Abstract Book

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Building the knowledge base for effective team science

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Science of Team Science (SciTS) 2015 Conference

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Concurrent Session 1

Engaging Community Stakeholders in Team Science (Papers) 1:15–3:00 pm

Paper 1: Community Engaged Scholars Program: Advancing Team Science through Academic and Community Partnerships to Overcome Health Challenges

Authors: Dana Burshell (Medical University of South Carolina), Dayan Ranwala (Medical University of South Carolina), Jeanette Andrews (University of South Carolina), Susan Newman (Medical University of South Carolina), Cathy Melvin (Medical University of South Carolina) and Carolyn Jenkins (medical University of South Carolina)

Objective: The Medical University of South Carolina (MUSC) CTSA—South Carolina Clinical & Translational Research (SCTR) Institute—Community Engagement (CE) Program and the MUSC College of Nursing Center for Community Health Partnerships has developed the Community Engaged Scholars Program (CES-P) to: incentivize and foster translational team science through community and academic partnerships, facilitate the effectiveness of collaborative science, encourage shared identification of community health priorities, and advance a community-based participatory research (CBPR) curriculum for academic and community partners.

Methods: In response to the SCTR Institute CE Program CES-P funding announcement, applicants assemble their team of academic and community partners who share a community health goal. The CE Program offers assistance in identifying potential partners. As Co-Principal Investigators, the community and academic partners submit an application which includes a description of the partners, their partnership capacity, research proposal related to a key area of research that may have a community health impact such as childhood obesity, and a signed memorandum of understanding. Academic and community reviewers score the applications based on partnership, environment for CBPR, health issue significance, project approach, and innovation. Selected teams based on the review scores attend a 15-week curriculum of weekly didactic and interactive group co-learning sessions designed to strengthen their teams and projects by incorporating CBPR research principles. The curriculum topics include: partnership readiness, research frameworks and theory, community problem identification, ethics and the Institutional Review Board, feasibility and pilot testing, intervention development, data collection and analysis, evaluation, translation and dissemination, and grant writing. As part of the curriculum, teams collaboratively complete the CES-P Are We Ready toolkit and a team readiness assessment to identify strengths and areas to address in building a robust, equitable partnership and study. Speakers and instructors include a multidisciplinary team of academics, community members, and CES alumni who are involved with the community engaged research. Following an Institutional Review Board approval for their proposed research, each team receives up to $10,000 pilot funding to conduct the research and collect pilot data for future funding applications to sustain the research.

Results: The Institute of Medicine highlighted the innovative CES-P in the 2013 CTSA Report. Since 2009, the CES-P trained 5 Cohorts, 21 teams, and 65 team members with 3 to 6 teams per year. Nearly half of the participants were community members (48%). Community partners (n=32) consisted of 24 different organizations in 8 different cities throughout rural and urban South Carolina. Community members included a variety of professions which are not limited to the following: executive directors, program directors, coordinators, research assistants, pastors, case managers, support group leaders, a community health nursing instructor, a mayor's assistant, and a nutrition educator. CES-P projects addressed community priorities from adolescent to veteran health; lack of food access in rural Appalachia to obesity in urban areas; and diseases from Lupus to mental health disorders.

Academic partners (n=34) consisted of multiple disciplines at the MUSC, Clemson University, and VA: Medicine (27%), Nursing (24%), Psychology and Behavioral Sciences (18%), Food and Nutrition (12%), Pediatrics (9%), VA (6%), Health Professions (3%), and Dental Medicine (3%).

Outcomes generated from the CES-P include 8 peer-reviewed publications, 17 podium presentations and posters, and 9 follow-on grants amounting to $6,344,358 with a return on investment of $46:$1. Some of the research pilots spurred sustainable community projects such as the Community Compass Project which has celebrated its 4th annual community event to help people learn how to make healthier lifestyle choices.

Advancing the SciTS field: The CES-P research training and pilot funding support to community and academic partner teams can be an effective method for fostering collaborative team science strengthened through CBPR training, addressing community priorities, building and maintaining partnerships, and contributing to health improvements among diverse populations.

Paper 2: The Aer and the Smoak: Enabling Constructive Stakeholder Dialogues on Risk and Science with Decision Processes

Authors: Matthew Wood (US Army Engineer Research & Development Center), Ben Trump (University of Michigan), Igor Linkov (US Army Engineer Research & Development Center) and Jose Palma-Oliveira (University of Lisbon)

Abstract: In this paper, we compare complementary approaches for developing problem solving teams that seek to develop collaboration and a common problem framing between the scientists and engineers that design new technologies and infrastructure, the risk assessors that evaluate and communicate the impacts of deploying new technologies and infrastructure, and the residents and other stakeholders who incur a disproportionate amount of the costs from that deployment. Traditional risk communication processes can be effective for this purpose when [1] the science used to understand and describe the risk is mature and uncontroversial, [2] the action(s) to mitigate the risk are readily available to stakeholders, and [3] stakeholders are motivated through their own self-interest to enact the action(s) that reduce risk (Ajzen, 1991). Risk communication campaigns to promote hand washing, wearing seat belts, vaccinations, and other behaviors often use this model successfully for exactly these reasons.

Unfortunately, traditional models of risk communication breaks down in NIMBY (not-in-my-backyard) situations, when the goal of the exchange is to convince a group of stakeholders that a new technology or infrastructure project is beneficial for everyone and the risks to the most-adversely impacted individuals are minimal, though these individual risks may be perceived to be quite dire. This is especially the case in contexts like siting decisions for waste handling facilities, where a small group of individuals believe they are being asked to bear the negative consequences of a capability that is quite beneficial for the rest of the community. As a consequence, individuals often refuse the siting proposal, preventing execution from going forward. This coordination breakdown where some stakeholders for a single resource (land, neighborhood access) prevent others from using it and therefore a socially desirable outcome is known as the TRAGEDY OF THE ANTI-COMMONS (Dawes, 1980; Hardin, 1968; Heller, 1998; Palma-Oliveira, 2000). In situations like the above example, not only is it individually more rational to refuse the project irrespective of the project's nature, but also the risk communication community has produced answers to these concerns that only include the prior assumptions made by risk communicators and assessors instead of the individuals which are most impacted by these decisions. The result is a misalignment of problem framings that often contributes to project delays and/or cancellations due to entrenched differences of opinion and belief.

To overcome this conundrum, one should be able to define alongside local stakeholders a decision process based on scientific reasoning, where stakeholder worries and perceptions of risk can be tested "de novo". Citizen science and decision science fields collectively provide an opportunity to address such stakeholder concerns in a way that elevates stakeholders as active participants in the decision making process for typical NIMBY situations. We describe and compare three such processes (Hypothesis Testing, Stakeholder Engagement with Technology Support, Structured Decision Making) in terms of the mechanisms they use to enable inclusion in the decision making process and their ability to address stakeholder concerns in NIMBY situations. Furthermore, this process will be illustrated from cases across the world

where jointly community–institutional research produced not only acceptance of the proposed projects but also research breakthroughs (e.g., Arvai & Post, 2012; Augusto et al., 2015; Collier et al, 2014; Palma-Oliveira et al, 2012; Zemba et al, 2011).

Paper 3: Operational Model for Effective Integration of Translational Science Stakeholders

Authors: Laurie Hassell (Institute of Translational Health Sciences/University of Washington), Kelly Edwards (University of Washington), Andrea Lazarus (Washington State University) and Laura-Mae Baldwin (University of Washington)

Introduction: Science is changing. The paradigm in which scientists in the laboratory develop ideas, make discoveries, test them first in animals, then in humans has generally been a one-way street. Scientists have not routinely asked whether their discoveries are relevant to and feasible for their intended settings or populations. Many promising discoveries never progress to become treatments, and when they do, it takes an average of nearly two decades for them to make their way into practice. The Institute of Translational Health Sciences (ITHS) and other institutions funded by the Clinical Translational Science Award (CTSA) program are uniquely positioned to engage stakeholders with the diverse skills, perspectives and experience that investigators need to translate their research discoveries into practice, and assess the effectiveness of these efforts across institutions, grant cycles, and teams. The goal of the ITHS Stakeholder Integration project was to identify the current state of stakeholder integration in the ITHS, to develop a generalizable, operational model for effectively integrating stakeholders relevant to translational science, and to evaluate these efforts. As projects and priorities evolve over time, teams need a simple, well-integrated process to continuously assess the need for and facilitate integration of new or different stakeholders. The ITHS' project-oriented operational strategy and adoption of Lean Process Improvement methodologies facilitates the incorporation of tools and processes for stakeholder integration into existing systems, and can provide foundational data to explore the impacts of stakeholder engagement in translational science.

Methods: The project team quantified the number, type, and level of integration of ITHS stakeholders from the perspective of its staff and faculty through a staff survey, review of key source documents (e.g., annual progress reports), and interviews with directors of ITHS programs. To develop a stakeholder integration operational model, the project team conducted: 1) a literature review of approximately seventy (70) articles from divergent fields relevant to diverse types and levels of stakeholders: "defining and engaging stakeholders;" "building relationships;" "trans-institutional partnerships;" "team science;" "methodology;" and "metrics and measures of success," and 2) key informant interviews of 30 staff and faculty across the ITHS' diverse translational science programs. An interview guide addressed engagement with stakeholders most relevant to the program or unit, including typical methods of interaction, institutional impacts on effective integration, and the characteristics of ideal partnerships. Themes identified from the literature review and the key informant interviews were synthesized and used to develop a four-part Stakeholder Integration Model with associated tools and templates.

Results: Over 200 ITHS stakeholders were identified, most serving in advisory roles, and less often as collaborators and leaders. Staff and faculty felt that key ITHS stakeholders were not sufficiently integrated into the organization. A Stakeholder Integration Model was developed to include four core steps: 1) identification of stakeholder needs and collaborative development of ideas, 2) creation of teams, 3) building partnerships, and 4) evaluation. The model is grounded in the principles identified in the literature and through key informant interviews as critical for successful relationships: trust, transparency, and alignment of interests. A "Blueprint Process" was developed for identifying stakeholders critical to a program or project's success and for defining stakeholder roles, responsibilities, and expected level of involvement. A "Team Assessment Survey," adapted from the Agency for Healthcare Research and Quality's TEAMSTEPPS Team Questionnaire, assesses team function and quality. The Current State Heat Map is a comprehensive benchmarking tool created to visualize stakeholder integration across the ITHS.

Next steps: The ITHS is implementing the Stakeholder Integration Model in four ways by: 1) asking each of its programs to use the Blueprint Process to identify its key stakeholders, 2) pilot testing the 4-step model in at least 2 high priority ITHS projects/programs, 3) integrate tools and critical partnership principles into existing systems, and 4) evaluating the integration of key stakeholders into the ITHS over time. If the Stakeholder Integration Model is successfully deployed across the ITHS, the project team envisions disseminating this model and its tools so that stakeholders can be identified as a routine part of programs' operations and projects' development, highly-involved primary stakeholders are engaged at multiple touch points across the ITHS and its partners, and relationships with stakeholders yield tangible, mutually-beneficial outcomes.

Paper 4: Carpe Opportunitatem: Developing Disciplinary Diversity for Petcoke

Authors: Donnie Sackey (Wayne State University), Judith Moldenhauer (Wayne State University) and Joseph Caruso (Wayne State University)

Abstract: Petroleum coke dust ("petcoke") is an oil refinery by-product of heavy crude from the Alberta (Canada) tar sands. In 2012, Marathon Petroleum Corporation's refinery received a $2.2 billion equipment upgrade, and started processing up to 80,000 barrels a day of the heavy crude, of which ~30% (w/v) per barrel is removed as petcoke. In March 2013, growing piles of petcoke stored along the Detroit River, which separates Detroit from Windsor, Canada, began to alarm residents on both sides of the border as windy days meant clouds of black dust filling the sky and their homes. Shortly thereafter, a Wayne State University environmental health scientist, Joseph Caruso, talked with the WSU Associate Vice-President for Research about creating a Petcoke group; a research development professional, Freda Giblin from the Office of the Vice-President for Research, was brought in to help. Together, they started to build an interdisciplinary group that developed goals to understand, characterize and communicate potential hazards of petcoke, especially in relationship to the residents of southwest Detroit who lived adjacent to the petcoke piles.

Integral to the success of this project is both the collaboration between environmental and health professionals and community groups and the active participation of faculty with skills to build and enhance communication with the community groups. Petcoke project members were recruited from departments across the university for the Petcoke project: leader Joseph Caruso and co-leader Shawn McElmurry in Engineering/Civil and Environmental, Judith Moldenhauer in Art and Art History/Graphic Design, Robert Reynolds in Computer Science, Donnie Sackey in English, Nicholas Schroeck in the Law School/Center for Environmental Justice, Judy Westrick in Chemistry, and Kezhong Zhang in the School of Medicine/Molecular Medicine and Genetics as well as Immunology and Microbiology.

Through the course of many group meetings, three aims were identified: enhancing communication between scientists and community residents, characterizing the environmental impact of petroleum coke dust, and determining the toxicity of petcoke in human cell models. Of particular note is the group's recognition of the fundamental importance of communication and community engagement to determining the focus of the scientific research. This means developing communication tools that enable the community residents to interact with the scientists, both in shaping and participating in the research process. Those communication tools would be based on learning how the residents communicate with one another about neighborhood issues, their neighborhood priorities, what their knowledge of and experience with petcoke, and their understanding of the connection between health and environment.

Methods: Two methods were used to move the project forward: (a) group planning and actions; and (b) seizing upon opportunities that were available and timely. Planned Actions: The leaders, Joseph Caruso and Shawn McElmurry, developed scientific foci as well as convened meetings to discuss community outreach goals and actions. Freda Giblin provided definitions of interdisciplinarity, information on leadership and team conflict, and notes from previous SciTS and NORDP meetings to jump-start Caruso and McElmurry's knowledge of team science processes and its barriers. Giblin also provided introductions to other members of the university to provide information and advice (e.g., IRB director, seasoned community researchers). Carpe opportunitatem: Team Science practitioners talk about the importance of having space and opportunity for researchers to meet serendipitously and develop novel collaborations. Giblin, Caruso, and McElmurry invited various WSU faculty to who had a mix of research knowledge and interest in interdisciplinary collaboration to participate in exploratory meetings about petcoke

research; the membership of the group was an unknown at that point. The result was a collection of individuals who decided to seize the opportunity to investigate of the effects of petcoke and to do that in collaboration with the residents of southwest Detroit. Thus enhancing communication between scientists and community residents is key to the success of the scientific research.

Summary of Findings: Within a one year, the Petcoke group has amassed a range of skills and methods, some through forethought and some serendipitously. Meeting discussions are informative and collegial, and progress is excellent. Several things distinguish this group from less successful groups: (a) Joseph Caruso's leadership style is conducive to participation and mutual respect, so group relationships and dynamics are positive, and group cognition is increased; (b) members are motivated to participate, thus issues are resolved and next steps are identified; (c) individual efforts (e.g., designing the logo and website) abound, thus advancing the overall progress of the group; and (d) the Vice-President for Research's office provides meeting space and access to institutional structures and expertise, thus underlining the value of this group to the university. The result is a project that envisions communication and community engagement as the foundation for scientific research.

Paper 5: Assessing Stakeholder Engagement in Infrastructure Development: A Logic Model and Longitudinal Results

Authors: Sarah Daugherty (PCORI), Consuelo Wilkins (Meharry-Vanderbilt Alliance, Vanderbilt University and Meharry Medical College), Madeleine Shalowitz (NorthShore University Health System Research Institute) and Laura Forsythe (PCORI)

Abstract: The ways by which patients and other key stakeholders engage in research, in particular, how they participate and the quality of their participation in the deliberative process is a growing area of interest. To date, few studies have systematically reported on stakeholder engagement in research infrastructure development. To address the limited empirically-based guidance for optimizing stakeholder engagement in infrastructure development, we conducted a longitudinal assessment to describe the level of engagement, influence, and impact that patients and other stakeholders have across stages of research infrastructure development (proposal development, governance, data sharing and privacy, recruitment, topic generation and prioritization, dissemination strategies).

Methods: A systematic assessment of stakeholder engagement within the National Patient-Centered Clinical Research Network (PCORnet), a distributed research resource initiative with 29 networks sponsored by the Patient-Centered Outcomes Research Institute (PCORI), has been designed jointly by PCORI staff and stakeholder representatives engaged in building individual networks. A logic model was developed as a framework for assessment and surveys were designed to capture elements of the model including contextual factors, stakeholder engagement methods, and outcomes at baseline and 6 month. Stakeholder representatives identified key domains, established frequency of survey implementation, refined questions and response options, and contributed to strategies for disseminating results. Both surveys were sent to principal investigators, other scientific investigators, and patient representatives (n=145; baseline or 6-month) from the 29 networks in PCORnet. Overall response rate was 86%. Responses were analyzed using quantitative (STATA) and qualitative methods (nVIVO).

Findings: Descriptive results emphasize factors identified as relevant to stakeholders including organizational culture, sensitivity to diversity, co-learning and stakeholder training, and principles of engagement such as trust and transparency. Stakeholder engagement and perceived influence by stage of network development at baseline and 6-months will be described and the overall multilevel impact of stakeholder engagement will be highlighted. Results reinforce the notion of stakeholder engagement as a dynamic and subjective process and indicate the need for further attention to role definition and training for all stakeholders even at the research proposal stage. Research advances: This logic model may be helpful as a guide to other science teams implementing and/or evaluating stakeholder engagement in infrastructure development. Several practical solutions for improving the quality of deliberative stakeholder engagement will be highlighted.

Concurrent Session 2

Maximizing the Effectiveness of Interdisciplinary Team Interactions (Papers) 1:15–3:00 pm

Paper 1: The Mars Exploration Rover Mission: Findings from a Large Multidisciplinary Team

Authors: Susannah Paletz (University of Maryland), Joel Chan (Carnegie Mellon University) and Christian Schunn (University of Pittsburgh)

Abstract: In 2004, the Mars Exploration Rover (MER) mission landed two rovers on opposite sides of Mars (Squyres, 2005). The mission has been a resounding success: The science team found strong evidence of historical liquid water, and the rovers themselves far exceeded their estimated life of 90 Martian days (Spirit went dark in 2010, and Opportunity is still functioning as of 2015). The MER science team had over 100 members from a mix of disciplines (atmospheric sciences, geology, geochemistry, social sciences, etc.) and was broken into two main groups, one per rover. This success was driven by a multitude of small, daily interactions, creativity, and decisions within ad hoc subgroups.

The objective of this talk is to showcase high-level findings from two separate studies of the MER mission, thus demonstrating empirical lessons learned for other multidisciplinary science teams. We examined the team's micro-processes, i.e., the interactions between team members at a very fine-grained level. We annotated each utterance (clause, or thought statement) in over 11 hours (over 12,000 utterances) of informal conversations between the scientists to study analogy, uncertainty, and brief disagreements. Each of these processes are central to team problem solving. Analogy is a fundamental cognitive process in which a known piece of information is linked to a problem or current domain of knowledge by systematically mapping relations or elements, which then allows for the transfer of existing knowledge (e.g., Gentner, 1983; Holyoak & Thagard, 1996). Psychological uncertainty is the recognition or feeling of missing, vague, or incomplete information (Schunn, 2010). A brief disagreement is an instance of discord or contention, even for just one utterance (Paletz, Schunn, & Kim, 2011). In our first study, we found that spikes in uncertainty reliably predicted analogy use, and that problem-focused analogies were associated with a subsequent drop in levels of uncertainty (see Fig. 1, Chan, Paletz, & Schunn, 2012). This study suggests that in multidisciplinary teams, analogy may serve to reduce uncertainty.

Using multilevel modeling, in our second study we found a relationship between analogy and brief disagreements (Paletz, Schunn, & Kim, 2013). Analogies that drew on closely related domains ('within-domain' analogies) significantly preceded work process and science-related disagreements, suggesting that in multidisciplinary teams, representational gaps in close domains will be more likely to spark disagreement. In addition, disagreements that involved work processes and/or negative affect, but weren't task-focused, significantly preceded within-discipline analogies (a broader type). This finding suggested that these types of disagreements may be productive in the short term, given the known benefits of analogies.

This talk will conclude with a brief overview of the lessons learned from this mission, aimed to assist researchers across different disciplines. Multidisciplinary teams under the right conditions can use brief disagreements to trigger analogy use, and can leverage analogies to reduce uncertainty and spark debates. Given the overall success of the Mars Exploration Rover team, we are inclined to view these strategies as positive rather than negative, and we will present other qualitative information of how the MER mission was structured (Squyres, 2005).

Paper 2: Building Effective Transdisciplinary Research Teams

Authors: Candace Gibson (University of Western Ontario) and Dag von Lubitz (Central Michigan University)

Abstract: Effective cross-boundary, transdisciplinary research teams are imperative in today's operational environment. Medical research is no longer conducted by the lone, renegade scientist working in isolation in the laboratory. Multidisciplinary, interdisciplinary and transdisciplinary research teams are being funded to take on cancer, diabetes, infectious disease, neurodegeneration and Alzheimer's disease. Although the need for interdisciplinary teams to tackle these complex health problems is acute, there is little evidence on how such 'science teams' should be developed, and what factors can ensure success (or even what we might define as success for such groups; Stokols et al, 2008; Masse et al, 2008). The increased level of complexity demands a new approach for forming, assembling and launching research teams capable of tackling complex issues. We have worked with the US military in introducing to the civilian world a structured approach to building cooperation and collaboration among individuals and teams belonging to a variety of organizations, agencies, and departments that are tasked with solving complex, frequently transboundary problems. The Teams of Leaders (ToL) approach has been piloted in the U.S. Armed Forces and, by us, in programs within the healthcare field, and has been proven effective as a way of overcoming common team dysfunctions. It provides a specific methodology to help teams form and work effectively to achieve results more quickly. We will present two case studies of how this methodology has been used in launching an interdisciplinary health research team and a community-based, rural health consortium. Structured Team Launch workshops were used with significant impact to create shared actionable understanding, build trust and reach a level of high performance in both established and newly forming leadership teams. The state of actionable understanding transforms task oriented, independently acting individuals, teams, or organizations into an operational entity that is mission-focused, fully structured, unified and collaborative. All participants, individual and organizational, agree on what defines the mission, its purpose, the pattern of its execution, resources, responsibilities, execution timetables, and the success measures. We present results from a set of evaluation criteria applied before and after the workshops to measure several dimensions of these high performing teams.

Paper 3: Building Community in a Transdisciplinary setting: The Forced Migration Group as a Developmental Project

Author: Larry Hirschhorn (Georgetown University)

Abstract: This paper reports on the first year of a project that took place at Georgetown University. With the support of a planning grant from the National Science Foundation, a group of social scientists and computer scientists convened to develop a computer model of "forced migration" that is the conditions under which people are forced to leave their homes, often due to political violence. The teams consisted of members from computer science, anthropology, political science, public health, business, and engineering. Team members were committed to developing a model that not only had scholarly standing but that could become a tool that humanitarian relief agencies could use to anticipate refugee crises and plan their work. I was a participant observer in the project with the explicit role of helping the team understand its own developmental process.

The paper proposes that this transdisciplinary setting can be understood as a Developmental Project (DP) that differs in significant ways from what I call a Regular Work Organization (RWO). The paper examines this difference along several dimensions, for example the Task versus the Boundary object, Continuity versus Disruption, Authority versus Deadlines, Boundaries versus Edges, Structure versus Scaffolds, and Routine risks versus Existential risks.

The paper examines these distinctions by reference to events and decisions taken as the project unfolded. For example, I highlight how people at the edge of the project, but not part of it, shaped its development, how the project unfolded through intentional and unintentional disruptions, and how progress was marked by moments of truths and discontinuities when insights were achieved. The paper's methodology is based in the tradition of ethnographic case studies.

The paper describes the roles and backgrounds of the projects members, their relationship to the wider social system in which they were embedded, and the central role that "boundary objects" played in shaping work and integrating the different disciplines. The paper ends with a reflection on the strengths and limitations of this new organizational form, the DP, as a potentially a good container for transdisciplinary work.

Paper 4: The Anatomy of Teams: Division of Labor in Collaborative Knowledge Production

Authors: Carolin Haeussler (University of Passau) and Henry Sauermann (Georgia Institute of Technology)

Abstract: Teams are increasingly important in knowledge production, yet how teams divide tasks among their members remains ill-understood. Complementing recent work that views innovation as the recombination of prior knowledge in different disciplinary domains, we conceptualize knowledge production as a process involving a number of functional activities such as conceptualizing the research study, performing the experiments, analyzing data, and writing the paper. We develop a theoretical framework to study the functional division of labor in scientific teams that highlights three different perspectives and also suggests three associated measures: (1) an individual level perspectives considering to what extent team members are specialized vs. engage in multiple activities; (2) an activity-level perspective considering to what extent activities are concentrated among few team members vs. distributed across many, and (3) an integrated perspective considering which activities tend to be performed by the same team members as well as which activities tend to be performed by specialists vs. generalists.

In the second part of the paper, we use this framework to examine division of labor empirically using novel data on the activities of all authors who contributed to over 13,000 scientific articles. The data are from the journal PLOS ONE, which ask teams to disclose the individual contributions of all co-authors. We find that division of labor is stronger with respect to some functional activities than others, likely reflecting differences in the benefits from specialization and the interdependencies between activities. We also find a wide distribution of degrees of specialization across individuals, and specialization is systematically related to individual characteristics such as professional age and prior scientific accomplishment. Consistent with economic theories, division of labor increases with team size but at a decreasing rate, leveling off well above the theoretical minimum. Thus, teams members do not specialize as much as they could, potentially reflecting high coordination and communication costs associated with high division of labor. Moreover, while the share of members performing empirical activities is largely stable across the team size distribution, the share of members engaged in conceptual activities declines sharply, suggesting that conceptual activities may benefit less from parallel processing by multiple team members.

In the third part of this paper, we use the data to explore differences in the levels and nature of division of labor between projects of different types: projects that are in one discipline vs. multiple disciplines, in established vs. new fields of science, and projects performed by purely academic teams vs. teams with industry involvement.

Overall, our paper advances the SciTS field in two important ways. First, we propose a conceptual framework that clarifies and conceptualizes functional division of labor and suggests a range of empirical measures that can be used for future work. Second, we use these measures to provide empirical insights into the division of labor in a large number of diverse projects. Given the difficulty of studying team processes at a large scale, these insights should be of interest in their own right; in addition, they illustrate an empirical approach that can be fruitfully exploited to address a number of important questions about the organization of scientific research in teams.

Paper 5: Innovative Approaches to Researching Transdisciplinary Teamwork for Effective Science-Policy Action in the Americas

Authors: Gabriela Alonso-Yanez (Werklund School of Education, University of Calgary), Lily House-Peters (University of Arizona), Sebastian Bonelli (Columbia University), Martin Garcia Cartagena (Universidad de la Republica), Michelle Farfan (Universidad Nacional Autonoma de Mexico), Ignacio Lorenzo (Universidad de la Republica) and Jeremy Pitman (University of Waterloo)

Abstract: The Science of Team Science (SciTS) is a rapidly growing, cross-disciplinary field of study that aims to build evidence-based knowledge that helps maximize the efficiency and effectiveness of team research. As SciTS evolves, research reveals several factors that improve or hinder processes and outcomes of scientific collaboration within interdisciplinary (ID) teams (i.e. teams composed by scientists from multiple disciplines conducting research together). However, there is limited information about the dynamics of transdisciplinary (TD) teams (i.e., teams of scientists and non-scientific stakeholders that work together). There is a scarcity of SciTS research focused on exploring TD teamwork dynamics on projects confronting current socio-environmental concerns, such as climate change, disaster risk management and/or land use change in the Americas.

This research introduces an innovative empirical research design to explore individual and team dynamics of ID and TD research teams. Our approach integrates previous findings from the SciTS scholarship, Agent-Based Modeling techniques, and Situational Analysis, a recent approach to qualitative data gathering, analysis and interpretation. This multi-case research draws on a robust sample of international ID and TD team research projects (n = 23) that address pressing socio-environmental concerns in the Americas region. The sample spans projects that are currently ongoing and projects that have concluded their research activities. All ID and TD projects in the sample received funding from the Inter-American Institute for Global Change Research.

The contribution of the work is twofold: 1) advances scholarship the field of SciTS in the scope of collaborative teams that currently address socio-environmental challenges; and 2) advances existing SciTS methods to study ID and TD teams by presenting a novel approach that integrates qualitative situational analyses with agent-based modeling.

