig. 1b gives an outline of ideas and directions generated from this

last discussion. Successful completion of such studies indicating effects on health risks has the potential to inform city planning, waste site management, and public policy.

7) The 30-Minute Rule – Primary challenges to effective TD research include how to navigate discipline-specific communication styles, understand discipline-specific terms and create a shared lexicon, develop shared research objectives, and jointly conceptualize scientific problems [12]. We sought to navigate these barriers with the case study approach. Previous studies have proposed that TD research transpires in four phases: development, conceptualization, implementation, and translation [12]. This model applied to our case study discussion experiences. The first approximately 30 minutes of each case study was devoted to defining the topic through the lens of each representative field, referred to as the development phase [12]. We found that regardless of topic, a shift in mutual understanding occurred after 30 minutes. At this point, the team entered the conceptualization phase and began to generate novel ideas. We referred to this as the "30-Minute Rule." As the sessions progressed throughout the year and a shared lexicon was developed, this lag period shortened slightly and the amount of ideas generated in the developmental phase increased. Therefore, we found that team members must persevere through initial communication barriers during the development phase *and be willing to meet for 90 minutes.* We also provided opportunities for team members to continue discussions outside of meetings (e.g. an online forum). Because many classical training methodologies do not require lengthy latency periods before ideas are generated, if unanticipated, this lag period could be demoralizing for new initiate TD case study teams.

8) Benefits of Participation – *Long-term collaborations*: An unanticipated finding of this exercise was the development of new cross-disciplinary collaborations between team members. For example, a basic scientist and an epidemiologist initially investigated entirely disparate topics. Yet, a new collaboration arose in which epidemiological expertise was utilized to assess human survey data relating to findings identified in animal models. Survey data would then reciprocally inform the development of future animal studies. Collaborations such as these are unique because the two disciplines came together to generate the research idea and methodology of study, as opposed to one discipline using another to achieve the individual aim of the initiating discipline. Because the research questions were generated together, the scope of the project was broad. Yet the ability to anticipate disciplinary pitfalls added to feasibility of the study. As team members formed long-term relationships during the case study journey, they felt comfortable asking for each others' expertise and thus anticipated many future collaborations.

Marketable Skills: Postdoctoral fellows on the job market found that potential employers favorably viewed their team-based experiences. Indeed, an evolution of attitudes within the team seemed to progress towards open-mindedness over time. Team members exhibited a high willingness to engage with one another so that collaborations matured over the course of the year. By the end of the term, members existed as a team rather than individual experts. At the conclusion of each case study interaction, team members anecdotally reported high feelings of energy and optimism around the topic and ideas generated. The evidence of collaborative skills gained during this process was easily leveraged into leadership and cooperation talking points during interviews.

Direct measures: The effectiveness of TD interactions is often measured by co-authorships on manuscripts and grant proposals [13]. As we are only a few months removed from this experience, these metrics are premature. However, confidence in team members by WUSTL-TREC mentors has increased as reflected by additional TD opportunities offered to our team members including: national meeting oral presentations, manuscript authorships, and investigator status (rather than trainee) on projects and grants.

9) Plans for Sustainability – As our team members move on to other positions or encounter career-stage pressures, sustainability of this specific collaboration will be a challenge. However, there is optimism that case study-based TD training initiatives will be sustainable within the WUSTL organization as TD infrastructures could provide a pool of candidates for future teams. We anticipate that the skills developed in the case study process will transfer to future TD endeavors. The case study team has achieved acknowledgement from institutional authorities, which gives it credibility. To ensure sus-

tainability, proof-of-principle recommendations for a problem identified by the team need to be published. Determining whether a team member number ceiling exists for this training methodology is important. Additionally, the case study process will be refined by presenting the project at national meetings.

3 Conclusions

In conclusion, TD research is an exciting opportunity for teams of researchers to leverage their training differences to shorten the latency between intervention discovery and implementation in the community. TD research has historical barriers that require training to overcome. We suggest that case study based practice approaches can limit inherent power structures that disrupt equitable idea generation that is present in other training forums. The approach described here is particularly well suited to postdoctoral fellows and early stage investigators. We found that a 30-minute development phase was needed before conceptualization and idea generation became prolific. Our case study approach fostered open, authentic communication in a safe environment where team members engaged in problem solving. This technique was low cost, making it a potential training opportunity for all institutions interested in TD research.

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Author Contributions

ECB, LEL, KHM, GC, and SG designed the initial group methodology. ECB, LEL, SC, GF, KF, JH, KM, and AR all participated in idea generation, discussion, and group observations. ECB and LEL wrote the manuscript. ECB, LEL, SC, GF, KF, JH, KM, AR, and SG outlined and edited manuscript.

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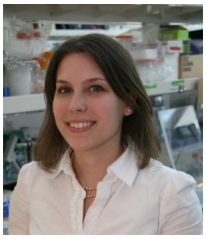

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