Concurrent Session 3

Training for Interdisciplinary Research and Team Science (Papers) 1:15–3:00 pm

Paper 1: Training the Next Generation of Transdisciplinary Cancer Researchers

Authors: Sarah Hohl (Fred Hutchinson Cancer Research Center) and Beti Thompson (Fred Hutchinson Cancer Research Center)

Abstract: Complex public health problems such as the relationships between diet, physical activity, and cancer require innovative, integrated scientific solutions. Thus, efforts must be made to train investigators who are able to work across disciplines to develop novel conceptual models and research methodologies. Few precedents exist for training the next generation of transdisciplinary team scientists. In this study we gathered perspectives of trainees and mentors from the Transdisciplinary Research on Energetics and Cancer (TREC) initiative to determine if and how TREC training programs at TREC Research Centers were preparing trainees for integrating TD research into their future careers.

Description of research methods: Between January and February 2014 we conducted focus groups (n=4) consisting of 5-6 trainees (n=22) at each TREC Research Center and one-on-one interviews with TREC investigators who identified as a mentor to a TREC trainee (n=17). Focus group questions aimed to elicit trainees' perceptions of training goals and expectations, mentorship experiences, and the benefits of a transdisciplinary training program, including if participants thought they their TREC training experiences was aptly preparing them to conduct transdisciplinary research in their future career. Interview questions aimed to elicit mentors' views of mentorship expectations, unique transdisciplinary training approaches, and challenges regarding transdisciplinary training. Interviews were transcribed verbatim, checked for accuracy, and uploaded into Atlas.ti for coding and analysis. The team applied a constant comparison content analysis approach, in which emergent themes are identified and compared within and across all qualitative data sources.

Summary of findings: TREC trainees and mentors described multiple expectations of their participation in TREC training activities, represented by 3 overarching categories: 1) Becoming transdisciplinary; 2) Developing career skills; and 3) Benefitting from collaboration and mentorship. Trainees expected to learn about transdisciplinary research, and gain experience applying transdisciplinary frameworks in their own research.. Additionally, they expected to be exposed to a wide range of investigators conducting transdisciplinary research and to develop their abilities to network and collaborate across disciplines and institutions. Trainees also hoped to build career skills not specific to transdisciplinary science, such as grant-writing and public speaking. Similarly, mentors hoped to provide opportunities for trainees to implement transdisciplinary research projects, to increase their knowledge and respect of other disciplines, and expand their scientific networks.

Statement of how the research advances the SciTS field: Preparing the next generation of transdisciplinary team scientists requires the development of successful training programs that prepare emerging scientists to address complex public health problems using collaborative and innovative approaches.

Paper 2: Population Health Science: A Model for Interdisciplinary Training

Authors: Christine Bachrach (University of Maryland), Jo Ivey Boufford (New York Academy of Medicine) and Gerard P. Lebeda (New York Academy of Medicine)

Abstract: This presentation presents a successful model of post-doctoral training in the highly interdisciplinary field of population health science, highlights lessons learned over a 12 year period, and describes steps underway to advance cost-effective models for future training programs. It advances the goals of SciTS by addressing elements of training that are critical for producing scientists who can participate effectively in team science, identifying areas of consensus and controversy based on a review of population health science training programs.

Population health science is a rapidly expanding field of inquiry that harnesses the combined power of diverse disciplinary tools to answer complex questions about health and health improvement. Population health scientists conceptualize health and disease/disability as the product of multiple determinants at the genetic, biologic, behavioral, environmental and social levels and mechanisms that link these determinants to health and to each other. Population health science requires scientists from different disciplinary backgrounds to combine their knowledge and expertise to answer questions individual disciplines alone cannot answer—for example, questions about the causes of health disparities, the mechanisms through which toxic stress produces disease, and the reasons as to why specific policies work or fail to improve health. Training in population health science must not only provide broad knowledge of disciplinary contributions, but also the skills to move beyond disciplinary frames and engage effectively in team science.

The Robert Wood Johnson Foundation (RWJF) established the first national post-doctoral training program in population health science in 2003. By the time it concludes in 2016, the RWJF Health & Society Scholars (HSS) program (HSS) will have provided 193 individuals with in-depth interdisciplinary training in population health science. This two-year program of intensive research, training, mentoring, and immersion in an interdisciplinary culture has transformed trainees' research agendas and led to outstanding records of research productivity and NIH funding. Within a decade of the initiation of the program, program alumni had received NIH support through 185 different grants from 16 NIH institutes or centers.

Several interlocking efforts now underway will build on the experience of this model program to develop next generation models for training in population health science. HSS is currently assessing "lessons learned" from its 12-year experience through a review of annual evaluations and interviews with alumni, faculty, and other key informants. The IOM Roundtable on Population Health Improvement has commissioned a paper that will draw on the experience of HSS and other training programs with population health-related missions to develop a set of key findings about the critical principles and elements for training in this interdisciplinary field. A June 1-2, 2015 meeting hosted by the IOM Roundtable will occur just prior to the SciTS 2015 meeting. Results from that meeting will be included in this presentation.

Paper 3: Development of a 'Team Science in Clinical Research' Course for Clinical Investigator Trainees

Authors: Damayanthi Ranwala (Medical University of South Carolina), Marc I. Chimowitz (Medical University of South Carolina), Perry V. Halushka (Medical University of South Carolina), Patrick D. Mauldin (Medical University of South Carolina), Jihad S. Obeid (Medical University of South Carolina), Joann F. Sullivan (Medical University of South Carolina) and Daniel T. Lackland (Medical University of South Carolina)

Objective: To introduce the concepts of "team science" to clinical investigators, a formal course was implemented for trainees in the Master of Science in Clinical Research (MSCR) Program. The course consists of lectures, assigned references, discussions, panels, participation in online modules and case discussions, and small group exercises with a seasoned faculty involved in team science concepts in conducting translational research. The course content is focused on team science engagement; development of the critical study question with a team approach; team organization of the interdisciplinary, multidisciplinary and transdisciplinary research team; evaluation of team functions; meta-cognitive processes for team functioning; factors that contribute to scientific team success; conflicts; and evaluating a scientific team. The competencies included in this course focus on translational team work to produce high impact outcomes. At the end of the course students will be able to build an interdisciplinary, multidisciplinary or transdisciplinary research team that matches the objectives of their research problem; advocate for multiple points of view; demonstrate group decisions making techniques, manage the research team and study; work as a leader of a research team while managing conflicts; maintain skills as mentor and mentee; foster innovation and creativity.

Summary: All students in the MSCR program are enrolled in the class. The interactive class has been evaluated as valuable to the translational and clinical research training with the concept of 'team science', team assembly, team management, team maintenance and transition, and team evaluation.

Statement of how this course advances the SciTS field: The knowledge gained from the course will help the students to be successful team members of a research team to work collaboratively to produce high impact outcomes.

Paper 4: Developing a Skills-Based Workshop Series for Early Career Clinical and Translational Health Scientists

Authors: Elizabeth W. Anderson (University of Michigan, MICHR), Nancy Calvin-Naylor (University of Michigan, MICHR) and Laura Denton (University of Michigan, Medical School)

Abstract: Clinical and Translational Science Awards (CTSA) programs aim to accelerate discovery toward better health. CTSAs support new efforts to address complex problems through collaboration in a competitive funding environment. We see innovative scientists racing forward with collaborative scholarship in response to funding. Yet collaboration requires additional uncelebrated skills in "cognitive, structural and processural task areas" (Gray, 2009). A recent Institute of Medicine (IOM) report recommends that CTSAs emphasize "innovative education models…which focus on team science, leadership…" Authors of a 2013 survey of CTSA Education programs echoed this call, recommending identifying competencies and using active learning and multiple perspectives in teaching team science approaches to early career investigators (Begg et al 2014).

Problem: Over the last three years, Michigan Institute for Clinical and Health Research (MICHR) at the University of Michigan has held a series of educational events focused on team science with resource people from business, science, and health disciplines: talks by panels of team scientists intended to inspire others. Medical School faculty planners have mostly been interested in the scientific sparks that result from collaborations, like the excitement about the product of team science that drives new funding initiatives like MCubed (a seed funding project) and the UM Center for Innovation and Entrepreneurship. In response to the IOM Report, however, MICHR Education decided to address gaps in competency development for scientists working in collaborative teams. What else is needed beyond garnering interest? And how do we frame educational offerings for early career translational scientists to overcome the general blindness to process over end point?

Methods: This year a new partnership with the School of Medicine Office of Faculty Development provided an opportunity to explore these questions. Charged with developing an offering for early career health science faculty investigators, we chose to conduct an informal needs assessment. We reviewed the MICHR translational science competencies and qualitative evaluation data from two previous workshops. We conducted a literature review to see who among University of Michigan faculty had published on collaborative research team process, and surveyed a convenience sample of nine investigators known to us as experienced leaders of scientific teams.

Findings: As a result, with limited funding, we designed a 3-part interactive workshop series. Group formation, study team management and communicating for shared understanding were themes in survey responses that lead us to select three central topics: frameworks for forming the team, developing language and values, and strategies for effective meetings. Additionally, we planned to further assess investigator needs through note taking at the workshops. Three two-hour sessions took shape, led by non-health scientists, experts in the fields of team dynamics and change management, management performance, and interdisciplinary studies. Presenters and planners met ahead to discuss overall goals. We framed the workshop series using Barbara Gray's survey article, "Enhancing Transdisciplinary Research Through Collaborative Leadership". This unusual approach to marketing was intended to introduce clinical scientists to the literature in interdisciplinary collaboration.

SciTs: After the series, program planners will analyze notes from workshop discussions and program evaluation surveys. As we use data to address scholar competency gaps, learn what instructional design elements participants prefer, and inform how to best frame future training around non-scientific content, other CTSA educators may learn from our experience as they expand their offerings.

Paper 5: Core Competencies in Team Science

Authors: Sawsan Khuri (Center Computational Science, University of Miami) and Stefan Wuchty (Department of Computer Science, University of Miami)

Abstract: It is now a given that scientific achievement is best conducted by teams working within teams. Grand technologies and big data capabilities have allowed us to ask more sophisticated questions for which the answers are to be found using a cross-disciplinary approach. However, very few institutions are actively teaching Team Science as a course topic at graduate or undergraduate level, and there are too few examples of workshops that teach students or young faculty how to navigate a career through teams of other scientists. This may be partly due to the fact that core competencies in this area have not yet been properly identified. As is common with soft skills education, the ability to work in teams is seen as something you learn on the job, instead of being a defined skill set that needs to be taught within a structured framework of a curriculum. However, our observations have shown us that students and young academic scientists are actively seeking guidelines to follow in this domain, and are asking for more in-depth instruction on how to proceed with issues of team dynamics, conflict resolution, and team leadership.

Here we propose a set of core competencies that should be incorporated into curricula that are targeted at upper undergraduate or graduate level courses in Team Science. These are based on the SciTS literature and on the authors' personal experiences, and have been tested to a certain degree at the University of Miami (UM) with U-Inspire, a 3-credit undergraduate course in team science, and with a series of seminars that were given to audiences at a variety of levels at UM. Core Competencies in Team Science:

1. Identify the different stages of team dynamics and their iterative nature
2. Describe the importance of "Know Thyself, Know Thy Team, Know Thy Stuff"
3. Identify the different levels of trust and how they impact good science
4. Describe the issues of credit and acknowledgement in scientific collaboration
5. Define causes of and possible resolutions for different conflicts in scientific teamwork
6. Define the role of team members, leaders, and mentors in a scientific team
7. Describe the importance of culture, both academic and ethnic, in team performance
8. Collaborate with someone of a different discipline on a pre-defined project

Concurrent Session 4

Using Bibliometrics to Understand Impact of Team Science (Papers) 1:15–3:00 pm

Paper 1: Connections: STEM Educational Research Communities, Knowledge Transfer, and Contributions to Innovation Pathways

Authors: Jan Youtie (Georgia Institute of Technology), Alan L. Porter (Search Technology and Georgia Institute of Technology), Gregg Solomon (National Science Foundation) and Stephen Carley (Georgia Institute of Technology)

Abstract: Innovation is widely believed to come from the combination of different disciplines. Sometimes this combination is directly represented in multidisciplinary teams working on a research project together or at least working alongside one another within an institution, such as a multidisciplinary research center. Other times, this combination occurs among researchers working with the same or similar instruments (Meyer and Rafols 2010). More broadly, Bainbridge and Roco (2006) envision that research in various disciplines will converge around work at the nanoscale. Perhaps most common are connections made through the diffusion of knowledge. Bozeman and Rogers (2002) call this a knowledge value collective. Here researchers in different disciplines may be working on similar topics but without knowledge of one another's work. However, gradually, the researchers become aware of one another and subsequently begin to cite one another's work (Carley and Porter 2011). Such awareness can lead to the formation of a nascent network (Youtie et al., 2006) which could either come together into a new field or remain separate. Funding can help the former happen by bringing together groups from different disciplines to collaborate across these boundaries on an emerging topic; however, it has been shown that when the funding ends, the collaboration often also ends (Chase et al. 2012).

These studies leave unanswered the proposition about establishing connections across disciplines doing similar research. Our research addresses this topic by examining the extent of knowledge sharing, as proxied by citations, between researchers in the field of Cognitive Science and those in Science, Technology, Engineering, and Mathematics (STEM) Education. Leydesdorff and Goldstone (2014) find that Cognitive Science in the 1980s was comprised of experimental psychology, linguistics, and philosophy. But by the 1990s and through the 2000s, learning has become an increasingly important topic in Cognitive Science. STEM Education and Cognitive Sciences have been observed to be working on the same topics in parallel, but using different terminology and methods. Encouraging greater connections between Cognitive Science and STEM Education could potentially achieve educational benefits, and, thus, studies (e.g., How People Learn (Bransford et al., 2000)) and funding programs (e.g., National Science Foundation's Research on Learning and Education or ROLE, and Science of Learning Centers or SLC) took place in the late 1990s and early 2000s to foster such cross-fertilization.

We test whether the knowledge flows between Cognitive Science and STEM Education have increased since the late 1990s through an analysis of cross-citations of articles from the Web of Science in journals representing these two areas. Our research considers 42 journals as Cognitive Science (a list that we base in part on Leydesdorff and Goldstone's work) and 28 journals in STEM Education (drawn from the Web of Science Category Education, Scientific Disciplines). We examine cross-citations between these journals in 1994, 1999, 2004, 2009, and 2014, years chosen to obtain snapshots before, during, and after the aforementioned studies and funding programs and attempting to track the extent to which the communities and, more particularly, their literatures have come into systematic contact.. Preliminary results suggest that the extent of cross-citations between the two fields has not dramatically changed. However, we do note the presence of several specialized fields—Educational Psychology, Learning Technology, and Human Computer Interaction—that act as "border communities" in that they attract citations from both Cognitive Science and STEM Education.

Paper 2: Cross-Disciplinary Research Knowledge Flows: How Multidisciplinary are Articles in Multidisciplinary Journals?

Authors: Gregg Solomon (National Science Foundation), Alan Porter (Georgia Tech) and Stephen Carley (Georgia Tech)

Introduction: The Web of Science (WoS) categorizes journals into some 224 Web of Science Categories (WCs). Especially prominent are leading journals in the Multidisciplinary (MDR) WC, including Science, Nature, & PNAS. But, in what ways are articles published in those journals interdisciplinary? This study explores this question in terms of citation patterns. We key on Integration and Diffusion scores as indicators of research knowledge interchange. Put simply, we wonder if, perhaps, a bio article in Science is apt to draw narrowly within its field, but be cited widely in many fields? Are patterns similar for chemistry or psychology articles published in, say, Nature? And how do these compare to articles in those fields published in leading journals in the respective fields?

Methods: We analyzed sample article sets published in the afore-mentioned MDR journals in three areas—Cell Biology (CellBio), Cognitive Sciences (CogSci), and Physical Chemistry (PChem)—chosen to tap life, social, and physical sciences. To compare, we sought two leading (high Journal Impact Factor) journals in each field—one more specialized, one more general in scope—Cell & PLOS Biology; Cognitive Science & Psychological Science; Journal of Physical Chemistry A & Journal of the American Chemical Society (JACS). We sampled for publications in 2009, allowing some 5 years to accrue citations. We categorized articles from Science & Nature into our three target areas based on the prevalence of cited references in WCs associated with each area. Our reasoning was that an article had to draw at least 20% of its cited references from journals in a particular field (e.g., journals categorized with the WC "Cell Biology"), for us to consider it as in that field (e.g., a Cell Biology article). We sampled comparable size sets of articles from the disciplinary journals.

Results: We derive Integration Scores for each of the articles; these reflect the diversity of cited journals, as categorized into WCs. There are differences in the mean Integration scores between fields; articles in Cell Biology are lower than those in Physical Chemistry, which in turn are lower than those in Cognitive Science. These differences are consistent with previous findings that fields differ in the extent to which they cite articles in journals in other fields. In our central comparison, we derive Integration Scores for the sample of articles in each field that appeared in the MDR journals. Strikingly, for each field, the mean scores for articles appearing in the MDR journals are not significantly different from those appearing in the disciplinary journals. In other words, Physical Chemistry articles appearing in the MDR journal, Science, were not significantly more likely to draw on multidisciplinary sources than were articles appearing in the Journal of Physical Chemistry A. Even if the articles appearing in the MDR journals are not themselves more multidisciplinary, there is the promise that they will have wider influence on other fields. We derive Diffusion scores, an indicator (analogous to Integration scores) of the extent to which the articles in question are themselves cited by articles appearing in journals in other fields. Our preliminary results suggest that articles in these high prestige MDR journals are not systematically influencing a broader range of disciplines than are articles appearing in field-specific journals. We discuss the results in terms of patterns of research knowledge diffusion and the prestige associated with publishing in a top MDR journal.

Paper 3: Subject Diversity by Researcher Role, and Its Effects on Research Performance for Three University Medical Centers

Authors: Charisse Madlock-Brown (University of Tennessee Health Science Center) and David Eichmann (The University of Iowa)

Abstract: This paper presents an analysis of publication diversity of basic science researchers at the University of Iowa, Northwestern University, and the University of Indiana. By testing quantitative measures of diversity, we demonstrate that diversity by role in the research publication process (e.g., appearing as first author, or secondary author) has a varying degree of correlation with research performance measures including h-index, and productivity. Also, the degree of correlation varies by institution.

Our presentation will address two main questions. First, what is the relationship between an individual's subject area diversity and research performance measures? More specifically, are those whose body of work is more diverse more likely to publish more, be accepted in high impact journals, and have high h-indexes? Our second question relates to differing roles individuals play in the research process. Recent research based on a survey of 101 scientists posits that what we measure with co-authorship is, primarily, the division of labor of scientific work (1). This type of collaboration is characterized by contributions from more than one researcher during the conceptual and experimental phases. However, each participant focuses on different aspects of the research, which is typically reflected in the position in the author list. Our second question is: does diversity have different correlations with desired outcomes by role?

We used data from VIVO ontology-based profiling systems for three universities, and data from PubMed. We used department classification information from a previous research project to identify basic science researchers (2). We used porter's diffusion score to measure the diversity of researchers' publication lists (3). We collected publication data from 2002 through 2012 for all basic science researchers. Publication data was further classified into two categories: first author publications and second author publications, based on the position in the author list. Only researchers with at least 5 first author publications were used in the analysis of first authors, and only researchers with at least 5 secondary author publications were used in the analysis of secondary authors. Pearson's R was used to find correlations between publication diversity and performance measures. Our presentation will include a discussion of methods, an in-depth analysis of the results, and their implications for researchers, administrators and governmental agencies.

Paper 4: Research Productivity over the Life Cycle in the Era of High Skill Immigration

Author: Wei Huang (Harvard University)

Abstract: Using the name-disambiguated PubMed data, I examine the research over life cycle for the scientists and researchers with the first research paper published in the United States. The results find that the team size, diversity in locations and surname ethnicity of the authors increase significantly over life cycle, for both Anglo-Saxon and non-Anglo-Saxon authors. However, the quality of the publications, measured by impact factor and forward citations, decline over life cycle, especially for those with non-Anglo-Saxon surnames. This effect is reinforced significantly when the research teams characteristics are controlled for. These results indicate an important role of research team in the research productivity over life cycle and that the motivation to research differs by their ethnic background. Further analysis will shed light on whether the immigrant policy contributes to the different research productivity over life cycle between Anglo-Saxon authors and non-Anglo-Saxon ones.

Paper 5: Sizes of Research Teams and the Growth of Knowledge

Author: Stasa Milojevic (Indiana University)

Abstract: The highly publicized results of large research teams suggest that 'big science' is more successful and innovative than the efforts of small teams and single authors. This raises the question of whether 'small science' has value in today's scientific landscape, and whether society should invest in it. A possible drawback of the move towards highly collaborative research is that it could affect the heterogeneity of research approaches and the topics studied. In order to determine whether this is the case, I developed an innovative big-data method to measure the cognitive extent of a scientific discipline, and its change through time. The method is based on an automated extraction of scientific concepts contained in the titles of research articles, in a way that is not biased by changes in the volume of research articles. I analyze 20 million articles covering more than a century of research in physics and astronomy, as well as sixty years in biomedicine, and show that the knowledge domains in these fields have been expanding, but not exponentially. More importantly, I find that the largest knowledge domains in all three fields are still covered by works of single authors, author pairs, and small teams (3-5 authors), while teams with more than 20 members cover significantly smaller cognitive extent (50–80%). These results provide evidence that the efforts of small teams are essential in maintaining the intellectual diversity of science, and are likely to be instrumental for its further growth.

Concurrent Session 1

Decade of Review of Team Health Science Initiatives at the University of Saskatchewan: Lessons Learned from a Magnificent Start to Current Reality (Panel) 3:15–4:45 pm

Authors: Jim Thornhill (University of Saskatchewan), Rachel Nelan (Flad Architects), Hugh Townsend (University of Saskatchewan) and Brad Steeves (University of Saskatchewan)

Abstract: The Team Science 2015 conference will be celebrating 10 years of dialogue from institutional experiences across North America and beyond of important, if not essential elements for sustaining successful Team Science initiatives, from the smallest collaborative efforts of a few researchers within a single Department or College to large, transdisciplinary initiatives that could include Universities, communities, government and industry. The University of Saskatchewan, in Saskatoon, Saskatchewan, Canada (a member of the U15 medical-doctoral Universities in Canada with both instructional and research mandates as part of their core mission) is the only English speaking Canadian University that has all the major Health Science professional programs (Medicine, Nursing, Pharmacy/Nutrition, Veterinary Medicine, Kinesiology, and Dentistry) plus a new School of Public Health (SPH). Importantly, the University has spent over a billion dollars in the last 20 years constructing health science research infrastructure that includes the Canadian Light Source Synchrotron, Vaccination Infectious Disease Organization and Level 3 International Vaccine Centre (InterVac), Sylvia Fedoruk Centre for Cyclotron Research, as well as new research wing to the Western College of Veterinary Medicine. In addition, the University was granted $>350M of Provincial resources to build an Academic Health Sciences (AHS) complex to foster 8 core training, service and research principles in the Health Sciences Colleges and the newly formed SPH. Two of the major principles to be augmented in the building of the AHS complex were intra-professional health science teaching among our 6 health professional Colleges and collaborative health (biomedical, clinical, health services, or social-population health) research clusters (teams), in areas of need and strength.

Our University wishes to share with you our journey for the last 10 years of how the AHS building was designed and constructed for Team Science success. Two critical components in supporting Team Science are modern research facilities and operations. Rachel Nelan with Flad Architects and Brad Steeves, the University Director of Operations for the AHS complex will discuss the planning, process, and implementation efforts to date that are enabling research team success. Rachel will share the diverse planning and design work completed, from alignment of institutional goals with building expectations, to user engagement for program development in a new research paradigm, to equipment planning for a shared lab environment, to the physicality of supporting a culture of collaborative research. Brad will relate the governance and organizational structures tested over the years to oversee the building construction and current operations of the building and how staff, students and faculty were engaged with the building concept. He will relate the institutional barriers that were, and, in many cases, are still present in fostering and sustaining the teaching and research principles, aspired to for the AHS complex and how a lack of leadership for presentation of academic vision, expectations, rewards and recognition, communication, training, all necessary to build trust among the researchers and research clusters, hindered individual and institutional productivity. All the important Team Science elements for fostering and sustaining team science were not known to us when we began.

With the help of Team Science consultants at NIH since 2012, we have twice surveyed our Health researchers, who moved from previously siloed laboratory settings, their experiences over 2 years within the new collaborative (shared) team science setting of the AHS complex, as how this new collaborative research setting

helped their research programs. We will share those findings with you, including our successes, failures and challenges around the implementation of Team Science.

An important and positive development in the advancement of Health Team Science initiatives at the University of Saskatchewan was the establishment of One Health as a core signature research and training theme for our University, a theme that pertains to faculty and students across all our natural and social science Colleges and Schools. University of Saskatchewan One Health Program co-leader Dr. Hugh Townsend will outline the undergraduate and graduate training programs, facilities and research initiatives that have been established during the growth of our transdisciplinary, One Health Program. He will discuss the principles of effective Team Science research that we trying to master are being used to establish and grow and enhance One Health research teams and their work.

In 2014, a pivotal announcement by University central administration advocated several new mission priorities for the University going forward, including the University priority to emphasize the importance of supporting Team Science initiatives across campus, and in particular, in the Health Sciences. We will discuss (Jim Thornhill, Special Assistant to the VPR, Brad Steeves and Hugh Townsend) what those changes are for governance structure for the AHS building, along with reviewing promotion, tenure and merit guidelines for team science research. What will these changes mean to the promotion of Health Team Science initiatives within the AHS building team clusters, to One Health team researchers and students, and for other team science initiatives on campus?

Concurrent Session 2

Developing and Disseminating Research-to-Practice Tools and Products: Findings from the SCTC Research Initiative (Panel) 3:15–4:45 pm

Authors: Elizabeth Ginexi (National Cancer Institute), Grace Huang (National Cancer Institute), Sophia Tsakraklides (Westat) and Keith MacAllum (Westat)

Abstract: The National Cancer Institute's (NCI) State and Community Tobacco Control (SCTC) Research Initiative is a 5-year program targeting high-priority research areas in tobacco control. Scientists from seven research sites and one coordinating center are developing strategies to optimize the dissemination of research findings to a wide array of audiences, including tobacco control programs, public health practitioners, researchers, federal, state, and local policy makers. These stakeholders have formed collaborations across sites and with community partners who will apply the products to advance practice and policy, thus providing an opportunity for studying how science conducted in teams can lead to the effective dissemination of scientific findings.

While creating and implementing plans for dissemination is often encouraged by this and other grant mechanisms, the processes and successes of these efforts are rarely studied. Therefore, an external evaluation is being undertaken, using a mixed method approach, to examine research-to-practice gaps, thereby providing a window into the processes of disseminating evidence-based tools, products, and findings in community public health settings. Data on structural and cultural factors are being collected through project records, web surveys, telephone interviews, and focus groups. This panel will present findings from this research initiative with a specific focus on how lessons learned can inform both the effectiveness of team science in similar collaborative efforts and future research in this area.

Abstract Summary of Each Section

1. Overview of the SCTC initiative and its contribution to the Science of Team Science

Although significant progress has been made in reducing tobacco use in the United States, many challenges remain. Approximately one in five adults (17.8%)—42.1 million Americans—are current cigarette smokers (Jamal et al., 2014). Significant disparities in smoking prevalence exist, based on income, education, race/ethnicity, and other factors. Historically, states and communities have played an important role in implementing tobacco prevention and control policies and programs, and in designing and implementing mass media campaigns.

The National Cancer Institute's (NCI) State and Community Tobacco Control (SCTC) Research Initiative is specifically designed to target high-priority tobacco control research areas at the State and community levels in the United States and to support innovative research that will yield rapid and actionable findings for State and community tobacco control programs. Moreover, the SCTC investigators are charged with developing effective strategies to translate and disseminate their research findings to a wide array of audiences.

In order to get a better understanding of the dissemination processes in SCTC the NCI is conducting a mixed-methods approach process evaluation of the initiative. The objective of the evaluation is to identify effective strategies from the SCTC that may inform future science-to-practice dissemination efforts at the NCI and throughout the NIH. Past efforts at NCI have been made to develop comprehensive conceptual frameworks to guide the assessment of complex team science initiatives (Holmes, et al., 2008; Stokols et al., 2003; Stokols et al, 2010; Trochim, 2008) and to develop multi-method approaches for assessing the collaborative and cross-disciplinary processes and outcomes of team science (Hall et al. 2012, Hall et al., 2008; Masse, et al. 2008; Provan, et al. 2008; Stokols et al., 2003; Stokols et al. 2010; Trochim, 2008). However, there is little program theory available to guide an evaluation of team science initiatives that are intended to disseminate rapid and actionable findings to State and community public health programs. Therefore the goal of this evaluation is to assess science-to-practice dissemination activities by focusing on the iterative interactions between scientist teams and State and community public health practitioners.

2. Composition and structure of the SCTC networks over time

This segment of the presentation will feature the network findings from a multi-year evaluation of the SCTC initiative. Survey data were collected at two points in time from scientists and community partners. Social network analysis is used to elucidate collaborative relationships as well as dissemination bridges and gaps within the network. Network centrality metrics identify key collaborative partners, such as opinion leaders with high visibility and gatekeepers who serve as information brokers, between research sites. Network-level metrics such as density, centralization, and cohesion are used to indicate whether the network facilitates or hinders diffusion of ideas and whether subgroups are organized around particular focal points. Changes in network structure and properties are quantified by examining the formation and maintenance of network relationships over time. These data and findings are being used to identify replicable collaborative strategies and gaps to be addressed and may inform future initiatives designed to promote science to practice dissemination.

3. Qualitative interview and expert panel analysis of SCTC

This segment of the presentation will feature findings from a series of 58 telephone interviews conducted with lead scientists as well as affiliated partners from government, advocacy, and practitioner organizations. Interviews focused on subjective experience of networking and collaborating with colleagues both within and outside of academia. Data were collected on what the respective research centers accomplished, the processes used, and the relevant supports provided by NCI designed to promote and facilitate team science. Additional qualitative data were collected through a pair of expert panels (i.e. focus groups) comprised of PIs, Co-PIs, and other lead scientists. These sessions yielded subjective impressions on how well the design and components of the SCTC initiative accomplished their intended effect of promoting research-to-practice products by leveraging extant strategies that have been associated with effective team science. Recommendations for future initiatives and strategies to enhance research were also gathered.

4. Lessons learned and new directions / next steps for continued research

It is our hope that results from this evaluation will advance the current understanding of the science-to-practice gaps in large NIH-supported research initiatives. This evaluation effort provides a critical window into the process of disseminating evidence-based research tools, products, and science findings in community public health settings. To date little is known about how this is done effectively. While collaboration with community practice partners and plans for science to practice dissemination are often encouraged in NIH research programs or even required—in the case of the SCTC Research Initiative—the processes by which this is achieved have never been studied. Thus, the primary purpose of this evaluation is to begin to develop the capacity needed to assess the dissemination, implementation, and community collaboration processes of the SCTC Research Initiative grantees and their respective state and community partners and stakeholders.

Concurrent Session 3

Disciplinary Diversity in a Multi-Stakeholder Governance Structure: Facilitating Engagement and Enhancing Relevance of Policies and Resources for Patient-Centered Research Networks (Panel) 3:15–4:45 pm

Authors: Sarah Daugherty (PCORI), Katherine Kim (Betty Irene Moore School of Nursing, University of California Davis), W. Benjamin Nowell (Global Healthy Living Foundation), Darrel Drobnich (midAmr Group), Jaye Bea Smalley (PCORI) and Hugo Campos (Stanford Medicine X)

Abstract: The National Patient-Centered Clinical Research Network, or PCORnet, is a national distributed data research resource comprised of 29 heterogeneous networks (11 clinical data research networks (CDRNs) and 18 patient-powered research networks-(PPRNs)). One of the defining features of PCORnet is the requirement to engage multiple stakeholders, including patients and caregivers, clinicians, health system leaders, in the governance of the national and individual networks. Three PCORnet networks (PSCANNER (CDRN), AR-PoWER (PPRN), and SAPCON (PPRN)), and the PCORnet Patient Council will be highlighted on this panel. An overview of PCORnet, the engagement framework, and the various governance models that have emerged among the PPRNs will be described. Each network and the PCORnet Patient Council will provide a rationale for their governance model within the context of their network and will discuss how their governance structure and processes facilitate engagement in deliberative decision-making. Key facilitators that contributed to the efficacy and impact of the multi-stakeholder governance structures will be highlighted including strategies for applying principles as a framework for governance procedures, selection criteria utilized to enhance role definition and responsibilities of individual stakeholders, bidirectional learning, training that prepares patients to deliberate on technical issues, and the value of organizational diversity. Examples of key policies, resources or tools that were refined to enhance research as a result of multi-stakeholder input will also be described. Finally, each panelist will address challenges encountered and discuss course corrections that have been incorporated into the governance structure or decision-making procedures.

Presentation #1: A Novel Stakeholder Engagement Approach to Patient Centered Outcomes Research Governance

With many clinicians and hospitals moving to electronic medical records, the potential for leveraging large-scale data to improve care and research is rapidly emerging. In electronic networks for healthcare and research, numerous technical challenges and ethical issues must be addressed, particularly incorporating views of stakeholders such as patients and consumers, clinicians and health organization leaders. There is a dearth of knowledge regarding how governance standards, strategies, or priority-setting approaches are best matched to principles of patient-centeredness. Patient-centered outcomes research (PCOR) as defined by the Patient Centered Outcomes Research Institute (PCORI) 1) focuses on patients' needs and preferences and on outcomes most important to them; and 2) helps patients and other healthcare stakeholders, such as caregivers, clinicians, insurers, policymakers and others, make better-informed decisions about health and healthcare options.

The engagement of patients and others stakeholders is a critical element in designing PCOR. However, methodology for patient and stakeholder engagement in governance and early phases of research are in a nascent stage of development and evaluation. The objective of this study is to develop and assess a novel method for engaging patients and other stakeholders in generating research priorities and operationalizing network governance policies for PCOR.

Presentation #2: Patient and Stakeholder Engagement in the Governance of a Patient-Powered Research Network

Healthcare and research are at an important crossroads in innovation. Technology and online connectivity have made it possible to understand the everyday experience of patients in real time. If patients are willing to share information about symptoms, treatments and behaviors via websites and mobile applications on smartphones and tablets, these data may be used in research to compare treatments and create treatment plans tailored to specific patients' needs. Inflammatory arthritis, such as rheumatoid arthritis (RA) and spondyloarthritis (SpA), presents a key disease focus for patient-centered comparative effectiveness research. The Patient Centered Outcomes Research Institute (PCORI) supports such research and prioritizes the engagement of patients in designing and governing it. There is scant research on methodology for patient engagement in research governance. This presentation describes and assesses engagement approaches in a patient-powered research network for inflammatory arthritis

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Presentation #3: Building a Diverse and Sustainable Community To Support Patient-Centered Research Networks: A Learning Environment

The creation of networks of engaged patients, researchers, clinicians and other stakeholders to support patient-centered comparative effectiveness research present exciting opportunities as well as organizational, communication and logistical challenges. Over the first eight months since its inception, the Sleep Apnea Patient Centered Outcomes Network (SAPCON), a patient-powered research network participating in the Patient-Centered Outcomes Research Network (PCORnet), has identified key principles and practices to support patient and other stakeholder engagement informed by ongoing review and iteration of its activities and sharing of best practices among other PCORnet members.

Presentation #4: Patient-centered data research network and cultural transformation

One of the goals of PCORnet is to not only improve the nation's capacity to conduct research efficiently, but to also transform the research culture from one that is expert-centered to one that is patient-centered. PCORnet's focus is patient-centered big data research, which presents complicated issues, such as privacy, autonomy and consent, which are of profound importance to patients. Initially, it was thought that the 18 Patient-Powered Research Networks (PPRNs), would be lead primarily by patients and result in an inherently patient-centered governance structure. However, many of the patient groups partnered with skilled researchers to serve as the principal investigators. Because the PCORnet Steering Committee was composed of one individual from each network, generally the principal investigators, effective patient engagement through the original structure was challenging. The few patients serving on the PCORnet Steering Committee would not be able to meaningfully affect majority consensus voting—which necessitated a midcourse organizational restructuring to ensure the integrity of the patient voice. This gave rise to the PCORnet Patient Council (PPC). PCORnet policies were being adopted with a very tight, ambitious timeline. The primary responsibility of the PPC was for reviewing the operational policies of PCORnet with an eye toward addressing issues that affected patient ethical and societal concerns regarding the use patient data. However, once implemented, the Patient Council faced a steep learning curve to become sufficiently informed so as to effectively deliberate on the complex societal issues before it. Effective patient engagement requires that patients be able to meaningfully affect the outcome of a decision. In the case of PCORnet, this required organizational restructuring, an intense educational training program, breaking through organizational silos, and finding methods of creating bi-directional learning opportunities under extreme time pressures.

Concurrent Session 4

Cross-Institutional Collaboration: Strategies for Success (Papers) 3:15–4:45 pm

Paper 1: Defining the Work of Coordinating Centers

Author: Betsy Rolland (National Cancer Institute)

Abstract: One tool being used to address the overhead of collaborative research is the employment of a Coordinating Center (CC), a central body tasked with coordination and operations management of a multi-site research project. Despite their proliferation as a way to support collaborative research, CCs are understudied and undertheorized, leaving each CC to develop new methods, policies and procedures. In fact, there is no standard, commonly accepted definition of what a CC is or does, how to start and run one, or how best to evaluate a CC's efforts. The calls for proposals that fund CCs take vastly different forms across initiatives, even within the same agency. The work of the CC may be described in vague terms such as facilitate, coordinate, or support. This fuzziness of purpose can leave CCs and the initiatives they support struggling to define what a CC is and does, causing them to spend precious time and resources on these definitions. The development of a standardized definition of CCs and their work may help them be more effective in supporting collaborative science.

Methods: This qualitative research study of two CCs took place at the Fred Hutchinson Cancer Research Center (FHCRC). The CCs, who share many staff and PIs, are part of two networks here called the Biomarker Network (BN) and Screening Network (SN). Both networks were formed by the funding agencies using a set of RFAs for the research centers and a separate RFA for the CC. I conducted semi-structured interviews with 17 members of the BN and SN, including nine participants from the CCs, two funding agency representatives and six external PIs. I also observed over 95 hours of meetings, including local CC operations meetings and three semi-annual face-to-face consortium meetings. Data were coded and analyzed using a grounded theory approach.

Findings: The CCs we observed engaged in a wide variety of complex tasks while facilitating collaborative work in the consortia. Some of these tasks were consistent between projects, such as organizing conference calls and meetings, while other tasks were more closely tied to the scientific objectives of the project. We have divided these tasks into four areas: (1) Structural work; (2) Collaboration development work; (3) Operational work; and (4) Data work. While coordinative work is often considered strictly administrative in nature, this research demonstrates that the work of the CC had a strong impact on the scientific outcomes of the initiatives.

Implications: Understanding the types of work typical of a CC allows us to develop theories of coordination that help explain how CCs function as part of a consortium. As new initiatives that include CCs are rolled out by funding agencies, a deeper understanding of CCs, their work and the impact of their practices can be utilized to build coordinative structures that are more efficient, more cost-effective and better support collaborative science. Furthermore, this knowledge will allow us to begin defining what a CC is and does, a necessary step for conducting meaningful evaluations of CCs within and across disciplines.

Paper 2: A Practical Application of the Science of Team Science Tenets = An Integrated Research Team

Authors: Nancy L Dianis (Westat) and Tracy Wolbach (Westat)

Abstract: In June 2009, the National Heart, Lung, and Blood Institute (NHLBI) teamed with UnitedHealth Group's Chronic Disease Initiative to reduce the burden of non-communicable cardiovascular and pulmonary diseases (CVPD) by building research and training capacities at 11 emerging Centers of Excellence (COEs) in Argentina, Bangladesh, China, Guatemala, India (Bangalore), India (New Delhi), Kenya, Mexico, Peru, South Africa, and Tunisia. NHLBI awarded a contract to Westat to serve as the administrative coordinating center (ACC) for the Global Health COE Program. As ACC, Westat supported diverse program needs and provided logistical expertise to the COEs.

All of the Network research activities would generate compelling new data about non-communicable CVPDs. During contract year 1, 9 COE PIs expressed interest in leveraging data generated from 14 epidemiological research activities through data harmonization. Data harmonization would answer non-communicable cardiovascular and pulmonary disease questions which may not be otherwise answered by any single COE research activity. Using a landscaping exercise to determine which variables were common among the 14 research activities, 45 common variables were identified. ACC staff harmonized the data and uploaded it into a database for the COE PIs and staff to answer additional research questions.

ACC staff applied principles from NIH's "Collaboration & Team Science: A Field Guide" with the top-down formation of this team of COE PIs, as the team was configured based on contract award, rather than self-selection. The challenge was to transform a group of CVPD researchers with no prior relationship into a functionally successful team. The following table illustrates how ACC staff used the tenets of team science to foster an integrated research team (the epidemiology subcommittee) with a focus on CVPD epidemiology.

Team Science Tenet	ACC Action to Foster an Integrated Epi Subcommittee Research Team
Leadership	Initially leadership was positional, but quickly emerged from team members which rotated annually.
Team's Evolution	Using Tuckman's model of team stages, the ACC staff recognized the team's stage and could plan activities to help the team move the next stage.
Trust	Identification of trust was fostered, as team members had compatible goals related to reducing the burden of non-communicable CVPDs; roles and responsibilities negotiated and accepted by all team members.
Shared Vision	Team members shared primary outcomes of research activities and how these could contribute to a richer database from which research questions could be answered.
Communication	Recognized the need for 'culturally sensitive/neutral communication'; convened meetings/calls at predetermined times with agendas; promoted respectful dialogue and debate, focusing on concepts, methodologies rather than the person, with the outcome of improving the research; engaged in active listening; practiced anticipatory and creative problem solving.
Strengthen Team Dynamic	Created a respectful, supportive environment; acknowledged strengths of team members; all agreed the team was stronger than any one team member and all shared in the team's success; members have formed another network since the contract concluded.
Recognition and Credit	Established decision criteria for authorship and credit—electing to be more inclusive than exclusive; acknowledging team members contributions to the research outcome.
Navigate and Leverage Systems	Social Network Analysis will show the progress of the team beginning as separate entities and developing collaborative relationships for research endeavors beyond the scope of the network.

A Social Network Analysis demonstrates how the relationships and collaboration of the 9 COEs evolved over time. We will present the team science tenets that were operationalized for the COE Epidemiology Subcommittee, successes (e.g. process for determining authorship), and challenges (e.g. team size, geographic dispersal, overcommitted COE PIs). We will also present our social network analysis of the relationships among the COEs, their sub-sites, their publications, and other data points.

Paper 3: A Framework for Assessing Strategy Management in Collaborative Clinical Research Networks

Authors: Jonathan Kagan (NIAID Division of Clinical Research), David Boan (Social Interventions & Research Inc.), Ellen Cull (Ellen Cull, Management & Organizational Consultant), Judith Zuckerman (NIAID Division of Clinical Research), Jerry Lassa (Data Matt3rs), Beth Grace (NIAID Division of Clinical Research) and Laura McNay (NIAID Division of Clinical Research)

Abstract: In recent years, there has been a broad transformation of the organization and management of science with increased emphasis on large, collaborative research initiatives of which clinical research networks are an example. There are nearly 300 clinical research networks in the United States and Canada, many of which involve partnerships among governments and organizations in different nations. These programs generally take a multidisciplinary team approach, and address research topics relevant to all partners. As such, they generally have broader goals than traditional individual investigator-initiated research. In addition to providing scientific outputs, these multi-institutional programs are also expected to foster multidisciplinary teamwork, develop new investigators, build scientific infrastructure, and demonstrate state-of-the-art prevention, diagnosis, and treatment techniques. Ultimately, the efficiency and synergism inherent in these systems of research is expected to positively impact population health and behavior and national policy by producing and completing innovative, relevant, and timely research. These broader goals, and the operational activities that support them, pose substantial management, implementation, and evaluation challenges.

Based on increasing evidence correlating strategic planning and organizational performance in research, NIAID's Division of Clinical Research has sought to establish strategy management as a core element of its partnerships with clinical research networks. Our cumulative practice base now presents opportunities to begin assessing the design and implementation of these efforts. Absent available models for assessing strategy management in collaborative clinical research networks, we have designed our own approach built on fundamental elements of the Kaplan-Norton (K-N) strategy management paradigm, and the Baldrige Criteria for Performance Excellence, both adapted for use in our clinical research environments. Briefly, the K-N model has been widely employed in the private and public sectors to help achieve improved outcomes because it has been shown that breakdowns in the execution of strategy are associated with organizational underperformance. The K-N model includes developing strategy; identifying strategic objectives, measures, and initiatives; linking the organizational strategy to the strategies of its operational units and staff; planning improvements in processes and linking strategy to resource capacity and budgets; implementing and monitoring the strategy, and learning from what is happening; and testing and adapting the strategy. The Baldrige Performance Excellence Program has established "Criteria for Performance Excellence" used by thousands of organizations to evaluate their strengths and opportunities for improvement on a developmental continuum. In the near term our research is designed to explore the utility and acceptance of our novel framework to establish a strategy management baseline, and begin identifying factors that enhance or inhibit successful strategy management in the clinical research setting. Longer-term outcomes will include improved methodologies and tools for strategic planning, monitoring strategy management, and understanding the relationship to performance.

Using a descriptive case study method, we have begun to pilot the utility of our framework to elicit relevant and useful information on the design and implementation of strategy in our research networks. A multidisciplinary team, guided by the integrated framework, gathered and analyzed information from document review followed by interviews with key informants from one our international clinical research networks. The interview questions were informed by findings from the document review both for validation and filling gaps in understanding. Our presentation will address the conceptual and practical basis for this strategy management assessment framework and initial findings, including aspects of feasibility and acceptability. At this early juncture, it appears that a logical framework synthesized from elements of the K-N and Baldrige models may have utility for leaders and managers guiding the work of international clinical research teams.

Paper 4: Factors Influencing Productivity in Interdisciplinary Synthetic Team Science Groups

Authors: Pamela Bishop (University of Tennessee, Knoxville) and Ana Richters (University of Tennessee, Knoxville)

Abstract: Scientific synthesis is the process by which researchers bring together heterogeneous data and knowledge sets in ways that yield novel insights or explanations. Over the last 20 years, there has been a rapid emergence of new research facilities around the world dedicated to scientific synthesis. Little is known, however, about team and individual factors related to success in synthesis teams. Evaluators of synthetic research groups face a daunting challenge of measuring not only the productivity of group members, but also the antecedents to successful production. This paper will demonstrate the use of hierarchical modeling methods to evaluate the factors leading to productivity of 20 interdisciplinary synthetic research groups that took place over six years at The National Institute for Mathematical and Biological Synthesis (NIMBioS).

NIMBioS is funded through a National Science Foundation award and located on the University of Tennessee campus. The institute draws a diverse cadre of researchers from around the world to take part in interdisciplinary synthetic research groups to find creative solutions to pressing problems from animal disease to wildfire control. The subjects of this presentation are Working Groups, which are assemblages of 10-14 researchers who focus on major well-defined scientific questions at the interface between biology and mathematics. The groups typically meet 2-4 times over a 2-year period and vary in their composition, size, and activities.

A known observation of scientific productivity is that is tends to be unequally distributed, with relatively few researchers being responsible for the vast majority of publications. This is also the case for NIMBioS, where 50% of the 44 working groups have produced the entirety of the working group publications for the center. In addition, only 35% of the working group participants are coauthors on these papers. A need exists, therefore, to evaluate the group and individual level factors that predict scientific productivity within these research groups. This paper attempts to evaluate these factors using multilevel modeling methods where the traits of individual research group participants (e.g. gender, ethnicity, discipline area) are modeled within group-level factors (e.g. number of meetings, group size, group composition) as determinants of Working Group-related journal article production.

The results of this study have implications for designing and evaluating synthetic interdisciplinary research teams, although the methods used could be replicated to evaluate many different types of team science groups. This presentation should be relevant to a diverse audience interested in research evaluation, team science, process evaluation, and multilevel modeling techniques.

Poster Session 1

Thematic Group 1

Bibliometrics 4:45–5:30 pm

Poster 1: Dissecting Scholarly Patterns in Biology and Computer Science

Authors: Majeti Dinesh (Computational Physiology Lab, University of Houston), Kyeongan Kwon (Computational Physiology Lab, University of Houston), Panagiotis Tsiamyrtzis (Department of Statistics, Athens University of Economics and Business) and Ioannis Pavlidis (Computational Physiology Lab, University of Houston)

Abstract: Biology and Computer Science are at the forefront of scientific and technological investigation, respectively, defining human civilization in the 21st century and absorbing large sums of public funds for research. Therefore, analyzing scholarly patterns in these two disciplines is important. At the same time such a comparative analysis is challenging due to disciplinary heterogeneity and the contextual dependence of available metrics. Biological research requires extensive experimentation that takes considerable amount of time and effort. Biology also follows a team-science model with impetus from the Human Genome Project. In contrast, Computer Science research is based on simulations and is characterized by short cycles. In this investigation we use standard academic measures of performance taking into account this differing context, in order to explore the scholarly cultures of Biology and Computer Science.

Method: We targeted the top 30 Biology and Computer Science departments according to the U.S. News Rankings 2014. For each department we collected publication data for the most cited faculty members (top ~37%) who have a Google Scholar page. The collection took place in September 2014. The data set includes n = 569 professors in Computer Science and n = 500 professors in Biology, representing an elite sample.

Results: We ran tests on distributions formed out of the departmental means of the corresponding variables.

1. Biologists publish less than computer scientists and have more authors per paper. The mean number of publications per year in Biology (5.21) is significantly lower (t-test, $p < 0.01$) than the respective mean in Computer Science (8.58). In contrast, the mean number of coauthors in Biology publications (5.57) is significantly higher (t-test, $p < 0.01$) than the respective mean in Computer Science (4.71).
2. Biologists publish mainly in journals, while Computer Scientists less so. The percentage of journal publications is significantly higher (t-test, $p < 0.01$) in Biology (73.36%) with respect to Computer Science (19.83%).
3. Biology's elite dominates publications in their top journals a lot more than the Computer Science elite does in theirs. Within the ranked set of all Biology journals, our Biology faculty sample publishes in the top 11%. In contrast, within the ranked set of all Computer Science journals, our Computer Science faculty sample publishes in the top 24%.
4. There is significant correlation between the citations obtained per year versus the number of publications produced per year in both disciplines, with Biology ($p < 0.01$, $\beta' = 81.15$, $R2 = 0.54$) having a steeper slope than Computer Science ($p = 0.01$, $\beta' = 40.81$, $R2 = 0.19$). The latter suggests that Biology has a tendency for higher mean citation-impact per article than Computer Science.

Conclusion: Differences in scholarship profiles between these two leading disciplines reflect to a significant degree the different nature of the respective enterprises (longer science cycles vs. shorter technology cycles). Monopolization of top disciplinary journals by Biology's elite, however, may be an issue with long term moral and performance implications that deserves further scrutiny.

Poster 2: Quantifying Interdisciplinarity with Jensen-Shannon Divergence and Entropy

Authors: Harish S. Bhat (University of California, Merced), Sebastian Rodriguez (University of California, Merced) , Rick Dale (University of California, Merced) and Evan Heit (University of California, Merced)

Abstract: This work builds on prior research looking at relations between interdisciplinarity and impact, notably focusing on two measures of interdisciplinarity based on distributions of journal publications and employing them in a very extensive data set.

In a two-level process, we have assembled a massive subset of the Thomson Reuters ISI Web of Knowledge database. In the first level, we used Journal Citation Reports to form lists of the top 250 journals by impact factor in both science and social science. For each of these journals, we downloaded database entries for all papers published from 2005-2010. In the second level, we downloaded database entries for all papers coauthored by first level authors from 2000-2006. The total number of bibliographic entries acquired in this process exceeds 20 million papers for over 800,000 authors.

Our goal is to use this massive data set to quantify interdisciplinarity at the paper and journal level, and then to explore statistical relationships between interdisciplinarity and measures of journal/article quality.

We use two metrics to quantify the interdisciplinarity of each paper. As a first step, we estimate each author's journal distribution: the probability that author i will publish in journal j, over all possible i and j in the data set. For a particular author, we think of the journal distribution as a proxy for that author's disciplinary background and/or preferences.

For each paper, the first metric consists of the Jensen-Shannon divergence of the journal distributions for all of that paper's authors. This metric encapsulates the idea that an interdisciplinary paper is one that brings together authors from different backgrounds. The second metric consists of the average entropy of each author's journal distribution. This follows the idea that an interdisciplinary paper is one in which each individual author has an intellectually diverse background. For both metrics, larger scores indicate higher interdisciplinarity.

In the figure to the right, we plot the Jensen-Shannon divergence (JSD) and mean entropy metrics for 433 journals in our top 500 list. Color is a function of each journal's impact factor, with blue (respectively, red) indicating low (respectively, high) impact factor. Higher scores on both interdisciplinarity metrics are associated with higher impact factors. Through findings such as these, we seek to improve quantitative assessment of interdisciplinarity and its effects.

Poster 3: Effect of Collaboration Modeling Approach on Collaboration Success Prediction

Authors: Fahimeh Ghasemian (University of Isfahan), Kamran Zamanifar (University of Isfahan), Nasser Ghasem-Aghaee (University of Isfahan), Anup Satish Sawant (Northwestern University) and Noshir Contractor (Northwestern University)

Abstract: One of the challenges in the study of research collaboration is to explore successful research collaboration patterns. As the collaboration contains both relational and temporal information, choosing the best approach to model this information on both dimensions is crucial. Some of the previous research has gained insights on this problem by using Dyadic Graph to model the relationships among scholars. While it appears to be a good approach, it fails to augment the search of collaboration patterns by excluding concepts or knowledge entities that play a vital role in any collaboration. In this paper, we use Hyper-Graphs to model the co-author relationship by virtue of its ability to capture the relationships with edge degree more than two. Further, we use Machine Learning (ML) techniques to predict the collaboration success. We measure 'collaboration success' by the citation count of a given collaboration. First, we construct a Hyper-Graph consisting of scholars and concepts that they collaborate on. Subsequently, we use Random Walk techniques to extract feature vectors for training our predictive model. We score and rank each scholar from each collaboration group and to do so, we use the temporal history of their collaboration through a Hyper-Graph collapsed over a period of 10 years and compute the average and maximum of the score (for each collaboration group) through Random Walk. These average and maximum measures of the scores are then used as the collaboration feature vectors. In our approach, we use two different

classifiers namely, Multilayer Perceptron (MLP) and Naïve Bayes to train predictive models. The predictive models predict if the citation count of a collaboration group will be more than threshold the 'T'. In order to achieve this task, we extract our scholar co-authorship and concept data from a VIVO compatible Northwestern University Sparql Endpoint and PubMed Database, respectively. Some of the key questions we want to answer in our research are, 1) How good is Hyper-Graph and Random Walk based model for predicting collaboration success? 2) How does addition of concepts / knowledge entities impact the prediction performance? Since the error of considering an unsuccessful collaboration being successful is more than considering a successful collaboration being unsuccessful, we use a cost sensitive approach to train classifiers andF_0.5((1.25*precision*recall)/(0.25*precision+recall)) measure to evaluate the results (shown in Table 1). While solidifying our hypothesis of Hyper-Graphs being a better modeling approach for representing relationship among scholars, our results for various thresholds (T=20,T=30,T=40,T=50) also show that including concepts in addition to scholars in a collaboration group improves the overall accuracy of predictive models. On the other hand, since the accuracy diminishes as per increase in threshold in both the approaches (with and without concepts), we can conclude that the features extracted from a scholar's previous collaboration, alone, are not sufficient in predicting collaboration success.

Poster 4: Using Research Networking Data to Assess the Impact of Translational Research Funding on Collaborative Publications

Authors: Jihad S. Obeid (Medical University of South Carolina), Dayan Ranwala (Medical University of South Carolina), Randal Davis (Medical University of South Carolina), Daniel T. Lackland (Medical University of South Carolina), Perry V. Halushka (Medical University of South Carolina) and Kathleen T. Brady (Medical University of South Carolina)

Abstract: The NIH Clinical & Translational Science Award (CTSA) program was launched in 2006 to enhance translational science infrastructure at funded institutions and foster collaborations across disciplines and institutions. Research networking systems (RNS) such as Harvard's Profiles Research Networking Software and VIVO were designed with this mission in mind and to promote team science. Data from RNS can be useful in observing the evolution of team science. We have adopted Profiles at the Medical University of South Carolina CTSA and are beginning to leverage RNS data for assessing the impact of CTSA funding on team science. Our objective is to identify meaningful metrics to assess the evolution of team science at our institution.

Methods: Analysis was performed using RNS bibliometric data. We evaluated the network of co-authorship before (2005-2008) and during (2010-2013) the CTSA funding period, which began in 2009. To minimize bias due to a simple increase in the number of publications, we created two randomly picked populations of authors during those two periods, matched by the same average number of publications per person. Interdisciplinarity was assessed by isolating publications that cited the CTSA grant vs. those that did not, and looking at the proportion of interdepartmental co-authorship links. We also looked at the evolution of MeSH term profiles of individuals based on their publications in the system using the MeSH tree hierarchy. The MeSH descriptors in the category of diseases C top level category in the tree hierarchy were included in the counts on the clinical end of translation.

Summary of Findings: The network analysis showed a more densely connected network of collaborative publications during the CTSA funding period with a significant increase in the average degree (number of unique co-authorship links with other individuals) for people in the network from 4.4 to 6.5 ($p<0.05$).

Assessment of interdisciplinary collaboration showed that publications citing the CTSA grant had significantly higher proportion of interdepartmental co-authorships (50%) compared to those that did not (45%), $p<.05$ (table 1). Although results look promising there are limitations to this work. Within the same cohort of individuals at an institution there is a tendency to establish stronger collaborative relationships over time. To reduce this bias, we limited the analysis to two randomly picked cohorts matched by size and average number of publications per individual during the two time periods under consideration. Moreover interdepartmental collaborations are not always interdisciplinary. Our CTSA Pilot Project Program has funded 110 interdisciplinary pilot projects

during the period of 2009-2014. We intend to evaluate the impact of the Pilot Project funding on collaborative publications in the manner, described above. This data will be presented on the poster. Future work also includes a more in-depth analysis of publication content to assess translational impact using different MeSH term methods and possibly a semantic representation of PubMed content in Unified Medical Language System concepts. Statement of how this research advances the SciTS field: The RNS metrics may prove to be helpful to evaluate the effects of translational research funding and stimulate team science more specifically on team collaborations.

Poster 5: Assessing the Impact of Team, Multidisciplinarity, and Collaboration in Neuroscience Research Publications

Authors: Norman Azoulay (Harvard University, Extension School) and Griffin Weber (Harvard University)

Abstract: This study assesses the impact of multidisciplinarity and team size on collaboration. Collaboration has been identified by bibliometricians as having an integral role in research productivity and performance. Co-authorship has been previously studied in terms of single authorship, institutional, national, and international collaboration, but few publications have analyzed the combined impact of collaboration, multidisciplinarity, and team size on research quality. Neuroscience articles published in the United States between 2003 and 2012 were identified using the Elsevier database, Scopus. Team collaboration types were determined based on co-authors' location and multidisciplinarity was determined by assigning a researcher to a discipline based on his or her publication history. Articles were considered either uni- or multi-disciplinary based the subject area(s) of the author(s). Multivariate analyses were then performed to test the effect of multidisciplinarity and collaboration on team size. This study found that large neuroscience teams benefit from having collaborators of different disciplines, while small teams performed better when all co-authors are neuroscientists. There were also subtle differences between collaboration types. In large teams, national collaborations were the most cited, followed by international collaborations, with institutional collaborations being the least impactful. This study suggests that the formulation of a team has significant impact on citations and that the relationship between multidisciplinarity, collaboration, and the quality of neuroscience research, depends on team size. It provides policy makers, funding agencies, and research administrators a quantitative means of assessing collaboration in the field of neuroscience.

Poster 6: A New Methodology for Measuring Interdisciplinary Research

Authors: Lei Pan (Elsevier), Sophia Katrenko (Elsevier), Jeroen Baas (Elsevier), Holly J. Falk-Krzesinski (Elsevier) and Judith Kamalski (Elsevier)

Abstract: Interdisciplinary research is an important aspect of 21st century scientific collaboration and team science. Interdisciplinary research integrates knowledge from multiple disciplines to advance the understanding of complex issues in our society and nature. Previous methodologies focused on measuring interdisciplinary research have focused on individual interdisciplinarity and journal categorization. We developed and applied a new bibliometrics-based methodology to conduct the first international comparison of the performance of interdisciplinary research.

The increasingly complex and interdisciplinary nature of research means that no country or research field can solve complex scientific problems alone. By integrating knowledge from various research fields, interdisciplinary research offers opportunities to address questions from new and innovative perspectives. Our analysis focuses on the extent that publications within the Scopus abstract and citation database are interdisciplinary employing a novel approach that combines traditional journal categorization combined with classifying the relatedness of references of the articles in Scopus. The central principle associated with the latter is that articles that cite journals "far away" from each other (in terms of the topics they cover) are likely to be more interdisciplinary and articles cited journals "close" to each other are likely to be in a single discipline. Combining this approach with other research impact metrics, such as the normalized field-weighted citation impact (FWCI), our findings provide important insight to the following questions that impact team science:

1. Which countries are leading in terms of research output in interdisciplinary research, in both absolute and relative terms?
2. What is the trend in interdisciplinary research in the recent years?
3. Which disciplines are most often collaborating and integrating their knowledge in interdisciplinary research?
4. Do interdisciplinary publications have higher citation impact?

Thematic Group 2

NIH Activities Around Team Science 4:45–5:30 pm

Poster 7: Coordinating Transdisciplinary Research Across Multiple Centers

Authors: Sarah Hohl (Fred Hutchinson Cancer Research Center), Beti Thompson (Fred Hutchinson Cancer Research Center) and Sarah Knerr (Fred Hutchinson Cancer Research Center)

Abstract: Coordinating centers have been increasingly funded to support transdisciplinary (TD) research across multiple sites. A well-designed coordination center has the potential to address challenges faced by researchers in a multi-institutional, TD initiative and more quickly advance TD research by allowing researchers to focus on their scientific goals. The Transdisciplinary Research on Energetics and Cancer (TREC) Coordination Center (CC) comprises staff and investigators with a range of expertise in administrative and scientific research coordination. The TREC CC's mission is to support, facilitate, and evaluate, transdisciplinarity and collaboration among TREC Centers. In this mixed-methods study, we gathered perspectives of staff and investigators at the TREC CC to assess how that coordination center supports multi-site, TD research. Results from the qualitative interviews were used to create a web-based survey for future administration among TREC members.

Description of research methods: In October 2014 we conducted semi-structured interviews with members of the TREC CC (n=11) to assess key roles and functions of the CC designed to contribute to transdisciplinarity among the four TREC Research Centers. Interview questions also aimed to identify measurable outcomes that would be useful for evaluating the TREC CC. We developed a quantitative, web-based survey based on emergent themes from interviews that will be administered to TREC members across the participating research centers as well as members of the National Cancer Institute.

Summary of preliminary (qualitative) findings: TREC CC staff and investigators aimed to promote disciplinary integration by participating in TREC Cores (i.e. Development Project, Evaluation, Training) and providing administrative support, thereby allowing TREC investigators to focus on individual projects and future collaborations. Administrative staff said their primary roles were to establish communications infrastructure, plan scientific and ongoing meetings, and manage projects. Investigators said their primary roles are to offer scientific expertise (e.g. statistical methods, cancer prevention and control, nutrition) and provide feedback to TREC Centers. CC members described barriers to coordination of TREC's multi-site TD research resulting from the RFA process and structure. Namely, because TREC Research Centers and the CC prepared concurrent independent applications with limited knowledge of each other's' needs and abilities, CC members perceive that the TREC Research Centers' need for CC capabilities are limited. Overall, CC members believed transdisciplinary science to be the appropriate, and increasingly prevalent, approach to addressing complex public health problems with innovative, integrated solutions. They suggested future models for coordinating multisite TD research in which CCs collaborate with Research Centers during proposal writing so that CC capabilities match Research Center administrative, methodological, and scientific needs.

Statement of how the research advances the SciTS field: A well-designed CC has the potential to address many of the challenges faced by researchers in a multi-institutional, transdisciplinary initiative by developing a communications infrastructure, harmonizing and managing data, and coordinating operations and administrative aspects. The data gathered in this study has the potential to assist the TREC CC in enhancing its ability to foster transdisciplinary research in the TREC initiative and inform future efforts to coordinate multisite TD research.

Poster 8: Comparison and Trends in Research Collaboration: Transdisciplinary Tobacco Use Research Centers Co-Authorship Network Properties, 1999-2015

Authors: Janet Okamoto (Mayo Clinic), Brooke Stipelman (National Cancer Institute), Grace Huang (National Cancer Institute) and Kara Hall (National Cancer Institute)

Abstract: This analysis updates and compliments a quasi-experimental, longitudinal study conducted to compare bibliometric indicators of collaboration and productivity from a center-based transdisciplinary team-based research initiative with traditional investigator-initiated R01 grants (see Hall et al., 2012 for the original study). Publication data were collected for all grants from the longitudinal study, which included publications for the time period between 1999 and the end of 2014. Co-authorship networks were extracted and compared across time to determine patterns and detect differences among the three study groups, which included center-based grants (TTURC), long-term R01 grants spanning 10 years or more (LR01), and standard 5-year R01 grants (SR01). Results confirm and support previous analyses from the study by Hall and colleagues in 2012, which reported a time-lag in productivity for the center-based grants, which eventually out-produced the traditional grants by the end of the 10-year funding period. Co-authorship network ties and number of authors in the network was greater for the two R01 groups through the mid-point of the original 10-year period, but leveled off around that time. The number of authors in the center-based network steadily increased across time until eclipsing the R01 groups. The number of co-authorship network ties began to dramatically increase in the center-based network around the mid-point, which ended up with 2½ times the number of network ties than the largest R01 network. While the center-based group out-produced the traditional R01 groups in publications, the distribution of the weight of co-authorship ties did not differ between the three groups. This indicates that the greater number of publications was not solely a result of a few groups of highly productive research teams in the center-based initiative. For all groups, the vast majority of co-authorship ties, between 70-80% of all ties, occurred just once. These findings demonstrate the highly collaborative nature of center-based grant initiative and suggest a greater diversity of co-authors could result in greater publication productivity.

Poster 9: An Analysis to Examine the Productivity and Impact of Training in the Transdisciplinary Research on Energetics and Cancer (TREC) Initiative

Authors: Amitpal Vohra (National Cancer Institute), Brooke Stipelman (National Cancer Institute) and Kara Hall (National Cancer Institute)

Abstract: The TREC I initiative was funded from 2005-2010 by the National Cancer Institute (NCI) to address the high prevalence of obesity in the United States and its influence on the formation of various types of cancer. One of the primary goals of TREC was to foster collaboration among investigators across different disciplines including social, behavioral, and biological sciences.1 In particular, the TREC initiative encouraged transdisciplinary research, a specific type of cross-disciplinary collaboration where researchers from different backgrounds transcend their disciplines and work together in an integrative fashion to develop new models, methods and frameworks that extend beyond each unique contributing discipline.

In line with this goal, the TREC initiative also placed a heavy emphasis on interdisciplinary training and provided opportunities for researchers at all career stages. Each of the four TREC centers developed a unique training program that consisted of a number of activities for trainees (Graduate Students, Post-doctoral Fellows, and Junior Investigators) to help support the competencies necessary to do productive transdisciplinary research. However, although training was a key component of the TREC initiative, there has been little empirical research to assess the outcomes of the TREC trainees. Therefore,

the goal of this study is to examine a number of outcomes related to the research careers of trainees who participated in TREC. Results will be interpreted within the existing literature on scientific training outcomes to better understand the unique value of transdisciplinary training.

Poster 10: Assessing the Effectiveness of the NCI's Alliance Initiative in Generating Multidisciplinary Scientific Outputs and Enabling Clinical Translation of Nanotechnologies Developed in Academia

Authors: Natalie Fedorova-Abrams (National Institutes of Health), Christopher Belter (National Institutes of Health), James Corrigan (National Institutes of Health), Elizabeth Hsu (National Institutes of Health), Ya-Ling Lu (National Institutes of Health), Alan Porter (Georgia Institute of Technology) and Piotr Grodzinski (National Institutes of Health)

Abstract: In order to compare scientific outputs of the Alliance network to individual-based research, we developed two cohorts. The test cohort was comprised of awards funded through the Alliance initiative in 2010 (U01and U54 awards: n= 21; individual projects: n=50). The control group (projects: n=32) was comprised of nanotechnology-focused single-PI R01s grants matched by start dates (awarded in 2010 as new grants or competitive renewals). These grants were identified by searching the NIH Research Portfolio Online Reporting Tools (RePORT) database using the Research, Condition, and Disease (RCDC) category of "Nanotechnology" (http://report.nih.gov/categorical_spending.aspx). Award-attributed publications were also retrieved using RePORT. For test awards with multiple projects, publications to were subsequently linked to projects using two criteria: research topic and investigator names.

Between 2010 and 2014, Alliance investigators generated more publications (1,092 articles including 132 reviews) than Controls (564 articles including 71 reviews). However, both groups demonstrated similar productivity per $1M of funding: 33 non-review articles for the Alliance and 35 for controls. To better understand why some awards were more successful than others, each project and publication was categorized according to its research topic, disease, application (e.g. therapy, imaging, diagnostics), and translation stage (T0-T4) using a combination of manual review and text-mining approaches. In addition, to assess the degree of cross-disciplinarity, for each article, we calculated an integration score based on subject categories of the journals that this article cited (Porter et al., 2007, 2008). Journal categories were obtained from the Thomson Reuters Web of Science database.

Furthermore, to estimate the extent to which the Alliance initiative contributed the field of nanotechnology, we developed a topic map by clustering all bio-nanotechnology articles published in 2013 regardless of funding sources. The articles were grouped using unsupervised clustering based on the number of citations that articles shared (bib-coupling). These clusters were then semi-manually assigned research topic-labels using words and phrases overrepresented and unique to each cluster (not overrepresented in other clusters) such as: Liposomes/Micelles, Gold nanoparticles, Magnetic nanoparticles, DNA/siRNA therapy, Carbon/graphene nanotubes, etc.

Further results from this analysis will be presented including comparisons of productivity, impact, disciplinarity, translational progress, research topic, and other project characteristics between the Alliance and control groups. The NIH supports and encourages research collaborations and clinical translation through a variety of funding mechanisms and programs. This study attempts to develop a framework to evaluate the effectiveness of the Alliance team-science structure by comparing its outputs with those of single-PI grants. It also provides foundation for future evaluation studies aimed to define the role of such team-science programs in promoting multidisciplinary collaboration, connecting different research areas, spurring innovation, and enabling commercialization of academic research findings.

Poster 11: SPOREs: Pioneering Translational Team Science

Authors: Peter Ujhazy (National Cancer Institute), Steve Nothwehr (National Cancer Institute), Rajeev Agarwal (National Cancer Institute), Julia Arnold (National Cancer Institute), Andrew Hruszkewycz (National Cancer Institute), Leah Hubbard (National Cancer Institute), Igor Kuzmin (National Cancer Institute), Tamara Walton (National Cancer Institute) and Toby Hecht (National Cancer Institute)

Abstract: The NCI's Specialized Programs of Research Excellence (SPOREs), a multi-project investigator–initiated P50 Specialized Centers grant mechanism, is designed to accelerate translation of cancer-related discoveries to the clinic and to enhance scientific understanding of clinical observations. A hallmark of the SPOREs is co-leadership of projects by basic and clinical scientists. Since the SPOREs have been in existence for 23 years and have pioneered and validated new approaches in cancer translational research, it has become clear what works and what does not work in a team science environment. The NCI has periodically evaluated the Program and modified its requirements to reflect changes in science and technology as applied to cancer research. The presented work will summarize aspects that relate to working teams of basic and clinical scientists, career enhancement, pilot projects, and productivity of the Program. We will analyze horizontal and vertical collaborative activities, review potential barriers that hamper collaborations, and discuss necessary elements for successful collaborations. In summary, we will share our experience with team science conducted by the SPOREs.

Poster 12: Two Unique Programs, One Mission: Partnering for Success!

Authors: Hana Smith (National Institutes of Health-Clinical Center), Cheryl Fisher (National Institutes of Health-Clinical Center), Pat Piringer (National Institutes of Health-Clinical Center), Jennifer Simmons (National Institutes of Health-Clinical Center), Jemelle Banks (National Institutes of Health-NICHD), Julie Orlando (National Institutes of Health-Clinical Center), Eugene Hyunga (National Institutes of Health-NICHD) and Frederick Ognibene (National Institutes of Health-Clinical Center)

Abstract: The National Institutes of Health (NIH) Clinical Center (CC) serves as a model institution for enabling scientific advances developed at the bench to be translated into innovative clinical therapies for a wide range of patients. By enabling collaborative translational research, the CC functions on the premise of collaborative teamwork across institutes in order to address scientific challenges and to leverage the strengths and expertise of professionals trained in a variety of disciplines. These collaborations represent a comprehensive team approach to advance research and scientific endeavors. In order to enhance these multi-disciplinary efforts, NIH offers two innovative opportunities to promote stronger team science: the Bench-to-Bedside (BTB) Program and Opportunities for Collaborative Research at the NIH Clinical Center (U01).

The BTB Program always encouraged collaborations, and at inception provided awards to NIH intramural teams. In 2006, the program's scope expanded to allow collaborations between intramural and extramural investigators for a two-year award period. The U01 collaborative grant program was implemented by NIH in 2012 after the Scientific Management Review Board recommended that the CC enhance access to its resources with extramural communities. This grant program awards an extramural partner with research support for up to three years and promotes collaborations between intramural and extramural researchers while also utilizing the CC's resources and capacity to enable that work.

Poster 13: Developing a Systems Map of Team Science: A Spotlight on Methods and Preliminary Results

Authors: Marina Dathe (National Cancer Institute), Grace C. Huang (National Cancer Institute), Brooke A. Stipelman (National Cancer Institute), Kenneth D. Gibbs (National Cancer Institute), Katrina J. Serrano (National Cancer Institute), Amanda L. Vogel (Leidos Biomedical Research, Inc.) Nina Larsen (Westat), Christopher Williams (Westat), Sophia P. Tsakralides (Westat), Ross Hammond (Brookings Institute), and Kara L. Hall (National Cancer Institute)

The Science of Team Science (SciTS) field has grown exponentially over the past decade, with an emergent literature base, and increasingly sophisticated scholarship. Due to the complex nature of team-based research, the field is in need of a holistic conceptualization of the many factors that influence the way scientists work together in teams, and shape the quality of their scientific output. The SciTS Team at the National Cancer Institute is leading the effort to develop a systems map of team science that will serve as a visual depiction of the complex set of factors – at the individual, team, institutional/ organizational, and societal/policy levels – that influence science teams, and the relationships among these factors.

The NCI SciTS Team has employed a mixed-methods approach involving 1) a systematic literature review involving detailed coding of the literature, to generate a first iteration of the map, and 2) an expert panel process to refine and validate the systems map, to produce a final version. This poster describes the strategies for developing the initial map.

Data Sampling—A systematic literature review was undertaken to identify research conducted about teams. The search process included identifying articles from key team science resources such as the Team Science Toolkit (a user-generated online repository of scientific resources that support team-based research), the Science of Team Science Mendeley Group, the references from the recent National Academies report "Enhancing the Effectiveness of Team Science", and an existing database of 3000 articles related to team effectiveness. For preliminary mapping, the literature was narrowed to include only studies that explicitly investigated associations among factors influencing scientific research teams, thus excluding literature on teams in other settings (e.g., healthcare, business, and educational teams). Approximately 1,000 articles were screened for relevance, resulting in about 250 studies for coding.

Protocol and Taxonomy Development—A small sample of articles was used to develop a group coding process to be used by the study team members. Through iterative group discussions, a formalized codebook and coding process were developed. The coding process was designed to capture relationships among key variables in each article, and ultimately, to link these to team science outcomes, including productivity, impact, effectiveness, efficiency, and creativity.

Study Team—Nine coders were recruited and trained to (1) identify and document the key study findings through diagrams, and (2) classify factors according to an evolving taxonomy based on the social-ecological framework and five levels of granularity. All articles were double coded and discrepancies were resolved through discussion.

Visualization—Relationships depicted in the drawings were transformed into an edgelist, a format commonly used to depict relationships among objects in a network, also compatible with network and computer software programming language. Formatted edgelists were then entered into Cytoscape 3.2.1, a network visualization software, to generate a preliminary systems map.

Upon completion of the literature review and coding, we will engage SciTS experts in a participatory process, to solicit their insights, comments, and suggestions for revising and elaborating upon the systems map. This will result in the final version of the map.

In addition to a published map, we plan to generate an interactive web-based version of the map that will be cross-linked with articles and resources in the Team Science Toolkit. The systems map and linked database will provide an in-depth overview of the state of the SciTS field, serve as a critical tool for identifying gaps in the SciTS field, and also inform team science researchers and practitioners about empirically tested strategies for maximizing the effectiveness of team-based research.

This poster will also discuss some of the challenges encountered over the course of this project, along with solutions, strategies, and lessons learned. This information may serve as a useful resource for other researchers who wish to develop systems maps using similar methods.

Thematic Group 3

Innovative Online Tools to Facilitate Team Science — 4:45–5:30 pm

Poster 14: CIELHO: A Platform for Enabling Reproducible Research

Authors: Omkar Lele (The Ohio State University), Erin Holve (Academy Health) and Philip Payne (The Ohio State University)

Abstract: As part of the EDM Forum's CIELHO (Collaborative Informatics Environment for Learning on Health Outcomes) collaborative methods project, we have implemented a proof-of-concept platform that can support and enable the reuse of data analytic tools associated with patient-centered research programs. The current implementation supports creation and maintenance of analytical bundles along with preliminary social networking features to enhance adoption and usability.

CIEHLO catalyzes research reproducibility by providing the research community with an "app store" platform facilitating the submission and sharing of both data sets and corresponding analytical tools/workflows. CIEHLO helps reduce time and costs of research by enhancing research reproducibility and transparency.

Key Features:

1. Creation of bundles, including upload & download of analytical code, corresponding data and publications.
2. License selection workflow to enable associating appropriate licenses to bundles.
3. Semantic annotations for bundles facilitating efficient discovery of relevant code and data.
4. Social networking features to follow users, bundles, publications and semantic annotations.
5. Comments/feedback to users and corresponding bundles.
6. Fully functional user registration process.
7. End to end authentication and authorization including admin role functional workflow.

Poster 15: Website for Large-Scale Automated Reviewer Assignment and Manuscript Scoring

Authors: Daniel Acuna (RIC), Titipat Achakulvisut (Northwestern University) and Konrad Kording (Northwestern University)

Abstract: The peer review process is an important component of the scientific process. Its success depends on the right formation of a team of peers that evaluates and scores manuscripts. These steps crucially hinges on editors who must juggle the expertise and conflicts of interests of mostly unknown reviewers, and decide whether to accept the suggested reviewers provided by authors. Recently, however, it has been shown that the peer review process is highly subjective, creating panels that rarely agree among themselves, and biased towards their own domains. Additionally, after the reviews are in, the editors must weigh the scores accounting for potential harshness or carelessness of each reviewer. It is thus important to address these shortcomings to make the review process faster and less biased.

In this work, we will present a website that implements our current research on automated article-reviewer assignment and manuscript scoring. Importantly, our article-reviewer assignment algorithm provides a good initial solution without using the authors suggested reviewers or reviewers bidding on articles. The algorithm does the matching by finding a global assignment that maximizes the topic similarity between articles and reviewers (Fig 1a). The procedure readily manages conflict of interests due to co-authorship and additional conflict of interests provided by the editors. The assignment is based on an extremely fast topic modeling approach and optimization based on linear programming. Therefore, if needed, the editors can iterate over many automated suggestions made by the system almost in real time. The website, therefore, gives an fast solution to the article-reviewer assignment, which allows editors to focus on the refinement of such assignment and other higher level decisions.

The second algorithm implemented by our website solves the manuscript scoring estimation. The estimation is based on a Bayesian random effects model that automatically control some problems with the naive average scoring per article (Fig. 1b). First, if a reviewer systematically gives higher scores than their peers, the reviewer's scores will have less weigh during the estimation. Second, the scoring system provides uncertainty estimates about each score, potentially signaling which articles are harder to grade. This can be taken into account by editors who would consider external criteria to rank articles and produce accept-reject decisions. This website scoring therefore solves an important problem of the review process and promises to remove biases commonly introduced by editors.

This presentation will describe the algorithms and the website to the science of team science audience, emphasizing the growing usage of data to assemble teams. The website and algorithms' source code are publicly available (Fig. 2) and they are constantly maintained by our laboratory.

Poster 16: HHS Profiles Pilot Project, Enterprise Expertise Mining & Collaboration Exploration

Authors: James King (National Institutes of Health Library), Kara Hall (National Cancer Institute) and Tisha Wiley (National Institute on Drug Abuse)

Abstract: The U.S. Department of Health & Human Services employs over 76,000 people who are charged with ensuring America's health and wellbeing. The community intelligence across the organizational spectrum is broad and runs deep, yet we lack a systematic way to locate expertise. This inability to easily catalogue and mobilize our human capital compounds status quo siloes and redundancies. The CDC, NIH, and FDA all have distinct knowledge to bring to bear, and collaboration is paramount to advancing mission goals.

The Science of Team Science clearly shows that science is no longer a solo effort and is no longer constrained to a single disciplinary. The breakout research is done across disciplines collaborating with the best researchers around the world. This "trans-disciplinary" research approach has been proven to catalyze innovation, promote translation, and increase the speed of research but also requires new connections that go beyond the traditional social networks our researchers have developed over the years. Finally, it is clear that publication history is inadequate to highlight the expertise of those actively involved in the grant management process.

Our vision is to create a web-based research networking tool that is designed from the ground up to help our researchers and scientific staff to collaborate with each other and with colleagues across HHS. Rather than rely upon an "opt-in" system of staff manually creating and maintaining profiles, like the old Community of Science tool, we wanted to use something that automatically created a virtual profile or CV based upon trusted data sources. Algorithms in many tools can now "mine" that information to expose connections between people like co-authorship networks. By mixing trusted sources with manually updated sections for narrative descriptions for things like new areas of research interest, we believe that this tool would encourage new connections across the department.

The HHS Profiles tool creates a "career snapshot" that combines directory information, user-contributed content, and publications extracted from publication databases like PubMed. HHS Profiles is based upon the Harvard Profiles Research Network Software and is currently being run at over 100 organizations around the world, including Boston Univ., Johns Hopkins, Penn State, Emory Univ., Ohio State, and the Chinese Academy of Sciences.

After an initial test with HR data combined with PubMed publications, the team will evaluate additional data sources to add including grants managed, SRO designations, intramural research conducted, patents, datasets created, lab equipment available, presentations made, awards received, FAES classes taught, videocasts participated in, and certifications like COR.

Poster 17: Mixed Methods Research as Simulated Environment for Team Development

Authors: Alexander Libin (Washington DC VA Medical Center), Ellen Danford (Washington DC VA Medical Center), Manon Schladen (Washington DC VA Medical Center), Samantha Cichon (Well-being Literacy, Multimedia Education & Psychological Research (WELL) Program), Dwan Bruner (Washington DC VA Medical Center) and Joel Scholten (Washington DC VA Medical Center)

Abstract: The rapidly developing field of mixed-methods, and more specifically, qualitative research, lacks widely accepted guidelines for virtual teamwork; oftentimes teams must develop individual approaches to structured collaboration. Within the framework of a mixed methods study, we tracked team functions to develop an innovative structure for virtual, technology-mediated, collaboration in the qualitative realm of data processing.

The undertaken study objective was to analyze narratives produced by interviews and focus groups with Veterans in order to develop and implement a manualized goal self-management intervention for Veterans with executive dysfunction due to mild traumatic brain injury (mTBI). Nine Veterans with mTBI were recruited from the DC VA TBI clinic to participate in semi-structured interviews and a focus group. Transcripts of narratives were collaboratively analyzed by 3 team members through a two-tiered review. Original audio recordings were available to all researchers via a shared drive and were frequently referenced to deduct and infer context and tone.

Qualitative analysis uncovered several themes that were successfully integrated into the manualized goal management intervention. In the process of condensing those themes, team members recorded facilitators and barriers within the established coding structure. Rigorous documentation of coding thought processes was highly informative, replacing in-person meetings and facilitating virtual discussions between the initial reviewer and subsequent reviewers. Frequent merging of initial analysis and review into a central master file encouraged numerous "check-in" points for team members to comment and expand on the work of other collaborators. Different operating systems on the virtual platform proved to be the largest barrier to virtual team collaboration.

Mixed methods research presents an exciting opportunity for development of research team collaboration. With interactive tools facilitating qualitative analysis, novel team structures enable technologically-mediated virtual teamwork. The facilitators and barriers uncovered in the presented study might benefit teams striving to embrace the burgeoning field of narrative approaches.

Poster 18: The Team Science Toolkit: Spotlight on New Content and Functionality

Authors: Amanda L. Vogel (Leidos Biomedical Research, Inc.), Kara L. Hall (National Cancer Institute), Sophia Tsakraklides (Westat), David Garner (Westat), Elliot T. Grant (Westat), and the Team Science Toolkit Editorial Board

Abstract: Are you an investigator who works in teams? Are you a SciTS scholar who studies science teams? Are you an academic administrator or organizational leader who would like to create an organizational climate that fosters success in team science? Are you a funder who would like to better support or facilitate team science? Then the Team Science Toolkit has resources to help you!

The Team Science Toolkit (www.teamsciencetoolkit.cancer.gov) is an online one-stop-shop for resources to help you engage in, lead, facilitate, support, evaluate or study team science. It capitalizes on the collective knowledge and resources of all members of the team science community to create a user-generated knowledge base of resources and information. Anyone can upload or download Toolkit resources, creating a continuously evolving knowledge store that represents the current "state of the science" in the SciTS field. The Toolkit currently includes over 2000 resources.

The Toolkit offers three main types of resources: practical tools to help engage in, facilitate, or support team science; measures to study or evaluate team science; and a bibliography that integrates resources from the wide range of disciplines generating scholarship relevant to success in team science. The Toolkit also includes a popular expert blog and a vibrant linked listserv (SCITSLIST), both of which leverage the expertise of the SciTS community.

The Toolkit was created by the National Cancer Institute, and debuted at the SciTS Conference in spring 2011. Since then, new content and functionality have been added each year. This poster highlights three key areas of the Toolkit that have been very popular, and supported the user experience in the last year: (1) practical tools for team science, (2) Editors' Picks, and (3) expert blogs.

The Toolkit's practical tools for team science have been generated by investigators, administrators, funding agencies, and SciTS scholars. Practical tools available on the Toolkit include: pre-collaboration agreements, operating manuals for cross-institutional collaborations, quality improvement self-assessment surveys, guidelines for translational research partnerships, model promotion and tenure guidelines recognizing team science, and more. The Editors' Picks functionality was created in the last year to help Toolkit users navigate the large and growing set of resources on the Toolkit. The Toolkit's editorial board of fourteen leading SciTS scholars and practitioners have each selected up to 20 resources they recommend as "Editors' Picks", serving as a sort of ratings system. The expert blogs are written by a set of hand selected experts who are using team science in the field, or studying team science. They represent a wide range of expertise and interests, such as virtual collaboration, interdisciplinary collaboration, management of large and complex collaborations, open science, and more.

Overall, the Toolkit aims to integrate and unify the diverse contributions to our growing knowledge about effective practices for team science, and to make this knowledge broadly available to the wide range of stakeholders interested in team science. By doing so, the Toolkit can reduce unnecessary replication of SciTS research and practical tools for team science, and stimulate research

and practice in new directions, ultimately helping to maximize the quality of the science produced by science teams.

Poster 19: Building a Meta-Study Team: Social Networking through Case Similarity

Authors: Alyson Young (University of Maryland, Baltimore County) and Wayne Lutters (University of Maryland, Baltimore County)

Abstract: Increasingly, researchers are confronted with scientific challenges at such scales and complexity that single disciplinary perspectives are no longer adequate, thus demanding the expertise of multi-disciplinary teams. One class of successful integration strategies are synthetic research practices, such as meta-study analyses. For the emergent transdiscipline of Land Change Science (LCS), meta-studies are seen as a way to uncover drivers and impacts of land use change in relation to global environmental change. However, due to poor computational tools, most analyses are tediously crafted by hand. Our team is designing GLOBE, cyberinfrastructure to enhance meta-study practice in LCS.

Our findings are based on an on-going, multi-year, ethnographically-informed investigation of meta-study practice in LCS. We have undertaken observations at four international workshops on synthetic scientific practices; conducted twelve international lab visits including semi-structured interviews with lead investigators and their students; and completed a systematic document review of all major published LCS meta-studies (20). We have also coordinated a community-led survey (N= 205) about common LCS-specific scientific practice.

One interesting finding is how researchers deal with the radically heterogeneous data that results from examining coupled human and natural systems. Here in LCS a single meta-study might integrate data as diverse as soil PH from geology, market access data from economics, biodiversity data from ecology, and social norms on farming from anthropology. A challenge of all interdisciplinary research is that data comes in multiple formats, which usually are not readily comparable. This often necessitates innovative approaches to compare the incomparable, for example, to integrate qualitative interview results with statistical spatial analyses. Further, in the process of moving from study site data collection to publication, important details about study procedures are often lost through the deletion of process. Lack of contextual details about how data were created leads to difficulties in data interpretation and concerns about data quality, which ultimately impact the credibility of the meta-study.

One way that LCS researchers deal with this is to partner with a subset of case study authors in a participatory meta-study approach. This involves finding original case-study authors and inviting them to code their data based on a standardized classification scheme or asking them to confirm that their cases were interpreted and coded accurately, allowing them to amend codes where necessary. Meta-study authors prioritize their partners to experts on the meta-study topic who can speak across multiple studies simultaneously. In turn, these individuals are then given co-authorship for their assistance.

The GLOBE system works to simplify these processes of participatory meta-analysis. Geocontextualized search allows users to find places in the world most like their own object of study (similarity search) or how much of the world they can represent from their own work (representativeness analysis). GLOBE makes case study author identification and participation a central focus by providing links to the author's email and project website. New user profile features allow users to identify similar users by topics in common and nearby users by geographic distance. A social dashboard also tracks who is using your own case or collection data in the system.

GLOBE was officially launched in March 2014 and has a slow but steadily growing user base. We are continuing to develop social matching functionality along with building our user population. The "who's like me" profile feature was released in April 2015 and evaluation is ongoing.

Poster 20: Open Science and Collaboration for Enhancing NeuroImaging Genetics through Meta-Analysis (ENIGMA) through the Organic Data Science Framework

Authors: Neda Jahanshad (University of Southern California), Sarah Madsen (University of Southern California), Yervand Azatian (University of Southern California), Derrek Hibar (University of Southern California), Paul Thompson (University of Southern California) and Yolanda Gil (University of Southern California-ISI)

Abstract: The Enhancing NeuroImaging Genetics through Meta-Analysis (ENIGMA) Consortium is a growing international team of over 300 scientists, spanning over 30 countries. It was formed in 2009 with 3 research groups around the world pooling together their resources in order to discover genetic influences on brain structure. Taking a meta-analytical approach to neuroimaging, a unique direction in the field, meant that research groups would perform harmonized protocols and statistical analyses and only share summary results of statistical tests and not raw data itself. Welcoming all interested imaging groups to join, ENIGMA has now expanded rapidly worldwide, and the opportunity to participate in high-powered collaborative work unbounded by data privacy and exchange policies has become scientifically rewarding with major, reliable, neuroscience and genetic discoveries being made and published in the highest impact journals (Hibar et al., Nature, 2015; Stein et al., Nature Genetics 2012). The Consortium now is involved in many projects beyond genetics, including studies of over 10 diseases with numerous sub-aims. Members may propose a project based on the common features and involve groups with relevant data available (scan modality, patient population, genetic information etc). Projects will start and each participating group has a set of necessary tasks; it will then complete or move towards a follow up project. The continual formation of these sub-communities, projects, and their termination, enforces the need for an organizational framework where projects can be maintained and the participation of groups as well as members accurately logged. The Organic Data Science (ODS) Framework offers this collaborative environment, using a task-centered approach and drawing design principles from social studies of online communities.

Methods and Strategies: Team science experts have developed ODS to provide a framework where information can be maintained and organized at the individual, group and project level. Within a group, different members contribute to different projects. Informing all members of all starting projects and all updates within the Consortium would be overwhelming due to the specific interests of individual members. On the other hand, if participants are not knowledgeable of proposed projects that may pique their interest there would be missed opportunities for their contributions. ODS provides means of dynamically creating special interest areas based on properties of the tasks and the participants, and ensures an open science process by making all the information about progress of members and pending tasks accessible to anyone. The many projects and hence tasks required of the groups can become burdensome, and continually contacting busy group leaders regarding individual projects can act as additional chores, thus we have opted for a more centralized organizational core. ODS also provides a user-friendly interface for organizing and monitoring all the collaborative activities in ENIGMA. Originally developed for an environmental science project, ODS extends a semantic wiki platform to support the description of users, institutions, projects, tasks, datasets as separate entities with semantic properties that can support structured queries. This enables the creation of special pages that dynamically aggregate projects, institutions, and participants with different criteria that allow users to easily find ongoing activities of interest.

Findings and Conclusions: ENIGMA has brought together top researchers in the biomedical field and therefore an ever-growing set of data and ideas. First formed with one goal in mind, initial maintenance of the network was possible in a few spreadsheets. ENIGMA grew exponentially out of pure scientific interest and has branched into dozens of projects, some completely independent of others, and others with substantial overlap. Due to the unexpected growth and the unforeseen projects initiated, the consortium needed collaboration support. We have set up the OSD framework and used it to describe the participating groups and ongoing tasks so that the tasks and groups are easy to monitor and accessible to newcomers. One lesson learned is that the representation of tasks and groups must highlight commonalities between the groups that may be the seeds for future collaborative projects.

Thematic Group 4

Stakeholder Engagement in Science Teams 4:45–5:30 pm

Poster 21: Inside Looking Out: Assembly of an Interdisciplinary Environmental Health Research Team from the Perspective of a Molecular Biologist

Author: Joseph Caruso (Wayne State University)

Abstract: There have been a two tectonic shifts in the way my research has evolved over the past two decades, and this is reflective of wider trends in biological research. The first is a transition from studying how a protein or a biological pathway is associated with disease, to a more systemic and unbiased approach where thousands of genes or proteins are simultaneously compared using '-omics' technologies. The second shift is the development of multi-disciplinary workgroups to solve problems in a way that transcends any one field of study. As an example of the latter, I co-lead a team of researchers that is studying the potential health and psycho-social effects of an emergent industrial by-product on an urban population. This group is composed of faculty from departments of medicine, biology, chemistry, engineering, law, computer science, English, and graphic design. Investigators with various expertise were invited to the initial meetings. This larger group could be broken down into three factions: those who did not want to continue with the group; those who were somewhat interested and kept a foot in the door for future developments; and the core membership who are personally invested in the team. From my perspective there were three key factors that led to an effective working group. First, we had strong support from the University administration. This included a specialist with a background in interdisciplinary team building that offered mentorship in team science and had knowledge of which investigators to bring together. Also, competitive pilot funding, professional and academic development (PAD) seminars in team science (1,2) and meeting space were provided. Second, the research topic was prominent in local and national news headlines, and there was a lot of interest from the community. It was an easily visible environmental health issue which could be tackled from social, basic science and medical standpoints. The third and final key factor was an intangible team chemistry that developed which is necessary for any group, from sports to business to science, to flourish. In the next phase community partners will be brought in to work alongside the academic team.

Poster 22: Exploring Power and Legitimacy in Technical Communication in U.S. Environmental Protection Agency Work Related to Environmental Justice

Author: Sheryl Mebane (Environment Protection Agency)

Abstract: With many U.S. Environmental Protection Agency projects, the optimal use of citizen insight in collaborative teams and networks will require wise treatment of power differentials, of issues of legitimacy and of technical communication between federal workers and their partners. Federal environmental justice efforts handle similar issues. Environmental justice includes nondiscrimination relating to environmental and human health.

This case study involves environmental justice and EPA activities, and examines technical communication in a workshop in which power and legitimacy are critical issues. The workshop was a main activity of a council aiming to network EPA and tribal partners.

Through a review of a workshop on traditional ecological knowledge, the theory of culturally relevant pedagogy elucidated technical communication strategies, power and legitimacy. All reviewed presentations tackled some aspect of legitimacy by evoking the expertise of tribal members or stating that traditional ecological knowledge could stand as the basic for decisions and action. All reviewed presentations mentioned empowerment or explored power by noting sovereignty or past or current differentials in abilities to take action. All presentations examined engaged in critiques that follow the culturally relevant pedagogy critical consciousness criteria to varying degrees.

The shared focus of the reviewed presentations underscores how critical it is to openly discuss issues of power and legitimacy when working in teams and networks across communities to combine knowledge and advance complex aims such as environmental justice. Future case studies of EPA's work with green infrastructure and cook stoves are mentioned as places to examine approaches from the traditional ecological knowledge case study that can help technical communicators who are federal staff as they support environmental justice in their teams and networks.

Poster 23: Bringing Voice to Policy Building: A Cross-Population Multi-Stakeholder Conceptual Model for Management of Acute Unscheduled Care in the US Using Group Concept Mapping

Authors: Gaetano R. Lotrecchiano (George Washington University, Office of Clinical Practice Improvement), Mark Zocchi (George Washington University, Office of Clinical Practice Improvement), Mary Kane (Concept Systems, Inc.), Danielle Lazar (George Washington University, Office of Clinical Practice Improvement) and Jesse Pines (George Washington University, Office of Clinical Practice Improvement)

Abstract: To utilize and evaluate group concept mapping as a methodological tool for engaging focus groups and increasing voice in the development of a cross-population multi-stakeholder informed conceptual model for management of acute unscheduled care in the US for the Assistant Secretary of for Preparedness and Response (ASPR).

Background: The U.S. acute care medical system includes a variety of medical settings, including hospital-based emergency departments (ED) and hospitals, urgent care clinics, retail clinics, doctor's offices, freestanding EDs and telemedicine (Morgan et al., 2012). There is variation in service by condition, service, and time of day for many conditions, including acute time-sensitive issues. This results in highly variable performance within and across stakeholder communities. Group concept mapping is a method used to plot visually and assign values to knowledge that is generated on a shared topic of interest (Kane & Trochim, 2007; Trochim, 1989). It has been used in a number of biomedical and science management contexts systematically to organize complex concepts into manageable and participant–rated scales in order to develop theoretical frameworks for continued research (Falk-Krzesinski et al., 2011; Kagan, Kane, Quinlan, Rosas, & Trochim, 2009; Leischow et al., 2008; Quinlan, Kane, & Trochim, 2008; Robinson & Trochim, 2007; Trochim, Cabrera, Milstein, Gallagher, & Leischow, 2006; Trochim, Marcus, Masse, Moser, & Weld, 2008). In this presentation, we highlight an Assistant Secretary for Preparedness Research (ASPR) funded project, tasked with building a new "stakeholder-informed" conceptual model of acute care based on well-defined and accepted emergency care models (Andersen et al., 1973; Asplin et al., 2003) including input from providers, payers, patients, and policy makers. Using group concept mapping as a methodological tool for gathering and collating perceptions about critical concepts for the building of this model, the study informs how acute care systems can be envisioned in the future that accommodate diversified patient demands, delivering good value, and demonstrating resilience regarding disasters from multiple disciplinary and stakeholder perspectives. The study provides an important case in which to assess the value of cross-population multi-stakeholder input and increasing voice in shared problem stakeholder groups.

Methods: We will use group concept mapping (Kane & Trochim, 2007) software (CSGlobal MAXTM) to organize and identify strengths and directionality between concepts generated through data collected across several sub-samples of stakeholders: acute and non-acute care providers, patients, payers, and policy makers. The development of a clustered concept map made up of relational data points will produce a taxonomy of issues related to goal of the study which is to produce a stakeholder-informed model that will improve upon historically accepted models, and inform a proposed model created from an environmental scan of the literature. In four online and in-person focus groups of 9 participants each (one of each type per sub-sample) GCM will be used to seek feedback, assign relationships and articulate priorities from participants. producing an output map that. We will conduct four online and four in person focus groups of 9 participants each. In each session the participants will view a short presentation that includes an overview of the literature informed model, material specific to each of the subgroups and a tutorial on navigating the CGGlobalMax™ interface. With a single universal focus prompt "An additional issue that needs to be addressed in this model of acute care management is…" participants will contribute feedback to the prompt. Each participant will be encouraged to answer as many times as they choose. Statements will be aggregated and all participants will be asked to sort and rate statements thereafter.

The process with each focus group will be the same utilizing the main steps of the concept mapping process: Brainstorming through anonymous answers to the prompt; individual Sorting of statements gathered from the brainstorming step into related "piles" of information, based on the individual sorts subjected to mutlidemensional scaling (MDS) to understand the relationship between individual concepts, Rating, on a scale of importance or centrality of the characteristics for the purpose at hand; analysis follows that produces Maps, Clusters, and Labels of the knowledge entities providing visualization of relationships based on clustering of statements of greatest shared meaning shown in proximal spatial relationship. CSGlobal MaxTM software will be used within each of these steps to organize the data. The investigators will be able to infer from the cluster outputs major themes of concern by the stakeholder population and degrees of importance of these concerns by subgroup. This data will inform an expert panel about the development of the finalized model.

Summary of findings: We plan to present two related strains of findings. We will provide "up-to-date" group concept mapping results and an analysis through visualization of the relational characteristics both within and across sub-populations involved in the study emphasizing how the data informs team policy building practice. In addition, an assessment of observational key factors supporting how voice is increased as a result of this type of cross-population multi-stakeholder involvement will be explored.

Statement of how the research advances the SciTS field. The findings of this study have important implications for federal cross-population multi-stakeholder policy building enterprises including a consideration of the place of scientific inquiry in the policy making process. The research method and results will mediate criticism for team approaches to policy building. In addition, the consideration of the importance of voice through cross-population inclusion in conceptualizing universal needs and structures can inform team decision-making strategies.

Posters 24 and 25: Selections from the *Places and Spaces* Collection

Abstract: We are pleased that the SciTS 2015 Conference is host to a selection of images of the *Places and Spaces* collection.

Places and Spaces introduces visualizations of the evolving science and technology 'landscape.' The maps show connections between scientific disciplines, the birth of new 'lands' of science, and the diffusion of ideas across the landscape of science. Each iteration showcases the benefits of data visualization for a particular audience, e.g., for economic decision makers, science policy makers, scholars, and kids. At its heart, *Places and Spaces* promotes validated and replicable workflows for data visualization design.

Places and Spaces (scimaps.org) debuted in 2005 as a ten-year project. Each year, a themed call for maps is issued and a team of international reviewers and exhibit advisors selects the most insightful maps submitted. The exhibit now includes 100 maps, featuring the work of 215 mapmakers from around the globe. The maps include historically significant firsts in science mapping as well as best examples of knowledge domain mapping, novel location-based cartographies, data visualizations, and science-inspired art works.

Drawing from across scholarly disciplines, *Places and Spaces* demonstrates the power of maps to address vital questions about the contours and content of human knowledge. The maps empower data to tell stories, and model innovative, inspiring ways to grapple with new methods of information gathering and sharing.

Concurrent Session 1

Team Science Coaches: Career Paths for Fostering Successful Team Science

1:30–3:00 pm (Panel)

Authors: Holly Falk-Krzesinski (Elsevier), Amy Davis (University of Utah) and Christine Hendren (Duke University)

Abstract: Despite the approach being common to assembling academic-based, interdisciplinary research teams—selecting the very best investigators from various involved disciplines—a team of experts does not tend to result in an expert team. Research has demonstrated that work teams (a category of teams in which scientific teams reside) operate most effectively when they contain both a mix of experts as well as team-players, and that these teams demonstrate superior performance when they rely on intervention, coaches, to help the group maximize their collective set of resources.

These coaches must be an integral part of the science team on an ongoing basis, with subject matter expertise and a level of interactional expertise to weave together skills across team members. They must also understand how each team member, accountable for excelling in their individual roles, can complement one another and add to the team's overall shared mental model. Coaching may take the form of perspective setting, by communicating an overall framework and each team member's place in the framework, or by explicitly operationalizing how collaboration will happen. By clarifying a team's mission and exploiting its external and internal relationships, the coach can enable a scientific team to function as more than the sum of its parts.

The three panelists will describe their experiences as team science coaches and discuss career possibilities for individuals with scientific and research development backgrounds:

Prior to joining Elsevier in her current role as Vice President for Global Academic & Research Relations, which is focused on developing strategic alliances to enhance the global research enterprise, Dr. Holly Falk-Krzesinski had been a faculty member in arts & sciences and medicine at Northwestern University where she led initiatives related to research development, grantsmanship, and team science. She facilitated a multitude of trans-institutional collaborative grant programs spanning art history to bioenergy to translational medicine, with a special interest on approaches to effective training and coaching for collaborative and interdisciplinary research. Through her leadership with the Annual International Science of Team Science Conference, Dr. Falk-Krzesinski has been instrumental in developing a strong community of practice for team science and interdisciplinary research. She continues to consult for universities across the United States around team science training and evaluation. She also launched the National Organization of Research Development Professionals (NORDP) in 2008, serving as the organization's founding president and co-chair of its Enhancing Collaboration working group with a focus on interdisciplinary research centers. Her penchant for coaching extends back to a number of STEM related career development programs with special emphasis on early career scientists and women in STEM fields.

Dr. Amy Davis serves as Director of Research Program Development for the School of Medicine Dean's Office Research Unit. The Dean's Office Research Unit is responsible for supporting University of Utah Health Sciences Center strategic research initiatives, including the Utah Genome Project, the Neurosciences Initiative, the Diabetes and Metabolism Center, and a Heart and Vascular Initiative. Dr. Davis' roles in the strategic research initiatives include building sustainable, trans-departmental organizational units; aligning research service lines with clinical service lines; catalyzing collaboration among faculty from multiple disciplines; and increasing research funds by developing federal and foundation grant proposals, by establishing private-public partnerships, and by teaming with development officers to cultivate philanthropy. Dr. Davis oversees and mentors a research development staff of seven, including four

PhD-level scientists pursuing careers in research program development. Prior to joining the School of Medicine, Amy served as Associate Director of the University of Utah Brain Institute.

As Executive Director of CEINT (Center for the Environmental Implications of NanoTechnology), Dr. Christine Hendren serves in complementary administrative and research roles. Headquartered at Duke University, but including a total of 7 universities across the US and multiple international collaborators, CEINT's mission is to elucidate general principles that determine nanomaterial behavior in the environment, to translate this knowledge into models to forecast risk, and to provide guidance in assessing existing and future concerns surrounding the environmental implications of engineered nanomaterials. Dr. Hendren's research centers around developing methods and supporting data to assess the risks of nanomaterials, and on informatics approaches to integrating and analyzing datasets across CEINT and beyond. These efforts involve input and collaboration across the multiple disciplines and institutions that make up the center, and therefore rely upon some of the administrative work necessary to keep the center coordinated around its unified mission. In her role, Dr. Hendren provides support in the form of planning and facilitating annual meetings with internal researchers and the external advisory board and with various interested funding parties. She also consolidates the work produced throughout the Center into an annual report, and acts as a liaison to funding bodies, external collaborators, and the media. She also creates additional avenues to identify and tie together common threads or complementary work throughout the Center by convening one-off or standing small group meetings dedicated to developing crosstalk and knowledge management around shared interests across multiple institutions and departments, acting as the knowledge broker who stays abreast of individual researcher developments while communicating the overall research framework into which everyone fits.

Concurrent Session 2

Knowledge Networks and Shared Mental Models (Papers) 1:30–3:00 pm

Paper 1: Boundary Spanning Patent Applications, Teams, and the Patent Examination Process

Authors: Ryan Whalen (Northwestern University) and Noshir Contractor (Northwestern University)

Abstract: Patent applications represent the work product culmination of many research teams. In them, applicants seek legal title to the underlying intellectual property generated by the research team. Many will go on to receive patent protection, but others will ultimately be rejected by the USPTO and abandoned by the applicants. Despite the unique perspective that patent applications allow us on the innovation process—a view into what teams create, what prior art they cite, and whether they are ultimately successful in attaining their goals—the majority of empirical patent research focuses on granted patents, largely ignoring the applications that precede them.

We address this gap by assembling a novel patent application dataset and examining how the information networks relied upon by applicants relate to the patent examination process and eventual probability that a patent is granted. The data includes all patent applications filed at the USPTO between 2001 and 2006. From these, we use regular expression matching to extract their citations to relevant prior art. Federal law requires applicants to disclose all relevant prior art of which they are aware. These citations, in conjunction with the granted patent citation network reveal the knowledge structure that underlies patent applications.

We further nuance the information this citation network provides by looking to the technology class information provided by the USPTO. This categorizes applications according to their technology type, and allows us to identify those inventions that span across technological boundaries by citing disparate technology classes. In

conjunction with the citation network and technology class data, we also incorporate a team size variable allowing us to examine how team size affects propensity to make boundary-spanning inventions.

We posit the following three hypotheses and one research question:

- Because there is evidence to suggest that valuable patents are more likely to include citations, and because citations ease the examination process: H1: Patent applications that include citations to previously patented inventions are more likely to be granted patents by the USPTO.
- There is conflicting evidence about the effect that spanning technological boundaries may have on patent applications. Some evidence suggests that boundary-spanning inventions are likely to be more valuable—and hence potentially more likely to be granted. Alternately, spanning technological boundaries may signal more complexity and make the examiner's job more difficult—perhaps decreasing the probability of an eventual grant. RQ1: Are patent applications that cite across disciplinary boundaries more or less likely to be granted by the USPTO?
- Inventions that span technological boundaries require more diverse expertise in the research and development process, thus leading team size to correlate with boundary-spanning: H2: Patent applications with larger teams larger are more likely to cite across disciplinary boundaries.
- Because they complicate the examination process, boundary spanning patent applications will experience longer examination times: H3: Patents citing across disciplinary boundaries will have longer pendency periods.

Our results indicate that: citing prior art improves the likelihood an application will be granted—supporting H1; boundary-spanning applications are less-likely to be granted—answering RQ1; larger teams are more likely to span technological boundaries—supporting H2; and citing across disciplinary boundaries does extend the pendency period—supporting H3.

This project advances the SciTS by furthering our understanding of team performance, showing that increasing team size expands the diversity in the team's knowledge network and makes it more likely they will span technological boundaries. We also further our understanding of the patent examination process and have produced a new dataset of patent application citations that can be utilized to address additional questions about the processes by which teams generate scientific innovations.

Paper 2: Collaboration and Advice Networks among Dissemination and Implementation Researchers: Implications for Strategic Initiatives to Advance the Science

Authors: Alina Lungeanu (Northwestern University), Wynne Norton (University of Alabama of Birmingham) and Noshir Contractor (Northwestern University)

Abstract: Broadly speaking, the science of dissemination and implementation (D&I) is focused on integrating evidence-based interventions within clinical and community settings and translate research so practitioners can understand the significance of scientific discoveries and consequently use it in various settings (Meissner et al., 2013). Significant foundational research has been conducted in the past decade or so to advance the science of dissemination and implementation in health. However, a critical examination of factors influencing how D&I research is conducted has largely been absent from scientific investigations to date.

In an effort to better understand how D&I research is conducted, we investigated factors affecting patterns of D&I-specific collaboration and advice that exist among members of a D&I community. Consistent with well-documented characteristics of other scientific disciplines, we hypothesized that actors in the D&I community tend to work in closely knit communities of practice that, although efficient, may not capitalize on the benefits of collaboration and cross-pollination of ideas across boundaries. The premise of this hypothesis is that these two activities—collaboration and advice—influence the quality, scope and content of research conducted in D&I. Therefore, understanding factors responsible for observed trends in these two activities should inform strategic initiatives to foster more effective and diverse collaboration and advice networks in the field and consequently help advance the science.

We conducted an online survey targeting the 1,419 individuals who were subscribers to the Implementation Network, an e-Newsletter and associated website that provides late-breaking information about D&I-related research, practice and policy activities (e.g., publications, conferences, resources, trainings, jobs, webinars, etc.) to members worldwide. The survey, which had a response rate of approximately 30%, asked questions about demographics, D&I expertise, participation in various professional meetings and conferences, as well as information on areas of work based on health content (e.g., diabetes, cancer), target population (e.g., adolescents, veterans), and type of research (e.g., health services, prevention). In addition, the survey collected participants' information on two network relations: the collaboration and advice networks of actors within this D&I community. Participants were provided a roster of individuals who were subscribers to the Implementation Network but were also invited to generate names of additional contacts did not appear on the roster.

We used Exponential Random Graph Models (ERGM) to assess factors influencing the collaboration and advice patterns within members of this particular D&I community. We found that similarity in health content, target population, and the type of research undertaken strongly influence the presence of ties in the collaboration and advice networks. These results are potentially problematic given the interdisciplinary nature of D&I science and application across health content areas, populations, and types of research. Indeed, results suggest the need for policies that incentivize networking activities and strategic funding initiatives that increase opportunities for cross-pollination of ideas and purposeful assembly of interdisciplinary teams. One such intervention that shows promise is the Annual NIH D&I Conference. Our findings indicate that individuals who reported attending the Annual NIH D&I Conference were more likely to have advice and collaboration network ties with dissimilar others than those who do not attend this conference.

Paper 3: How facilitation and rules of interaction shape knowledge network structures and outcomes

Author: Jeni Cross (Colorado State University)

Abstract: Research on knowledge networks has focused primarily on how the structural components of the network facilitate knowledge creation, transfer, and adoption. In large, interdisciplinary teams, what factors foster the network structures associated with knowledge sharing and group success? This mixed-methods study examines twelve interdisciplinary knowledge networks tasked with a complex project design. Data was collected through interviews, focus groups, observations, document analysis, and social network surveys. Our results show that the rules of interaction and facilitation strategies significantly impact the structure of the network, including centrality, flow, and density. In addition, our results illustrate that the social interactions (shaped by rules of interaction and facilitation) shape the network in ways that overcome barriers to knowledge transfer and adoption and thus improve the quality and measurable outcomes of design. These results reveal the importance of the social processes crucial to the creation of network structures known to increase information flow as well as knowledge creation and adoption. In addition this study offers specific recommendations for facilitating interdisciplinary teams to maximize success.

Paper 4: Shared Knowledge Networks in Teams: Current and Future Applications to Engineering Design, System Safety, and Chronic Healthcare

Author: Mark Avnet (Texas A&M University)

Abstract: Much of the literature on shared mental models (SMMs) focuses on team processes and performance in two- to three-person teams. While some research has extended this idea to larger teams by computing averages of pairwise SMMs across all members, this

type of approach does not capture the influence of the myriad formal and informal relationships that inevitably affect shared knowledge in larger teams. The goal of the present research is to develop a methodology that overcomes this limitation by examining shared knowledge networks and the evolution of the structure of these networks over time. In such a network, each node represents a team member, and each edge represents an SMM between two team members. An initial study examined shared knowledge in engineering design teams made up of approximately 20 engineers working together for a short, well-defined period (generally five days) to produce a conceptual design of a scientific spacecraft and its surrounding mission architecture. By quantifying team members' common views of design drivers, a network of SMMs was built to reveal the structure of shared knowledge at a snapshot in time. A structural comparison of pre-session and post-session networks was used to compute a metric of change in shared knowledge, or team learning (i.e., the extent to which team members learn from each other). Based on survey data from 12 design sessions, a correlation was found between change in shared knowledge and each of several system attributes, including technological maturity, development time, mass, and cost. This research also involved the development of a metric for team coordination based on an overlay of expected and actual communication networks. The analysis demonstrated a statistically significant correlation between team coordination and team learning.

Building on the above work, follow-up studies are currently being developed to test the observed phenomena in two other settings: emergency response and chronic healthcare. The first of these studies focuses on the emergency response capabilities of a major multinational energy company interested in improving safety at its plants and refining facilities. Teams of ~40 emergency responders from the company will be placed in high-fidelity simulations of emergency situations in a fully equipped facility called the Emergency Operations Training Center (EOTC) administered by the Texas A&M Engineering Extension Service (TEEX). The second study is part of a collaborative effort to develop a "smart" system designed to more effectively facilitate targeted care for diabetes patients. The goal of the system is to automate the aspects of chronic healthcare that can be more effectively managed electronically so that providers are able to spend more time on the activities where they truly add value—actually caring for patients. The effect of such a shift is that it will allow providers to focus their efforts on alignment and team problem solving. Thus, perhaps counterintuitively, communication and learning will be even more important when such a system is in use. To help ensure that the system is designed to best facilitate effective collaboration among a multidisciplinary team of healthcare providers, a network-based analysis of shared knowledge will be conducted, and the results will be used to inform the system's design.

This research program makes important advances to the science of team science by providing a methodology for quantitatively assessing shared knowledge and learning in large real-world teams working together to solve complex problems. This work not only contributes to theoretical understanding of how teams work and learn, but it also promises to lead to the development of practical tools for improved processes and outcomes in such critical application areas as engineering design, emergency response, and chronic healthcare.

Concurrent Session 3

Team Science in Learning Health Systems: Lessons from the American Recovery and Reinvestment Act Infrastructure Investments for CER (Panel) 1:30–3:00 pm

Authors: Eric Holve (Academy Health), Gurvaneet Randhawa (Agency for Healthcare Research and Quality), John Steiner (Kaiser Permanente Institute for Health Research), Michael Kahn (University of Colorado) and Adam Wilcox (Intermountain Healthcare)

Abstract: Drawing on the experiences of investigators from a set of comparative effectiveness research (CER) infrastructure grants supported by the American Recovery and Reinvestment Act (ARRA), panelists will share lessons for team science within distributed networks using electronic health data for CER, patient-centered outcomes research (PCOR), and quality improvement (QI). As identified in a published review of major challenges and opportunities for emerging models of 'learning health systems (LHS), the themes of governance, data quality, and sustainability all highlight dimensions of collaboration that are important to understand in order to maximize the potential use of data from electronic health records, mHealth, and other novel sources.

Dr. Gurvaneet Randhawa from the Agency for Healthcare Research and Quality (AHRQ) will facilitate the panel based on his experiences as project officer for a set of eleven large infrastructure grants using electronic health data, and the Electronic Data Methods (EDM) Forum. Dr. Randhawa will provide comments on the goals of the ARRA CER funding in this space and reflections on the future of collaborative efforts among the grantees and their partners. He will subsequently guide a discussion among panelists using a question and answer format.

The aims of this panel discussion are to:

Enumerate key opportunities and challenges for team science in LHS based on collaborations among investigators supported by the ARRA CER data infrastructure investments;

Highlight key challenges for collaboration in research and QI networks with respect to governance, data quality, and sustainability;

Discuss ways in which scientific teams building learning health systems of the future can be engaged to facilitate and improve learning over time.

Opportunities and Challenges for Team Science in LHS -- A Bibliometric Analysis: Dr. Holve will discuss the EDM Forum's work to identify and address shared challenges among groups using electronic health data for CER, PCOR, and QI. She will present the results of a bibliometric analysis conducted by the EDM Forum to review trends in team science among groups engaged in learning health systems. The analysis builds on reviews of the peer-reviewed literature focused on the use of electronic health data for CER, which were conducted in 2011 and 2014. These results are supplemented with additional insights from related studies of ARRA CER infrastructure projects and those projects' productivity (literature as well as tools, resources, and follow-on funding). This analysis will assess the extent to which work in key areas is more likely to be conducted by teams and will assesses relationships between local and virtual teams engaged in building learning health systems.

Network Governance: Strong governance is a necessary, if insufficient criteria for building lasting collaborative networks for CER and PCOR. To better understand the complex maze of administrative and regulatory requirements for research conducted across geographically distributed teams, Dr. Steiner will share the successful approaches and templates from the HMO Research Network (HMORN) to facilitate multi-institutional collaboration. Approaches to enable data sharing and secure Institutional Review Board approvals will be addressed. Ten essential elements of infrastructure to facilitate team science across a network will be discussed, including: network governance; trustworthy data and processes for sharing data; shared knowledge about research tools; administrative efficiency; physical infrastructure; and infrastructure funding. In addition, Dr. Steiner will comment on the need for sustainable networks to have a clearly defined mission, vision and values; protection of human subjects; a culture of collaboration; and strong relationships with host organizations.

Data Quality: For investigators and analysts sharing data across collaborative networks, approaches to assess the quality and credibility of data must be ensured. Particularly for distributed networks in which the analysts' ability to scrutinize individual data elements is minimal, new approaches are needed. Dr. Michael Kahn will present his efforts leading the Data Quality Collaborative (DQC), a working group of leading experts from teams using electronic health data to address the need to ensure that CER and PCOR findings derived from diverse and distributed data sources are based on credible, high-quality data; and that the methods used to assess and report data quality are consistent, comprehensive, and available to data consumers. Dr. Kahn will present a data quality assessment framework and guidelines for the CER community, including draft recommendations that can guide the development of new analytic and reporting methods specifically directed to data quality assessment and reporting for CER studies in collaborative networks. Dr. Khan will also discuss a unifying data quality reporting framework and a complementary set of 20 data quality reporting recommendations for studies that use observational clinical and administrative data for secondary data analysis. The proposed recommendation can help teams working across multiple sites to have a common framework to ensure integrity of their data.

Sustainability: Sustaining infrastructure and long-term projects that have used a collaborative approach to research and quality improvement is an ongoing challenge for large, multi-disciplinary teams. Dr. Adam Wilcox will share successful strategies for maintaining sustainability of investments in national initiatives using electronic health data to build learning health systems. Based on a collaboratively developed framework, Dr. Wilcox will discuss three considerations that are critical to understanding and sustaining research and quality improvement: project maturity, commercialization activities and stakeholder support, including team composition. Dr. Wilcox will also share a separate framework for developing a flexible sustainability strategy, emphasizing the importance of assets, expansion, complexity, and stakeholders. In his discussion of the importance of creating value for stakeholders, Dr. Wilcox will address the need to define value for all key stakeholders and team members. In one case example of team science based on the Washington Heights/Inwood Informatics Infrastructure for Community-Centered Comparative Effectiveness Research (WICER), it was estimated that the tasks completed by the 'enthusiastic' partner were accomplished with about one-third of the effort compared to working with a 'reluctant' partner.

Concurrent Session 4

Cross-Disciplinary Boundary Spanning (Papers) 1:30–3:00 pm

Paper 1: How Methodology Reflects Disciplinarity in Education Research Funded by NSF

Authors: Gregg Solomon (National Science Foundation), Carolina Milesi (National Opinion Research Center), Kevin Brown (National Opinion Research Center), Barbara Schneider (Michigan State University), Mike Steketee (Westat) and Alan Porter (Georgia Tech)

Abstract: The Research on Learning and Education (ROLE) program was launched at NSF in 2000. Not since the short-lived National Institute of Education in the 1970's had a funding program at a major federal agency been conceived with the goal of supporting a multidisciplinary portfolio of fundamental educational research with a focus on building bridges between the cognitive science and educational research communities.

It served as the model for the NSF Science of Learning Centers program and the Dept. of Education's Institute of Educational Sciences. ROLE was eliminated in 2005 (multidisciplinary funding programs are usually short-lived), though the REESE program soon arose, Phoenix-like, from its ashes. Nonetheless, the question of how to measure the impact of a multidisciplinary basic research program is still pressing. A central part of NSF's original mission is to foster the ability of the nation to conduct research on issues of national importance. One promise of multidisciplinarity is that it will increase not merely the numbers of researchers working on am issue, but also the range of literatures and methodologies they draw upon. To that end, ROLE and REESE emphasized rigor but was methodologically agnostic.

In this paper, we first look at how multidisciplinary ROLE and REESE were, paying particular attention to the disciplinary mix on the specific project teams, and what effect that had on the research design employed. Our datasets included the proposals of funded projects, their publications, and PI survey responses. Comparisons were made to NSF educational programs, both those prior to 1998 and contemporaneous.

We found the ROLE and REESE portfolios to be more multidisciplinary both at the portfolio and project level. For example, cognitive scientists had rarely been PIs in NSF-funded education research in the 90's, whereas they made up about 15 percent of PIs in ROLE and REESE. The proposal references themselves show a significantly greater multidisciplinary influence, as measured by the number of disciplines cited as well as by metrics derived from journal cross-citation indices.

Among the effects that this influx of disciplines into education research had was a change in the range of research methodologies employed. In a great departure from previous programs, the PIs were more likely to do experiments and other methods that allowed causal claims. About 90 percent of education research funded prior to ROLE involved descriptive (e.g., case studies and ethnography) and other non-experimental methods, with virtually no experiments or quasi-experiments. In the ROLE and REESE portfolios, more than half of the projects involved experiments or quasi-experiments. In a sign of the range of methods and kinds of research funded, more than half of projects employed still descriptive methods (n.b., many projects involved mixed-methods, both experimental and nonexperimental).

Limits to the desired cross-fertilization of disciplines are also evident. For example, proposals had few cognitive science references unless a cognitive scientist was co-PI. Moreover, though PIs from all disciplines were more likely to do experiments than had previously been the case, only a minority of those without cognitive scientists on the team did so, whereas the great majority of projects with cognitive scientists as senior members of the team conducted experiments. Furthermore, the disciplinary composition of the teams influence the size of the projects and how the results were disseminated (e.g., whether they involved one large complex study published as a book or chapter or multiple smaller studies published separately in peer-review journals but linked logically to make an overarching argument).

We conclude with a discussion of multidisciplinary teams and metrics of scientific and technical human capital development

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Paper 2: Specialization and Diversity in Teams, When Teams are Self-Generated

Authors: Katharine Anderson (Carnegie Mellon University, Tepper School of Business) and Seth Richards-Shubik (Carnegie Mellon University, Heinz School of Public Policy)

Abstract: The literature on team-based production finds evidence for the importance of both skill specialization, and skill diversification. Teams whose members assume specialized roles perform better in problem-solving activities (survey: Ren and Argote (2011)), and researchers who specialize in a narrow field of study tend to produce contributions with more impact (Adamic et al. (2010)). At the same time, there is evidence that individuals with broader skill sets may play a vital role in communication between specialists, allowing teams to better take advantage of their diverse specialists (Woolley (2015)). More broadly, researchers who bridge between different academic communities are thought to play a vital role in spreading information between groups that would otherwise never interact (Burt (2004)), enhancing the flow of information, and speeding the process of innovation.

However, the mixture of specialists and generalists on papers and in the wider research population is the result of the decisions of individual researchers, rather than the community as a whole. This raises the question

of whether the choices of those individuals are at odds with the larger goal of aggregate productivity in scientific research.

In this paper, we consider the factors that lead specialists and generalists to work with each other, and how these individual choices affect the aggregate productivity of team-based scientific research. Building on a considerable existing literature on networks in science, we use data from a long-established academic field (economics), to construct a network of collaborations among individuals with various skill sets, in which researchers are connected if they have published a paper together. We then measure the output of this collaborative research based on the publication success of a paper.

We use the data on co-authorship and publication outcomes to examine several unanswered questions about the roles of specialists and generalists in a self-generated collaboration network. First, do specialists and generalists play distinct roles in the collaborative community? Under what circumstances do researchers choose to include a generalist in their team? And does the notion that generalists span communities hold true? Second, what effect does skill specialization have on the quality of a paper, taking network position and ability as fixed? And finally, what is the predicted effect of encouraging skill diversification in academic communities via interdisciplinary grant programs?

Our analysis uses several techniques that have only recently been developed. The first is a network-based measure of skill specialization, which takes advantage of the universal subject coding system employed by the economics community. The accompanying figure shows how papers have become increasingly specialized over time. The second is an innovative statistical technique, pioneered in de Paula, Richards-Shubik, and Tamer (2015), which recovers the individual valuations (payoffs) that rationalize outcomes in a network formation process such as our co-authorship network. We combine these with a existing measures of journal impact to assess the importance of a publication.

Administrative bodies and funding agencies put considerable time and funding effort into promoting interdisciplinary interactions, and the acquisition of cross-disciplinary skills, in an attempt to reduce the "siloing" of different academic communities, and improve communication across fields. Our work sheds light on the potential consequences, both intended and unintended, of such incentives for interdisciplinary research in settings where collaborations are self-generated.

Paper 3: Boundary Spanning in Academia: Antecedents and Near-Term Consequences of Academic Entrepreneurialism

Authors: Kevin Kniffin (Cornell University, Charles H. Dyson School of Applied Economics and Management) and Andrew S. Hanks (The Ohio State University)

Abstract: We examine the background traits of people who complete interdisciplinary dissertations that span at least two fields in addition to calculating the near-term outcomes for their careers.

Methods: Using the National Science Foundation's Survey of Earned Doctorates (SED) for 2010, we present regression analyses through which we identify—for the 42,957 respondents—antecedents and near-term consequences that characterize the full sample of PhD recipients, controlling for disciplinary differences.

Summary of Findings: Comparing the 32.5% of respondents who indicated that their dissertation was interdisciplinary with the rest of the sample, our analyses yield three main findings while controlling for gender, ethnicity, and age in addition to discipline. First, individuals who complete an interdisciplinary dissertation display near-term income risk since they tend to earn nearly $1,700 less in the year after graduation. Second, students whose fathers earned a college degree demonstrated a .8% higher probability of pursuing interdisciplinary research. Third, the probability that non-citizens (38.2% of the sample) pursue interdisciplinary dissertation work is 4.7% higher when compared with US citizens.

How the Research Advances the SciTS field: Previous research on boundary spanning in academia tends to focus on the cross-disciplinary exchange of ideas and the institution-level benefits of cross-fertilizations. In contrast, our analyses focus on the pathways that the individual boundary-spanners tend to face, shedding light on their experiences and drawing attention to potential conflicts with institution-level policies.

Paper 4: A Dyadic Perspective on Prior Experience and Productivity in Distributed, Interdisciplinary Science Teams

Authors: Jonathon Cummings (Duke University) and Sara Kiesler (Carnegie Mellon University)

Abstract: Over the past several decades, teams have dominated production in science (Wuchty, Jones, & Uzzi, 2007). These teams are often interdisciplinary and distributed across geography and institutions (Cummings et al., 2013). Many government agencies, including the U.S. National Science Foundation and National Institutes of Health, and the EU Framework Programme, have sponsored research involving investigators working together across disciplines and universities (Olson, Zimmerman, & Bos, 2007). Teams distributed by geography, institutions, and disciplines can experience tensions from the pressures of sheer distance, and from the different ways educational institutions are organized, how faculty are rewarded, and how disciplines are structured (Metzger & Zare, 1999). Researchers in these kinds of groups have reported many barriers to multiple-institution proposals and projects (Cummings & Kiesler, 2005). Given the large national, institutional, and individual investments in these kinds of teams, it is important to understand who works together on these teams and what can be done to support their productivity.

To address the question of who publishes together on a team, we analyzed dyadic data from our study of the Information Technology Research (ITR) Program of the U.S. National Science Foundation. The ITR program lasted for 5 years, and supported interdisciplinary information technology research and education. The program was a major NSF initiative, growing from U.S. $90M in 2000 to U.S. $295M in 2004. Seventy percent of the N=549 ITR projects were funded through the Computer and Information Science and Engineering (CISE) directorate of NSF, and we received a list of the N=2692 "senior personnel" across these projects. The original data was based primarily on final reports submitted by projects to the NSF, which included information about senior personnel institutions, disciplines, and project publications. We used Google Scholar to collect new dyadic data on who had published together prior to their project, and recoded the final report publications into dyadic data to determine the number of unique publications for each pair of senior personnel on the project.

Controlling for a number of factors (e.g., project length, project funding, project size, number of institutions, and number of disciplines) we used Hierarchical Linear Modeling (HLM) to predict how often pairs of senior personnel published together on a project. Sixty-six percent of the senior personnel pairs had not published together before their ITR project. Fifty-four percent of senior personnel pairs on ITR projects were in different institutions, and fifty-two percent of the pairs were in different disciplines. Being in a different institution was negatively associated with a pair publishing together in their project ($B = -.81$, $p < .001$), but being in a different discipline was not associated with a pair publishing together in their project ($B = -.05$, ns). Moreover, prior experience publishing together reduced the negative impact of being in a different institution (interaction $B = .06$, $p < .05$), but did not moderate being in a different discipline (interaction $B = .01$, ns). That is, pairs working in different institutions with no prior experience publishing together were significantly less likely to publish together than pairs working at different institutions with prior experience publishing together.

New relationships and newcomers increase the likelihood the project will pursue innovative directions and methods (Guimera, Uzzi, Spiro, & Amaral, 2005). If all members of a project have prior experience with one another, by definition there are not any newcomers to bring new knowledge and ideas to a project. Thus, teams need to avoid too much inertia in the membership that constrains potential creativity and innovation. Our results contribute to better understanding this tension between having new and existing members by pointing to the positive role that prior experience can play in helping to reduce the negative impact of distance and institutional barriers. That said, additional research is needed on the issue of how much prior experience, or alternatively how many newcomers, are optimal for teams in science and engineering that are distributed across institutions.

Concurrent Session 1

Virtual Collaboration and Distributed Teams 4:00–4:45 pm

Paper 1: Email as Telescope in Distributed Scientific Collaborations

Authors: Matt Willis (Syracuse University), Sarika Sharma (Syracuse University), Jaime Snyder (University of Washington), Carsten Østerlund (Syracuse University) and Steve Sawyer (Syracuse University)

Abstract: We report on a study of email and related digital technology uses among scientific collaborators as a view (from a telescope, at a distance) into understanding distributed scientific collaborations. As might be expected, findings make clear that email is a—if not the—primary mechanism for interaction, communication and information sharing mechanism among distributed scientific collaborators. The more pertinent insight, and the primary contribution of this work, is insight into the ways in which email are embedded into scientific practices and serve as record and structure of the work being done.

This analysis comes from an exploratory study of distributed collaborative scientific practice. As a formative part of a larger study, we focus on the ways in which scientists share and manage documents, we pursued field research in order to bring together what is known in the research literatures on scientific practice, distributed collaboration, documenting practice, and e-science/uses of cyberinfrastructure with contemporary practice. We used both purposive and snow-ball sampling to identify 22 active scholars from the intellectual communities of science and technology studies, information science, information systems, computer-supported cooperative work (CSCW) or human-computer interaction (HCI). While collaborators come from a range of disciplines, the projects described were each grounded in social science practices around similar research interests, providing a basis for comparison. Reports of collaborative practices provided to us by our primary informants gave us insights into the work practices of over 170 researchers and project staff.

Data collected for this study are drawn from a comprehensive inventory of software and tools the participant uses in their collaboration and semi-structured face-to-face or phone interviews. Interviews were transcribed and then coded. One of the collaborations allowed us to follow project emails for more than a year and we analyzed the metadata to categorize the purpose of the email in relation to project research activity. The participants have evidence through publication, funding, and other visible products of their work that they were part of an ongoing, successful, distributed scientific collaboration. Participants also have experience with digital tools and computer-mediated collaborations because of these projects. The highest number of collaborators on a single project was over 30 and the lowest was two, most had four to six. These participants used a variety of digital tools, platforms and other online technologies. While there were patterns, a distinctive similarity across all distributed scientific collaborations is the intense use of email as the most common means of communication.

Analysis highlights three distinct roles email plays in supporting distributed scientific collaboration: (1) articulation, delegation and coordination work; (2) document management and archiving; and (3) shared cognition. First, and as expected, much of the email among scientific collaborators focuses on either articulation work—work done in order to do goal-oriented work (e.g., following the right template in order to submit a paper)—or on project goals, meeting times, detailing tasks and to-dos, and coordinating schedules.

Second, while document management and file sharing software/platforms are widely available, we find file sharing through email is a common practice in these distributed collaborations. Email appears to serve as a redundant file of record. Team members often put a file in a shared repository such as Dropbox, but also attach the same file to an email to edit and review. Third, we find

email serving as social cognition. It is a script or record for what has happened previously for the project, and helps plan the future goals and tasks of the project. It is also visible, arriving to each participant's email inbox to be seen by each member but each member can work with the email separate from the rest of the collaboration.

These findings make clear that email practices are deeply integrated with the lives of the scientists we studied. Email messages often contain personal or non-project related information, come in waves of light or heavier email use, and email practices and etiquette shift over time in a single group. Specifically, one shifting practice is that email subjects do not always relate to or represent the content of the email body. This presents a challenge for similar studies which only collect email metadata and rely on subject lines to derive context of the email.

Mundane and often complex, emails' pervasive, ubiquitous and multi-faceted roles in distributed scientific collaboration practice suggest that it is deeply embedded in practice. This suggests that opportunities to shift project management techniques into email (imagine if the task and to-do email were posted to a team wiki for editing and updating), instead of the reverse, will likely lead to more fruitful uses of these techniques. Likewise, developing documenting systems and practices that work off of (instead of in parallel or even as opposed to) email sharing (imagine document platforms that monitored and curated email attachments) will improve document tracking. Finally, we imagine that, increasingly, project emails are the distributed digital equivalents of physical laboratory notebooks and systems should be harnessing these as part of the team's digital interactions.

Paper 2: Do International Collaborations Necessarily Produce More Innovative or Impactful Biomedical Research?

Author: Vanessa Pena (IDA Science and Technology Policy Institute)

Abstract: Globalization, including the internationalization of science networks and mobility of scientists, has increased opportunities for knowledge production, dissemination, and access to information. Research collaborations are marked by university partnerships in joint-scientific projects and the increasing international flow of science students. In order to describe the characteristics and trends of international collaborations in science and technology research, we examine researchers from three U.S.-based research programs in the biomedical sciences. We describe significant dimensions associated with international collaborations across these programs, such as characteristics of the researchers and institutions as well as the interdisciplinarity and diversity of the fields and the type of research conducted. We examined international collaborations of 107 researchers and 465 of their publications in biomedical sciences. Using expert assessment as a measure of impact and innovative approaches, and research and researcher characteristics as independent variables, we identified the role of international collaborations in the success of the scientific research. Building on regression analyses, we identify the role international research collaborations play, generally, in the success of these research programs, and, specifically, in the research quality measured as innovativeness and impact.

Paper 3: Mapping the Network of Scientific Software

Authors: Christopher Bogart (Carnegie Mellon University), James Howison (University of Texas at Austin) and James Herbsleb (Carnegie Mellon University)

Abstract: Software has become an indispensible part of the infrastructure for scientific research. Yet much effort is wasted and misdirected in coordinating maintenance of this shared resource: for example good software is abandoned when funding runs out, efforts are duplicated when software is rewritten from scratch, while other software is packaged for anticipated users that never appear. In this fragmented environment, replication of results can be difficult, and quality of shared software can be uneven. Developing, supporting, and maintaining software can have potentially great scientific impact, yet incentives and other signals shaping these activities are not as direct and quantifiable as other scientific impact measures like publication counts and grant dollars. This is especially true for open source scientific software, downloaded anonymously, distributed freely, and run on desktops, laptops, and local clusters in a way that can be opaque to software authors and their funders and communities.

In this work, we present the Scientific Software Network Map, (http://scisoft-net-map.isri.cmu.edu), a tool for collecting, analyzing, and exposing the usage patterns and software citation data that stakeholders will need to overcome those barriers. We describe the tool's affordances, relating them to literature about the barriers to establishing rational incentives within scientific software communities. We will present two data mining case studies scientific software usage, comparing new measures derived from usage data to previously available measures. We show that usage data yields information that is important for the scientific software community, yet not easily available from existing sources. Finally, we describe a case study in progress, using surveys and interviews to understand how software users' and developers' decisions are influenced by exposure to data from our growing usage dataset from distributed, anonymous monitoring of software on scientists' desktops.

Our results echo prior findings that citations to software in publications do not relate closely to actual research usage. For example analysis of nearly a million supercomputer jobs over ten months in 2012 showed that more than a third of jobs (34%) used the FFTW library for Fast Fourier Transforms, yet in a randomly chosen sample of 10 of the 109 publications that those FFTW users cited in their applications for supercomputer time, only one paper mentioned FFTW, and that only by its acronym in the body of the text. In general, formal software citation statistics present a highly distorted picture of that software's usage in research, absent complementary usage data.

We have also seen that although explicit curation of collections of scientific software packages might help orient users to the repository's offerings, such collections are not accurate maps of communities' usage practices. We compared the domain-expert-curated "task view" collections of R-language packages in the CRAN and Bioconductor repositories with empirically observed clusters of packages used together in more than 8000 R scripts checked into the Github open source repository. We found for example that nominally "general-purpose" packages were sometimes actually associated with one domain; e.g. Rsolnp, tagged as "Optimization", was in Github used almost exclusively alongside "Financial" and "Econometrics" packages. This contrast shows the potential value in making usage data more transparent: these usage clusters could yield insights for users about the packages their colleagues are using, as well as insights for a community about de facto package membership and dependencies within their software ecosystem. Accurate understanding of such usage clusters could allow package authors to decide whether to continue maintaining and supporting a package, how to justify this work to employers and funders, and what functionalities of the package to focus effort on.

This research advances knowledge in the areas of Team Science and Open Science by identifying new measures and visualizations of software's impact on research practice, in support of a community's management of its scientific software resources. Our approach has the potential to help software users, authors, software ecosystem managers and funding agencies understand how their community is really using software. The right usage information, presented to the right people, can provide the right coordination signals for building, shaping, and supporting the software and ecosystems that truly underlie the practice of science in their fields.

Concurrent Session 2:

Open Science: Sharing Data and Analytic Approaches 4:00–4:45 pm

Paper 1: Breaking Down the Barriers to Team Science for Cancer Imaging Research

Authors: Justin Kirby (Frederick National Laboratory for Cancer Research), Brenda Fevrier-Sullivan (Frederick National Library for Cancer Research) and John Freymann (Frederick National Laboratory for Cancer Research)

Abstract: In 2006 the National Cancer Institute (NCI) joined forces with the National Human Genome Research Institute to launch The Cancer Genome Atlas (TCGA). The program aimed to collect and analyze 20 different cancer types by collecting tissue specimens from approximately 500 patients per tumor type. All resulting data were stored in a public database called the TCGA Data Portal. In parallel NCI's Cancer Imaging Program (CIP) initiated activities to archive and share the radiology exams from these TCGA patients via The Cancer Imaging Archive (TCIA). CIP's objectives were two fold. The first was to determine whether imaging phenotypes which could be used to augment or serve as non-invasive alternatives to discoveries made by researchers using TCGA genomics/ pathology data. The second was to catalyze the cancer imaging research community to adopt a stronger culture of data sharing and open science methodologies.

Sites which provided tissue samples to TCGA were contacted. Corresponding pre-surgical imaging exams were de-identified and transferred to TCIA where available. Publication embargoes were established for each cancer type which restricted any submission of manuscripts or abstracts until one year after the clinical images from 100 TCGA subjects were available on the TCIA. Researchers from institutions contributing the imaging data were invited to join volunteer analysis teams consisting of radiologists, clinicians, image processors, biostatisticians, and informaticists. The teams were granted a waiver from the publication embargo in exchange for their data and participation, granting them first opportunity to publish their findings on the data during the embargo period.

Each team focused on analysis of one of the TCGA cancer types. Virtual meetings were held weekly to discuss hypotheses for correlating image analyses with genomic signatures and patient outcomes. Projects were established and the workload was divided among participants. Progress was tracked and announced regularly to the group during meetings and via emails. Mailing lists, wikis, and shared file storage solutions were utilized to encourage group discussion and circulate meeting minutes, agendas, and project documents. Open source tools were deployed via Amazon Web Services cloud architecture and pre-loaded with the images from TCIA based on each group member's assigned workload. Radiologists and image processors used these tools to analyze image data. The results were tabulated and shared with the wider team to generate manuscripts detailing clinically relevant correlations with data from the TCGA Data Portal and/or findings from other TCGA publications.

These activities led to the creation of 6 cancer-specific research teams (brain, breast, renal, ovarian, head-neck, lung) made up of 174 volunteer researchers from 32 institutions. They have published 22 manuscripts in peer reviewed journals on TCGA/TCIA data thus far. Several of these manuscripts utilize TCIA digital object identifiers (DOIs) to share the full data sets which allow other independent investigators to more easily reproduce their findings. Those DOIs access both the raw image data and tables containing published analytic findings. Collectively this work has helped to popularize the newly forming field of radiogenomics and helped to create a path towards more transparent sharing of data and methodologies.

This also demonstrated how effective team science can be for imaging research if major barriers to participation are eliminated. For geographically dispersed, multi-disciplinary teams such as ours these barriers related to technology and communication. Open-access databases like TCIA/TCGA addressed the complex technical and regulatory issues associated with data sharing.

Centralized deployment of free and/or open source tools created a uniform analysis environment and standardized output of results. Regular communication of progress towards goals helped convey a sense of reliance among team members to spur productivity. The well-defined publication policy likely helped motivate people to some degree, but collaboration continues even though the publication embargo period has expired for some teams. This highlights the long term value of such projects.

Paper 2: Framing the Community Data System Interface

Authors: Kristian Garza (The University of Manchester), Carole Goble (The University of Manchester), John Brooke (The University of Manchester) and Caroline Jay (The University of Manchester)

Abstract: Researchers in public funded science consortia agree that making their data accessible with the community is their obligation. Those mandated to use Community Data Systems (CDSs) prefer to share data with their collaborators and funders rather than make it open access. Their rationale to choose against open sharing includes the lack of incentives and lapses of memory. Features that address these two aspects are not included in current CDS implementations. The use of “libertarian paternalism” in Web user interfaces has been shown to effectively modify user behavior. Libertarian paternalism is a method used to influence selections in a way that will make choosers better off, as judged by themselves. So far, however, no attempts to design Community Data Systems using libertarian paternalism to influence sharing have been implemented. Therefore, we propose to investigate the effects of a framed CDS interface on researchers sharing choices. We speculate that an interface framed as a device to secure data citations would positively influence researchers choices. We are performing a series of on-line experiments with subjects from the Life Sciences using the SEEK4Science platform as test-bed. The treatments were designed using three techniques from libertarian paternalism: emphasis framing, frame effects cues and structural complex choice. Preliminary results suggest slight differences between the placebo and treatments using emphasis framing and frame cues. Surprisingly, user’s satisfaction increased with the libertarian paternalism based treatment. Moreover, we observe a distinct difference on sharing choices between the placebo and the structural complex choice based treatment. So far our findings highlight the potential of framing interfaces, but a further evaluation needs to be completed. Additionally, the same experiment under different scenarios should be attempted. One possible implication of our results is that Libertarian paternalism could be included in the Community Data Systems’ design toolkit as a viable alternative to the current practices.

Paper 3: Collaborative Informatics Environment for Learning on Health Outcomes (CIELO): An App Store Model to Advance Team Science, Drive Innovation, and Support Discovery

Authors: Erin Holve (Academy Health), Philip Payne (The Ohio State University), Xiaoqian Jiang (The University of California, San Diego) and Indra Neil Sarkar (The University of Vermont)

Abstract: Feedback from partners of AcademyHealth’s Electronic Data Methods (EDM) Forum, Veterans Health Administration, Clinical and Translational Science Award (CTSA), and mHealth communities all support the need for sharing analytic methods and tools that support research and quality improvement use cases. There are a number of promising models to achieve these goals, including best practices for community-wide acceptance and use of standard application programming interfaces, such as those associated with projects including the Health Indicators Warehouse and REDCap, as well as a variety of multi-purpose web- and grid-service models for data sharing and computational “pipelining.” A growing body of “app store” constructs for the submission, quality assurance, distribution, community-wide adoption/adaptation, and re-contribution of software artifacts and corresponding documentation can provide a robust approach to interoperable and lightweight software “modules.” These trends suggest that managed communities for open source sharing can be very effective at extending opportunities for collaborative and team science. However, to date, an open source community to meet the sharing of analytic methods used in comparative effectiveness research, patient centered outcomes research, and quality improvement has not emerged. This session will highlight an EDM Forum collaborative project, Collaborative Informatics Environment for Learning on Health Outcomes (CIELO), a platform for sharing open

access data analytic tools which brings interdisciplinary groups together to meet these collaborative needs.

The primary purpose of the CIELO platform is to provide members of the research community with access to an open-source and standards-driven framework to enable data analysis and software sharing that can evolve to meet emerging community needs. Through CIELO, users can access others' applications, contribute back their own, and build upon each other's contributions to extend or assemble modules in new analytical "pipelines." A well-functioning community and platform promises to reduce time and cost of research while enhancing the reproducibility and transparency of data analysis. These outcomes have been realized in other open-source/open-standards communities such as Apache and Eclipse (http://www.apache.org, www.eclipse.org). Finally, through the adoption and use of platform- and language-independent software "bundling" frameworks and execution environments, such an "app store" for research analytics may considerably reduce the time-to-performance of common and reusable data analysis tasks supported by CIELO.

Mr. Lele will present the conceptual and technical architectures, user experience design, and current progress relative to the implementation and dissemination of CIELO. Mr. Lele will also discuss the partner community involved in the project and highlight issues and lessons learned experienced in the first year of development for the platform.

Concurrent Session 3

Leading Teams: Theory- and Data-Driven Approaches 4:00–4:45 pm

Paper 1: Knowledge Integration, Goal Commitment and Innovation in Interdisciplinary Medical Research Teams: The Role of Leaders

Authors: Maritza Salazar (Claremont Graduate University) and Theresa Lant (Pace University)

Abstract: This study explores the impact of leader characteristics and behaviors on the innovativeness of interdisciplinary science teams. We predict that leaders with intrapersonal heterogeneity, defined as a breadth of education and work experiences in multiple disciplinary areas, will have the integrative capability to help their teams develop research questions and approaches that draw on the diverse disciplinary perspectives of team members and yield innovative results. We posit that this relationship is driven by leaders' ability to garner commitment, which is a necessary condition for effective collaboration, from team members with varied disciplinary backgrounds because they will feel that the interdisciplinary research question is aligned with their own disciplinary interests. To test our predictions, we designed a cross-sectional survey and examined the relationship between leader characteristics (i.e., intrapersonal heterogeneity), members' attitudes (i.e., goal commitment) and performance outcomes (i.e., innovativeness). Survey data from 32 interdisciplinary medical research teams were used in combination with rosters providing demographic data about each team and expert ratings of team innovativeness. The results of this analysis support our predictions that leaders with greater intrapersonal heterogeneity foster greater team innovativeness, and, that this relationship is indirectly driven through team members higher level of commitment to group aims.

In order to explore how leaders with intrapersonal heterogeneity foster commitment and innovation in interdisciplinary teams, we conducted a supplemental comparative case analysis of 5 teams. We recorded, transcribed, and analyzed meetings of these teams, with a particular focus on team leader communication behaviors. Mirroring the quantitative study, teams with leaders with intrapersonal heterogeneity tended to develop knowledge outputs that integrated diverse perspectives and were more innovative than those teams led by a person without intrapersonal heterogeneity. Our comparative case analysis reveals that leaders with

intrapersonal heterogeneity developed goals or research aims differently than leaders with experience in only a single domain. Leaders with an integrative capability are more adept at striking a balance between depth (focus) and breadth (inclusiveness).

This research also sheds light on a potential means through which a team's integrative capacity, the potential to combine interests of distinct disciplinary groups, can be enhanced to better accomplish joint work (Salazar, Lant, Fiore, & Salas, 2012). We provide initial evidence that leaders who possess intrapersonal heterogeneity should be trained and selected to lead interdisciplinary teams. This research begins to address gaps in our understanding about which work experiences and facilitation practices best equip interdisciplinary research team leaders and members for the difficult tasks of novel idea generation and innovative knowledge transformation.

Paper 2: The Leadership of Teams: A Review and Integration

Author: Sheila Webber (Suffolk University)

Abstract: Leadership theories and models traditionally focus on leading individuals. Increasingly scientific teams are interested in fostering collaborative work situations involving teams to achieve innovative solutions. Our models and theories for leading teams in collaborative work environments are dispersed. In addition, traditional theories and models for leading teams are limited. Leadership theories often lack a temporal or team development component that is important for understanding team success. Critical to the future of team and leadership research is the integration of models and theories for leading teams.

Research examining the impact of leaders in team settings typically applies traditional leadership theories such as transformational leadership, LMX, and contingency models to the team domain. Review of this research demonstrates a dominant focus on the relationship elements of teamwork that include encouragement, empowerment, and communication. Surprising in this research is the focus on a snapshot approach to the examination of teams with limited consideration for the stage of the team's development or focus on a longitudinal examination of the impact of leaders in teams.

There are four primary goals for this paper. First, I review the research on the leadership of teams across a variety of contexts including 40 studies on the leadership of teams. Second, I discuss models for team development offered across the different team-based research outlets. Third, I overlay the leadership of teams with a team development model to map a comprehensive approach to leading teams. Fourth, I demonstrate the importance of developing a comprehensive model for future researchers to understand and enhance the effectiveness of leaders in team environments.

Overall, the research exploring the leadership of teams varies significantly and lacks a roadmap for successfully guiding future studies and team leaders of science teams. As seen by the findings above, a variety of leadership behaviors have implications for team effectiveness. Overlapping aspects include the use of transformational leadership ideas, particularly charisma, for leading teams as well as relationship behaviors included in LMX and fostering a collaborative team environment. Only a few researchers are examining different stages of team development and leadership needed to be successful. The application of traditional leadership models and theories has reduced the concern for building new theories particularly focused on the complexities of working in a team situation.

Integrating the leading teams research provides a more comprehensive review of the domain. Recognition for the unique aspects of teams that are different from leading individuals is critical as research expands in this domain. In addition, modeling and discussing the stage of the team's development is another important aspect uncovered in the review of the leading teams literature. This research proposes an integrated model for leading teams that will be a platform for future research in this domain.

Paper 3: Toward a Potential Model of Scientific Team Leadership: Proposed Grounded Theory Approaches to Study Leader Practices for Team Science

Authors: Kevin Wooten (University of Houston Clear Lake) and Allan Brasier (The University of Texas Medical Branch)

Abstract: The purpose of this paper is to propose the use of constructivist grounded theory (Charmaz, 2007) to study leadership applicable to team science, following

the general suggestions of Parry (2008). Considerable literature exist relative to a comprehensive examination of the leadership theory and practice (Stodgill, 1974; Yukl & Van Fleet, 1992), as well as more contemporary reviews and perspectives (Bass & Bass, 2009; Daft 2014; Dinh, et al. 2014; DuBrin, 2015; Nahavandi; 2014; Northouse, 2012; Yammarino, Dionne, Chun & Dansereau, 2005).

While there has been much articulated about the need for leader development and theory development within team science (Stokols, Misra, Hall, & Taylor, 2008; Börner et al., 2010; Falk-Krzesinki et al., 2011), much of the focus on team science leadership has involved collaborative team processes (Bennett, Gadlin, & Levine-Finley, 2010; Gray, 2008; Hall, Feng, Moser, Stokols, & Taylor, 2008). Recently, Wooten et al. (in press) have reported that transformational and shared leadership behaviors were the most resistant to interventions introduced.

To satisfy the need for practical research questions for the construction of a grounded theory, sixteen criteria will be proposed (Table 1), and known leader practices mapped to each. This will involve the use of three motivational theories (empowerment, expectancy, goal setting), five leadership theories (transformational, complexity, team based, relational, shared), three structural/design theories (self managed work teams, social networks, multiactor governance), five organizational change theories (integrative capacity, appreciative inquiry, team development/evolution, change readiness, learning organization), five communication and influence theories (social power, influence, collaboration, leadership language, interactional justice), and two knowledge management theories (innovation, knowledge transfer). The results of this initial proposed model will involve a six stage leadership process for team science involving the reciprocal practices of:

Inspiring → Connecting → Relating → Integrating → Enabling → Adapting.

Table 1: Criteria for the Development of Leader Practices in Team Science

Contextual Factors	Leadership Process Considerations	Desired Process Outcomes	Needed Leadership Roles
Scientific, Professional, and Autonomy Based Values	Emergent and Generative	Commitment and Trust	Facilitator
Scientific Method	Shared, Non-hierarchical, and Egalitarian	Collaborative	Social Architect
Non-Linear Project Cycle	Knowledge-based	Innovation	Expert Scientist
Dynamic and Episodic Task Environment	Multiple Disciplinary	Capacity Development	Problem Solver

Poster Session

Thematic Group 1—Training and Professional Development in Team Science 4:45–5:00 pm

Poster 1: Scaling UPP the Integration Between Research and Education: Lessons from the Undergraduate PIRE Program (UPP) Down Under

Authors: Janet Rowe (University of California, Irvine), Mariana Schmalstig (SmartStart Evaluation), Jessica Martone (SmartStart Evaluation), Sunny Jiang (University of California, Irvine), Jean-Daniel Saphores (University of California, Irvine), Richard Ambrose (University of California, Los Angeles), Lisa Levin (University of California, San Diego), David Feldman (University of

California, Irvine), Peter Bowler (University of California, Irvine), Amir Aghakouchak (University of California, Irvine), Brett Sanders (University of California, Irvine), Megan Rippy (University of California, Irvine), Brandon Winfrey (University of California, Los Angeles), Andrew Mehring (University of California, San Diego), Eric Huang (University of California, Irvine), Jian Peng (Orange County Public Works), Yiping Cao (Southern California Coastal Water Research Project), Keah-Ying Lim (University of California, Irvine), Ashmita Sengupta (Southern California Coastal Water Research Project), Lindsey Stuvick (University of California, Irvine), Andrew Hamilton (University of Melbourne), Lisa Khone (SmartStart Evaluation) and Stanley Grant (University of California, Irvine)

Abstract: The multifaceted problems encountered by today's engineers and scientists cannot be fixed with yesterday's siloed solutions. While growing populations and the impacts of climate change are straining vital resources, educators and researchers are faced with the challenge of preparing students to be ready to meet these growing demands, not straight-on, but from multiple fronts: engineering, biology, chemistry, governance, etc. New engineers and scientists need to understand how various fields must come together in order for truly sustainable solutions to be developed. Furthermore, they must be able to facilitate these critical, multidisciplinary collaborations. "Building" a multidisciplinary-conscious professional requires multidisciplinary effort. We will present the design and development of a multidisciplinary undergraduate educational program aimed at teaching students about sustainable water management in areas concerned with climate change effects such as drought. Researchers from fields including, but not limited to, hydrology, ecology, public health, climate change, environmental sciences, civil engineering, governance, and regulation were brought together to create common and individual learning objectives complemented with lectures, tours, hands-on guided research, direct interactions with professionals in industry and academia, and the experience of two weeks in Melbourne, Australia, a region familiar with extreme water challenges due to the Millennium Drought. Summative evaluations yielding Likert scale data were analyzed using paired t-tests to measure gains. Students representing two cohorts (2013 and 2014 UPP iterations, n = 24) reported significant improvement in their understanding of all key concepts; from minimal or fair to extensive. This included not just the principles of stormwater capture and sustainable water management, but also the importance of multidisciplinary and international collaborations. Students reported enhanced partnerships with US and Australian professionals and a strong desire to engage in such collaborations in the future. The majority of those who have subsequently entered graduate school, credited this program with being a significant determining factor in their decision. Though a program of this magnitude and expense may not be feasible for many research groups, there are a number of activities and basic components that can be redesigned to accommodate more limited resources while still providing the same multidisciplinary educational impact and furthering team science.

Poster 2: Science Diplomats: Educating the Next Generation of Scientists and Engineers Working Across Boundaries to Tackle Global Challenges

Authors: Marga Gual Soler (Arizona State University) and Thomas P Seager (Arizona State University)

Abstract: The solutions for most 21st century challenges in energy, health, the environment and security lay at the intersection of science, technology and international relations. Traditionally, states have been the principal actors exercising the practice of diplomacy, but the emergence of new global challenges such as pandemics, climate change, food security or cross-border energy and water distribution necessitate more effective engagement of the scientific community. Indeed, the globalization of science and the rapid expansion of technologies for knowledge and information exchange have resulted in a new appreciation for science as a mechanism for improving diplomatic relations, promoting international collaborations to advance global innovation, and addressing the contemporary challenges that transcend disciplinary and/or geographical borders.

However, the combination of diverse nations, cultures, development histories, stakeholders and political differences creates complex international dialogues. Scientists, as natural diplomats often working beyond national boundaries, cultures and languages, are uniquely positioned to help address this complexity and contribute to sustainable solutions in many ways, such as: incorporating science and evidence into foreign policy; building international infrastructure and collaboration networks; cooperating in trans-boundary issues

involving supranational spaces and shared resources; and using scientific interactions to stabilize relations between countries with discordant political ideologies. The success of these multi-faceted interactions relies on building trust and relationships across borders and among stakeholders, communicating effectively across disciplines, and sharing tacit knowledge that is often intangible and context-dependent.

Though it is clear that scientists can play an important role in interdisciplinary global programming, the training and development of this influential group requires refinement. Thus, the question guiding this presentation is: how can scientists develop the necessary interdisciplinary, cross-cultural, communication, interpersonal and leadership skills to effectively engage in global science, technology research and policy scenarios?

This poster will highlight prominent success stories, challenges and tensions within the field of science diplomacy and explore the ways in which team science research can inform the conduct and education of science diplomats. It will also present new approaches and strategies currently under development at Arizona State University which incorporate and evaluate science diplomacy education in graduate training programs.

Poster 3: Team Science Training Intervention: Pilot Study and Proof of Concept

Authors: Deborah Diazgranados (Virginia Commonwealth University), Kevin Wooten (University of Texas Medical Branch) and Bonnie Spring (Northwestern University)

Abstract: Over the past number of years, the National Institutes of Health (NIH) has established the National Center for Advancing Translational Science (NCATS), funding over 60 institutions with Clinical and Translational Sciences Awards (CTSA). The purpose of these awards is to support a range of research spanning the spectrum of translation. The CTSA was established to change the paradigm of clinical research, and to focus upon team based collaborative efforts to speed up the translation of discoveries to impact standards of care and treatment.

While many of the CTSA affiliated institutions have attempted to educate researchers in the use of team science, there has been relatively little coordinated effort to provide an agreed-upon curricula or uniform educational programs. Therefore, there is a profound need for translational scientists to develop team related skills (e.g. conflict resolution, team processes, etc.), most of which are not addressed in typical graduate school curricula nor available in continuing education for scientists.

The overall purpose of this research is to pilot test several modules of online educational team science material as a proof of concept that such is operationally feasible and potentially effective for the 60 plus CTSA institutions. This is a proof of concept study to show the value (e.g., change in knowledge, change in attitude, course site feedback) of an educational intervention upon real teams conducting translational research. The rationale is that evidence suggests a link between teamwork training and overall team effectiveness. However, this relationship has not been demonstrated for translational teams in a CTSA environment, nor for team scientists generally. The two overall aims for this educational evaluation are therefore:

1) To show the value of a team science educational intervention upon functioning teams conducting translational research, and 2) To provide evidence of training effectiveness in order to pursue an NSF grant to produce team science training modules needed by the CTSA consortium.

Poster 4: Delivering the Right Education, Training and Resources at the Right Time to Support the Development and Progress of Multidisciplinary Translational Research Teams in an Academic Health Center

Authors: Heather Billings (Mayo Clinic), Glenn Smith (Mayo Clinic), Karen Weavers (Mayo Clinic), Janet Okamoto (Mayo Clinic) and David Warner (May Clinic)

Abstract: Multidisciplinary research teams are essential for translating research findings into improved patient care and clinical outcomes. However, the translation of basic science discoveries to clinical practice faces a number of barriers including: 1) gaps in research workforce's teamwork knowledge and skills; 2) research centers which do not facilitate, sustain and capitalize on collaborations, and 3) an abundance of organizational silos. There is a growing field of study in the "science of team science", including formulation of conceptual models of team development and identification of specific

competencies and components necessary for successful progression through the stages of research.

The development and promotion of clinical-basic science partnerships in translational biomedical research is a priority for Mayo Clinic. In 2015 Mayo Clinic will award over a million dollars in internal funding to existing and nascent multi-disciplinary research teams. While this is a strong demonstration of institutional commitment there are limited internal education, training or development resources to promote, sustain and enhance integrated multi-disciplinary research teams working on translational projects. There are a number of comprehensive team science "toolkits" and education and training materials available online for investigators, research teams and institutions to access and utilize which have been created by external funding agencies and academic health centers. However, Mayo Clinic investigators are largely unaware of these tools, and indeed may not be aware of how education in team science can improve their research.

The overall objectives of this formative research are to assess: 1) current practices regarding the use of team science education, training and resources among Mayo Clinic investigators, 2) the perceived needs of investigators for tools to improve the function of research teams designed to translate research into practice, and; 3) the feasibility and impact of a pilot project to provide access of existing team science tools on validated measures of research team functioning. The subjects of this study will include recipients of internal Mayo Clinic awards supporting team science. The rationale for this work is to provide the data needed to craft an effective educational program to help teams be more efficient, productive and successful.

To meet these goals we will accomplish the following specific aims:

Specific Aim 1: To assess the perceived needs and current practices regarding team science principles using previously reported on assessment instruments, self-report tools and focus groups.

Specific Aim 2: To disseminate appropriate education, training and development resources to each team, aligned with level of readiness to collaborate and described stage of team formation based on the results of Aim 1.

Specific Aim 3: At project completion, to measure the utilization of these resources by the team members, perceived value and user satisfaction, and changes in pre-education parameters measured in Aim 1.

The expected results of this work are: 1) a representative assessment of the current state and unique needs of clinical and basic science investigators engaged in multidisciplinary team science projects at Mayo Clinic, 2) assessment of the feasibility and utility of dissemination of readily available education, training and resources to support and enhance the teams, and 3) identification of gaps in the current education and resources and defined topic areas and skill sets that warrant the creation of additional education and resources to address unmet needs and deficiencies.

This information will be critical in guiding the development of a team science curriculum which meets the needs of the investigative community in terms of effectiveness, acceptability and feasibility. At the time of the conference, it is anticipated that the project will be ongoing and that data from Specific Aim 1 will be available for presentation.

Poster 5: Achieving Superior Results with Cross-Functional Scientific Teams Using the Creative Teams Approach

Authors: Carol Manahan (Novartis Institute for BioMedical Sciences), Robert Myers (Novartis Institute for BioMedical Sciences), Danielle Imbeault (Novartis Institute for BioMedical Sciences) and Diane Silva (Novartis Institute for BioMedical Sciences)

Abstract: Cross-functional pharmaceutical teams, where there is an attention to both the scientific efforts (task) and how members work together (people), have been shown to produce superior results (1). Novartis Institutes for BioMedical Research (NIBR) has offered workshops and training for our drug discovery and development teams, with the goals of maximizing the teams' creativity and effectiveness. Since 2009, at least 40 global project teams from target discovery through clinical development participate in workshops annually.

These workshops allow intact teams to build their team skills while focusing on advancing science projects using the Creative Teams Approach, a set of Principles and Best Practices that enables high team performance

to advance drug discovery and development projects towards new medicines for patients. We have successfully used workshops to communicate expectations, resulting in teams focusing on key scientific/strategic questions (versus arbitrary milestones), creating project team goals annually and shared accountability for the projects (transdisciplinary versus multidisciplinary). Teams value the face-to-face time to focus on the project at workshops, allowing deeper thinking, creation of novel ideas and an opportunity to think strategically versus operationally about the project.

Workshops are facilitated by members of an internal pool of facilitators that are external to the team- bringing an outside perspective- but are experts in drug discovery and development and/or team effectiveness. Each team takes a pre-workshop survey that identifies the team's strengths and weaknesses, allowing open discussions about team performance and functioning. Information from this survey also helps inform the workshop agenda. As the team performs essential project work, key topics are covered including effective stakeholder engagement, creating a consistent message, clarification of roles and responsibilities and agreement on team practices, such as how decisions will be made.

Post-workshop assessments report that the participants think that the workshop will increase their effectiveness as a team and help advance their scientific project. Use of workshops to embed principles and best practices of high-performing teams has been a successful strategy for NIBR.

Poster 6: Core Competencies for Team Science—Proceedings from the Team Science Competency Domain Work Group of the Enhancing Clinical Research Professionals' Training & Qualification Supplement Award

Authors: Jonelle Wright (University of Miami Miller School of Medicine), Jan Fertig (Milwaukee School of Engineering) and Kay Wilson (Michigan Institute for Clinical & Health Research)

Introduction: Advances in team science call for the development of training programs that equip clinical research professionals with the necessary skills to carry out safe, effective, and high quality clinical research, especially that conducted by multidisciplinary teams. The NIH National Center for Advancing Translational Sciences funded the "Enhancing Clinical Research Professionals' Training and Qualifications" Clinical and Translational Science Award Supplemental Award (3UL1TR000433-08S1) to identify the minimum competencies necessary for clinical research personnel and to develop an efficient framework and training approach to be shared across Clinical and Translational Science Award hubs.

Methods: Building on domain competencies identified by the Joint Task Force for Clinical Trial Competency, the project's leadership defined nine performance domains in which a clinical research professional should be expected to engage during the execution of a clinical trial. These domains included: essentials of research design, ethics, patient safety, research regulation, clinical trial operations, data management, informatics, professionalism, and teamwork. For each domain, a work group was convened to perform the following: a) define behaviors, i.e., "competencies" that clinical researchers and research personnel should possess to optimally perform their professional tasks; b) identify existing training that supports the development of each competency; c) identify need for new areas of training; and d) recommend measures by which Clinical and Translational Sciences Award hubs could assess competence.

Results: Twenty volunteers from the cohort of expert Clinical and Translational Science Award (CTSA) representatives who attended a national meeting of the Enhancing Clinical Research Professionals' Training and Qualifications CTSA Initiative comprised the Team Science Competency Domain Work Group. Using surveys, in-person discussions, and a reiterative process of priority mapping of hundreds of competencies identified during an extensive literature review of team science, the Work Group qualitatively derived four key categories of performance: 1) interpersonal and group dynamics skills; 2) considerations relating the "The Science" and "Discipline" perspectives; 3) cyberinfrastructure skills; and 4) stakeholder engagement.

The following provides examples of identified competencies:

Interpersonal & Group Dynamics Skills: 1) Developing intra- & interpersonal skills such as professional responsibility, professional openness, and multidiscipline orientation; and 2) Group dynamics that include team building, leadership, communication, trust, role clarification, respect, task interdependence, and motivation.

Considerations Relating to "The Science" & "Discipline Perspectives": 1) Cross-disciplinary fluency in which a shared lexicon is developed and theoretical and research frameworks are integrated, and 2) Methodological expertise and methodological flexibility facilitate developing an integrative problem definition, analysis plan, and interpretation strategy.

Cyberinfrastructure Skills: 1) Regulatory knowledge that includes ethics, electronic data sharing, and providing regulatory-compliant access to private information, and 2) Technical skills and adeptness at cyber protocols, electronic information systems, visualization tools, and social media techniques.

Stakeholder Engagement: 1) Big pPicture orientation that incorporates different stakeholders' perspectives in research goals, and 2) Bi-directional relationships in which long-term trust-based academic-community partnerships that reflect mutual respect are built and sustained.

As a step toward facilitating the development and enhancement of training programs appropriate for specific individuals participating in team science activities, the work group differentiated between what competencies should be expected of investigators versus those expected of clinical research professionals. As measurable competencies were specified for each category, methods by which to assess competence were listed and existing training resources for the registered competencies were identified.

Poster 7: Engineering Empathy

Authors: Kaitlin Vortherms (Arizona State University), Thomas Seager (Arizona State University) and Sarah Tracy (Arizona State University)

Abstract: To responsibly design infrastructure, products and services, engineers must understand the social, environmental and economic implications of their work. Social and emotional intelligence are necessary in order to accomplish this. Empathy, the ability to understand and share the feelings of another, is an important aspect of both social and emotional intelligence that can be used to create more effective engineering teams and assist in interdisciplinary and cross-cultural communication. Engineers must have empathy for those in their team as well as for the end user. Empathy has the potential to provide engineers an awareness and understanding of other perspectives, increase social and emotional intelligence while also improving the way engineers frame and define problems.

Over the course of the next two semesters I will be analyzing if interventions such as LEGO Serious Play increase empathic capacity in engineers. Popular, existing empathy scales such as Davis' Interpersonal Reactivity Index will be used for measurement and compared to narrative based qualitative methods in order to see if empathic capacity can be fostered through these interventions.

This poster traces the way engineering has historically approached these concepts, identifies key problems that demand their incorporation into engineering education and sets out a future research agenda for how empathy and other concepts like compassion could improve engineering teams, pedagogy and design. This research will help to further advance the SciTS field through the study of how empathy and related concepts will help to eliminate communication barriers within teams, assist in the development of better team building practices and understand how building empathy within teams might have a positive impact on engineering research and design.

Poster 8: The Arterial Stiffness Affinity Research Collaborative (ARC): A Successful Example of Team Science

Authors: Francesca Seta (Boston University School of Medicine), Kathleen Morgan (Boston University), Richard Cohen (Boston University School of Medicine), David Coleman (Boston University School of Medicine), Barbara Corkey (Boston University School of Medicine) and Katya Ravid (Boston University School of Medicine)

Background: Arterial stiffness is a vascular condition characterized by progressive remodeling and stiffening of large conduit arteries and an independent predictor of cardiovascular morbidity and mortality. The Arterial Stiffness Affinity Research Collaborative (ARC) was conceived by a group of Boston University (BU) investigators as a cooperative and multidisciplinary research effort, with the goal of elucidating biomechanical, molecular and genetic mechanisms of arterial stiffness and its cardiovascular complications. The ARC existed as a pre-ARC in 2009, when the leadership of the Department of Medicine at the Boston University School of Medicine envisioned the creation of ARCs within the Evans Center for Interdisciplinary Biomedical Research (the Evans Center) to foster biomedical discoveries through an innovative and interdisciplinary approach, which would cross departmental and disciplinary boundaries.

Methods: The Arterial Stiffness ARC, established in 2011 through a peer-review process and re-evaluated yearly through metric-based achievements (grants, publications, seminars), brought together investigators from several departments at BU Medical and Charles River Campuses, and the Framingham Heart Study spanning expertise from bioengineering, cellular/molecular biology, animal models to epidemiology and genetics, as applied to arterial stiffness.

Results: The ARC completed 3 years of funding from the Evans Center, which supported monthly meetings, work-in-progress and seminars/mini-symposia, with intra-mural and extra-mural speakers, essential to spark creative discussions and collaborations. Special emphasis was given to training early stage investigators in the field of arterial stiffness by supporting two PhD students, one Postdoc and one Assistant Professor (Evans Fellow). ARC investigators have 1) discovered, through in vivo mouse studies, novel modulation of stiffness by high fat diet and aging, and identified potential molecular targets to prevent arterial stiffness, 2) established in vitro evidence that arterial stiffness can be modulated by smooth muscle tone by changes in the cytoskeleton adhesion plaque, and 3) established that arterial stiffness precedes the development of hypertension in the human population and in high fat diet-fed mice, providing a rationale for developing translational research to prevent stiffness and cardiovascular disease.

Overall, since the establishment of the ARC, >\$1.7M in new grants and >50 peer-reviewed publications related to arterial stiffness were accomplished by ARC investigators. In addition, several research activities and protocols were established and are the basis of ongoing and future collaborations including: (1) an "Arterial Function Core," consisting of ultrasound echocardiography, blood pressure instrumentation and a stretch-strain apparatus, to provide stiffness and blood pressure measurements (both non-invasively and invasively), and to measure biomechanical properties of rodent aorta ex vivo;(2) a paradigm to probe human GWAS databases to search for genes of interest to ARC members that are associated with stiffness and cardiovascular diseases, and (3) meeting and seminar series that serve as a forum for discussion of novel ideas.

Conclusions: The Arterial Stiffness ARC, within the Evans Center at Boston University is a successful example of implementation of team science, created and supported by institutional leadership and creative investigators, committed to advance the biomedical enterprise through a multidisciplinary approach to human diseases.

Thematic Group 2

Team Dynamics — 4:45–5:30 pm

Poster 9: Eating Together at the Firehouse: How Workplace Commensality Relates to the Performance of Firefighters

Authors: Kevin Kniffin (Cornell University, Charles H. Dyson School of Applied Economics and Management), Brian Wansink (Cornell University), Carol M. Devine (Cornell University) and Jeffery Sobal (Cornell University)

Objective: We investigate team-level benefits that firms might obtain through various supports for coworkers to engage in commensality (i.e., eating together). Our interests complement—and depart from—previous research that tends to focus on artificial team-building activities that tend to require extraordinary efforts, often away from the worksite (e.g., ropes courses).

Methods: With cooperation of a large urban Fire Department as well as the firefighters' union leadership, we conducted field research within firehouses in a large city to explore the role that interacting over food might have for Work-Group Performance. Phase 1 of the project entailed site visits and extensive group interviews at a diverse array of 13 of the city's 62 firehouses. In Phase 2, we surveyed the Department's full set of 395 officers (Captains and Lieutenants) since they function as the work-shift supervisors and we gained 244 completed responses (62% response rate) with at least one full response from 61 of the city's 62 firehouses.

Summary of Findings: Consistent with the interviews that we conducted, a significant positive relationship exists between Eating Together and Work-Group Performance ($r = .19$, $p < .01$). When we conducted multivariate regression analyses that also considered the relative intensity of the firehouse's activity as well as the relative size of the firehouse, the importance of Eating Together in relation to Work-Group Performance proves to be robust. Our analyses use a cluster-robust variance estimator to control for the multilevel nature of our sample whereby each of the 61 firehouses include 4 work-groups that serve non-overlapping shifts. For a within-participants test, when we asked respondents to compare their current firehouse with the last firehouse where co-workers did not eat together (since officers periodically need to work at different locations), participants reported significantly more cooperative behavior within units that routinely eat together ($t = 17.4$, $df = 165$, $p < .001$).

How the Research Advances the SciTS field: Our findings highlight the returns on investment that are feasible for teams and the firms that employ them when they leverage the mundane and powerful activity of eating.

Poster 10: A Transdisciplinary Study of Affect Influence and Contagion in a Closed Social Network

Authors: Patricia Schmidt (Uniformed Services University Health Sciences), Thomas Moore (Complex Adaptive Systems of Systems (CASoS) Engineering Initiative, Sandia National Laboratory) and Patrick Finley (Complex Adaptive Systems of Systems (CASoS) Engineering Initiative, Sandia National Laboratory)

Abstract: Background: Affect, experienced moods and emotions, influences behavior and interactions. Affect contagion, the transfer of moods and emotions among individuals, occurs with social interaction. The relevance of affect in influencing workplace outcomes is well established in psychological and organizational literature. Limited information exists regarding the primary and secondary effect of affect influencing stimuli in a natural setting. The study objective was to introduce an affect influencing stimuli to a closed social network in a natural setting and determine primary and secondary effects of affect contagion.

Methods: A collaborative transdisciplinary team was established to develop this research project. Systems scientists were brought together with nursing and psychology scientists to develop a plan for holistic investigation of affect contagion. The study population was 36 participants from a closed network of 60 first year advanced practice nursing students. Social network surveys were used to establish relationships among the participants. Surveys to measure participant susceptibility to affect contagion and affect expressivity were also completed. Students were surveyed twice daily to measure changes in affect. An affect influencing stimuli was introduced to a subset of participants mid-day and participants returned to the network. Participants were assigned to one of four small groups for stimuli exposure based upon participant betweenness and in-degree centrality. The stimuli exposure to small groups occurred on 12 separate days. The transdisciplinary team developed an agent based model (ABM) that visualizes the network's affect during the 12 stimuli exposure days as well as 3 days without stimuli exposure.

Social Network Analysis and agent based modeling will be conducted to understand affect contagion within the network. Modeling methods allow for observation of the affect contagion's evolution and the ability to modify affect within the model and observe whether it changes outcomes. The ABM uses a mathematical equation that represents the likelihood of a person to change their affect to be closer to the group affect in order to depict the affect contagion. The influence, if any, of the stimuli will be quantified in the new ABM.

Advancement of SciTS field: This study observed the interactions of a closed network over the course of 14 weeks. The evolution of interactions within the network provides insights to the dynamic relationships among

network members. An accurate ABM of affect contagion has the potential to demonstrate the importance of affect on employees and workplace behaviors. It is possible that employers can use the outcomes to modify the work environment or focus affective efforts on specific team members based on a particular characteristic to improve the shared affect and therefore improve workplace outcomes.

Poster 11: Teleconference & Face-to-Face Grant Peer Review: An Investigation of Score and Discussion Time

Authors: Afton Carpenter (American Institute of Biological Sciences), Joanne Sullivan (American Institute of Biological Sciences), Arati Deshmukh (American Institute of Biological Sciences), Scott Glisson (American Institute of Biological Sciences) and Stephen Gallo (American Institute of Biological Sciences)

Abstract: Objective: The use of teleconference (TCON) panels for grant peer review is becoming a desirable avenue for funding agencies, as they reduce costs while being an increased convenience for reviewers. In a previous study, we examined differences between TCON and face-to-face (FtF) peer review panels for an anonymous program (PrX) that convened panels for two funding cycles each of FtF (2009 & 2010) and TCON (2011 & 2012) reviews.1 Our results indicated that the most apparent difference between settings was the average discussion time per application, with TCON panels having shorter discussion time. In this follow-on study, to explore the effects of discussion time and review setting on peer review outcomes we analyzed the post-discussion score shifts (Δ) between the pre-meeting (primary & secondary reviewer) merit scores and overall merit scores (OS; average of voting panel member scores post-discussion) over the scoring range as well as over the scope of discussion times.

Methods: While studies have examined shifts in pre-meeting scores and OS before, to our knowledge, no published studies have investigated the differences in these scores as they relate to FtF versus TCON review settings, as well as discussion time.2 For this analysis, we examined the scoring of applications submitted to four PrX topic areas over a 4-year period, with 2 review cycles each of FtF and TCON review. Altogether, 472 applications were examined, with 260 and 212 applications reviewed by the FtF and TCON settings, respectively.

Results: The average of the pre-meeting scores (primary & secondary scores; APS) were found to be good predictors of the OS ($R2 = 0.74$ [$p<0.001$] and 0.82 [$p<0.001$] for the FTF and TCON review settings, respectively), although the mean squared errors of the linear fits were found to be significantly different for FTF (0.09±0.01) compared to TCON (0.05±0.01). Despite this, no statistically significant difference in Δ was found between the review settings for primary ($t[462] = -0.74$; $p = 0.46$) or secondary reviewer scores ($t[469] = -0.36$; $p = 0.72$), nor from the Δ of APS minus OS (Δs) ($t[464] = 0.17$; $p = 0.86$). Further examination of Δs revealed that 20.4% and 22.6% of scores did not change after discussion, while 26.2% and 20.8% of scores shifted to a better score, and 53.5% and 56.6% shifted to a worse score, for FtF and TCON settings, respectively. When the data were separated into sub-groups of positive and negative Δs, statistically significant differences were detected between the review settings for both the average positive Δs (0.3 and 0.2 for FTF and TCON, respectively; $t[110] = 2.37$; $p = 0.02$) and the average negative Δs (-0.3 and -0.2 for FTF and TCON, respectively; $t[254] = 2.37$; $p = 0.02$). Despite these differences, when grouping by common APS, Δs was found to be poorly correlated to APS for either review setting ($R2 = 0.10$ [$p = 0.12$] and 0.10 [$p = 0.11$] for FTF and TCON, respectively), indicating that the effect of discussion on application scoring was homogeneous across the scoring range.

The average discussion times for the four panels were 25.5 ± 1.1 minutes (FtF) and 18.9 ± 1.1 minutes (TCON). Plots of average discussion times versus common OS yielded no correlation for either review setting ($R2 = 0.02$ and 0.07 for FtF and TCON, respectively [$p = 0.46$ and 0.18]). In addition, poor levels of correlation were observed when grouping by common Δs and comparing these values to the average discussion time for either setting ($R2 = 0.23$ [$p = 0.06$] and 0.29 [$p = 0.04$] for FtF and TCON, respectively).

These results indicate that there are small but significant differences in the effect of discussion between the two review settings. While length of discussion does not seem to be an important variable, perhaps reviewers in FtF panels are more engaged and persuasive tasks are enhanced. It has been hypothesized that there is reduced engagement in TCON settings and that persuasive tasks are most susceptible to the effects of the communication setting.3,4 Additionally, the effect of discussion is more often negative than positive. It may be that persuading panel members of the potential merits of an application is more difficult than expounding on the less abstract identifiable weaknesses. Further input from psychological research (e.g., persuasion, team performance, etc.) is needed to inform future policy decisions regarding review settings for grant application evaluations. Our studies inform the field of Team Science by uncovering subtle differences in the group performance of peer review panels working collaboratively onsite and those that are distributed and collaborating remotely.

Poster 12: Pathway: Guiding Complex Efforts from Inception to Achievement

Authors: Barbara Heath (East Main Evaluation & Consulting, LLC) and Catherine Freeman (East Main Evaluation & Consulting, LLC)

Abstract: There is a growing need for individuals who are trained in different fields to collaborate on innovative efforts to a) solve the ever increasing number of complex problems that face our species and b) set related policies and practices. For the past 15 years, we have participated in or evaluated multidisciplinary collaborations and have identified a consistent set of barriers for complex efforts that impact project implementation and mission achievement. These include, but are not limited to management, decision-making, communication, and mission creep. Understanding the barriers for individual efforts and providing feedback in real-time is critical for project success. We have developed a process that does both and we call it Pathway. During the poster session, we will present Pathway and engage in discussion and debate about the process and its potential application for studying team science.

Pathway is a four-module process with an iterative segment. When the series of four modules are implemented as a whole, it assists a group with defining, executing, and revising their plans resulting in achieving their mission more effectively and efficiently (see diagram). Brief details for each module are described in the following:

1. We facilitate, you define: The first step is to facilitate discussion with the group to encourage communication among stakeholders by mediating jargon and discipline specific language use. The session(s) results in documentation that will drive initial implementation activities.
2. You execute, we collect and analyze: The group executes the plan generated during the define meeting(s). As they do, collection of pre-defined data ensues. Pathway includes a proprietary data collection and analysis framework developed over the past 15 years that provides tailor-made data and analysis solutions. A full report and a set of reflection questions/statements are generated at the conclusion of the analysis.
3. We recommend, you reflect: Each group member reflects on the results from the summary report and uses the reflection guide to share their thoughts. This information is aggregated and used to direct the discussion in the upcoming group meeting(s).
4. We facilitate, you revise or achieve: The final step is to facilitate a meeting with the team to discuss the results from the reports and reflection process. The session(s) results in either revising the execution plan and iterating or declaring success.

Poster 13: 1000(+) People, 4 Years, 1 Report: Producing the Third National Climate Assessment

Authors: Ilya Fischhoff (University of Global Change Research Program), Emily Cloyd (University of Global Change Research Program), and Glynis Lough (University of Global Change Research Program),

Abstract: The poster will address the challenges, successes, and lessons from a massive team science endeavor: the Third National Climate Assessment (NCA3). The NCA is a key deliverable of the U.S. Global Change Research Program (USGCRP), which is a consortium of 13 federal agencies working together to support the Nation's response to global change. Released by the White House in May 2014, the NCA3

summarizes the impacts of climate change on the United States. The chapters and appendices of the NCA3 cover our changing climate, sectors of the economy, regions, and response strategies. The NCA3 is intended to help inform Americans' decisions – about investments, about where to build and where to live, and how to create safer communities.

The NCA3 has been widely covered in the media and praised for its content and accessibility through its website (nca2014.globalchange.gov). Since its release, a number of decision-focused reports and activities have leveraged the NCA3. NCA3 team members have played an important role in outreach for the report and continue to serve as experts for public engagement and decision-making processes.

Over four years, teams developed the assessment process and report. Several types of NCA3 teams coordinated their work and made decisions. Teams included: Chapter author teams (approximately 300 people), federal Advisory Committee (60 members), and staff and agency support and coordination (approximately 100 people). Teams took on the challenges of being interdisciplinary, living all over the world, working together for the first time, and, in some cases, volunteering their time. A further challenge was responding to multiple rounds of review by the public, the National Research Council, and federal agencies.

USGCRP is currently conducting a sustained National Climate Assessment process that will facilitate continuous and transparent participation of scientists and stakeholders across regions and sectors, enabling new information and insights to be synthesized as they emerge. One critical aspect of the sustained assessment process is ensuring that contributors are able to sustain their participation. As plans are ramping up for the Fourth National Climate Assessment, this is a good time to consider how to improve the process for NCA teams.

Poster 14: Collaboration Planning: Planning for Success in Team Science

Authors: Kara L. Hall (National Cancer Institute), Amanda L. Vogel (Leidos Biomedical Research, Inc.), Kevin Crowston (Syracuse University School of Information Studies)

Abstract: While team science has the potential to successfully achieve complex and sophisticated research goals, it can also introduce unique costs, in terms of finances, time, and effort related to the management of large, complex teams.

Written collaboration plans help to maximize the likelihood of success in scientific collaborations by laying out a plan for maximizing effective team functioning. These documents aid in building a strong foundation for a scientific collaboration; identifying facilitating factors and challenges that are likely to influence the success of the collaboration, and developing related strategies to work within these influences; executing the collaboration; and engaging in quality improvement specific to team functioning.

Collaboration planning may benefit any scientific endeavor that includes two or more investigators working together, but such planning becomes increasingly important as a proposed scientific collaboration grows in scope and size. Poor management of large scientific collaborations may negatively impact the quality of the science that is produced, whereas effective management has the potential to foster innovation, creativity, and productivity.

Funding agencies currently emphasize evaluation of the technical and scientific merit of funding applications. But for team science applications, the merit of the proposed collaboration plan may be equally important to the success of the science. We propose that funding agencies consider requiring collaboration plans as part of funding applications, in parallel to research plans. Reviewers can then use submitted collaboration plans to assess the capacity of a proposed team to collaboratively execute its proposed scientific work.

This poster identifies ten components that we recommend as the core content for collaboration plans. It describes in detail the ten components for collaboration planning, which range from providing a rationale for the proposed team composition to identifying what technologies are needed to support communication and workflow coordination, to planning for conflict prevention and management, to budgeting for the planned resources and activities. The poster also highlights key elements for investigators, funders, and reviewers to consider related to each component.

These collaboration planning guidelines provide a strong starting point for investigators and funding agencies interested in collaboration planning. Future research directions may include study of the impact that collaboration planning has on both the collaborative functioning and scientific success of science teams.

Poster 15: Computer Science Teams

Authors: Katie Seely-Gant (National Science Foundation, Energetics Technology Center) and Lisa Frehill (National Science Foundation, Energetics Technology Center)

Abstract: Computer science pedagogy has typically encouraged individual work over team work. Additionally, many computer science programs focus instruction on technical skills, with little attention paid to professional communication, collaboration, and other more "social aspects of problem solving" (Fornaro et al. 2000). As the computer science and technology enterprise continues to grow and seeks to solve larger, more complex issues, collaboration is an increasingly important skill for the computer science workforce (Whitehead 2007).

While emphasis on individual work has traditionally been the norm, recent research shows that computer science students often perform better when working with a lab partner or mentor (Roberts et al. 2002; Gurer and Camp 2001) and may also benefit by learning more soft skills, such as communication and collaboration for problem solving by working in teams or research groups (Fornaro et al. 2000). Additional benefits of teams include developing shared cognition among teammates, ultimately reducing over stress around project work (Entin and Serfaty 1999), increased research productivity (Lee and Bozeman 2005; Kato and Ando 2013), as well as increased efficacy and inter-dimensional team learning as a result of varying skills and competencies (Salas et al. 2008).

There are differences in the use of teams among computer science subfields. Software engineering, for example, has long embraced collaborative teams as an effective means to complete the cumbersome and varied job functions often associated with large-scale software projects. Due to the nature of software engineering projects, these teams are often virtual, relying on a number of technology-based tools to facilitate effective collaboration (Moe et al. 2008; Whitehead 2007; Roberts and Sridhar 2003). The overall success of teams in software engineering may offer best practices and implementation models for other computer science subfields.

This poster will examine the individualistic tradition in computing pedagogy and explore strategies and recommendations for forming and supporting collaborative teams in computer science as well as metrics to assess team productivity outcomes. Research questions include: What is the effect of collaborative teams on research productivity? What metrics are best suited to assess team effectiveness and research productivity? What are best practices for implementing collaborative teams?

Thematic Group 3

Teaming to Enhance Healthcare Delivery 4:45–5:30 pm

Poster 16: Perceptions in Transitions of Care across Healthcare Settings Experienced by Healthcare Providers for Adults 65 Years of Age and Older

Author: Donna Volpe (Pennsylvania State University)

Abstract: I plan to interview healthcare providers to learn what are their perceptions to barriers in the transition of care of elderly patients across healthcare settings. Upon data collection, I will construct a poster presentation. This will be part of my proposed DNP capstone project.

Poster 17: Implementing Innovations into Community Practice: A Tool to Incorporate End-user Perspectives into Decision-Making

Authors: Karin Johnson (Group Health Research Institute), Anne Renz (Group Health Research Institute), Laura-Mae Baldwin (Group Health Research Institute) and Michael Parchman (Group Health Research Institute)

Abstract: Introduction: Health-related scientific discoveries are often relegated to bookshelves after publication rather than being applied in clinical settings. This presentation summarizes efforts of the Group Health Research Institute, in collaboration with the Institute of Translational Health Sciences, to bridge this gap by developing a strategy for assessing whether new discoveries are suitable for scale up and spread.

Methods: First, we identified evidence-based innovations introduced at Group Health or published by Group Health researchers in 2013. We used systematic review methods to select those with sufficient level of evidence and relevance to primary care. Second, we used dissemination and implementation theory concepts to develop a tool to capture primary care clinician stakeholder input about whether evidence-based interventions are suitable for implementation in their settings. Third, we asked primary care practitioners affiliated with a regional practice-based research network to apply this assessment tool to assess potential for spread of a subset of the identified interventions.

Results: We identified 446 articles about potential innovations. Of these, 28 were determined to be potentially ready for spread. We will present findings from primary care clinicians' use of the assessment tool to evaluate 5 of these innovations, reporting on their likelihood of adopting the innovation in the next year based on factors ranging from level of training required to adaptability of the intervention to the needs of their practice.

Conclusions: This team-based approach to research implementation, which blends an evidence synthesis approach with front-line perspectives about fit, will be applied over the next 3 years to promote adoption of evidence-based interventions in primary care and community settings across the 5-state WWAMI region.

Poster 18: Evaluation and Implementation of Interprofessional Collaboration and Practice in a Community Hospital Setting: Science of Team Science Applied

Authors: Terry Eggenberger (Florida Atlantic University), Bernardo Obeso (Florida Atlantic university) and Kathryn Keller (Florida Atlantic University)

Abstract: Background: There has been a surge of interest in the Science of Team Science and Interprofessional Collaborative Practice (IPCP) among healthcare providers (Bennett, Gadlin, & Levine-Finley, 2010). As a result, researchers from different disciplines have come together to form teams to work creatively to understand and improve communication, collaboration, and working relationships among frontline providers at the point of care. A transdisciplinary research team from academia was formed to assist a practice setting in improving interprofessional collaboration. This work was carried out in two phases. In Phase I, interviews with healthcare providers were used to understand their perceptions about the organization's culture, beliefs about existing attitudes towards team concepts, and communication patterns as a prelude to promoting an IPCP model. In Phase II, a pre and post-test design is evaluating strategies to strengthen working relationships, communication, and team collaboration. The intent is implementation of a hospital-wide IPCP model leading to improved interprofessional patient rounds and patient outcomes such as satisfaction, safety, and early discharge planning.

Objective: Typically research to understand hospital healthcare teams has taken place in academic teaching hospitals. Little is known about the attitudes and beliefs of healthcare providers towards interprofessional teams in non-academic community hospitals. There are distinct differences between community and academic hospital settings. One of the more apparent is that older community-based healthcare providers have not had an opportunity to engage in communication and collaboration initiatives such as formalized interprofessional education programs. The long-term goal of this project is to create a practice environment in a community hospital setting that promotes interprofessional relationships, collaboration and teamwork. This became a priority for this community hospital when a new Internal Medicine residency program began. This new

healthcare partner added to the existing team structure and impacted how others (e.g., nursing, pharmacists, current medical staff) interacted and collaborated. A transdisciplinary project team was formed to address this organizational change.

Research Methods: A mixed methods approach began with qualitative interviews, both focus groups and individual, conducted with internal medicine residents, nurses, case managers, pharmacists, and administrators that took place over 8 months. The interviews were audio recorded and transcribed. The interprofessional research team independently read the transcripts using conventional content analysis to code the data and to arrive at themes. The Relational Coordination Scale (Gittell, 2002) will provide pre and post testing of the interprofessional education program intervention.

Findings: Phase I focus groups (N=19) and individual interviews (N=26) provided qualitative data offering insights into the views of pharmacists, nurses, case managers, new residents, hospitalists and community physicians. Emerged themes included Disjointed Communication, Shared Mental Model, Impact of Residency Presence and Mechanisms for Interprofessional Collaboration. These findings were shared with the hospital leadership and were followed with brainstorming sessions on how to promote interprofessional practice. An Interprofessional Collaborative Practice Model is being implemented and evaluated.

Advancing Team Science: A transdisciplinary research team is successfully applying team wcience concepts when operating within and across organizational boundaries. This work will be repeated in other practice settings to improve teamwork in healthcare. Both qualitative and quantitative methods of evaluating teams are explored.

Poster 19: The Loud Surgeon Behind the Console: Feasibility Study in Understanding Team Communication During Robot-Assisted Surgery

Authors: Judith Tiferes (University at Buffalo, The State University of New York), Ann. M. Bisantz (University at Buffalo, The State University of New York), Mohamed A. Sharif (Roswell Park Cancer Institute), Nathalie M. Winder (Univeristy at Buffalo, The State University of New York) and Khurshid A. Guru (Roswell Park Cancer Institute)

Abstract: Objective: The operating room during robot-assisted surgical procedure is a complex environment in which communication between the console surgeon and the bedside team is critical. The introduction of robot-assisted surgery (RAS) has changed the arrangement of the surgical team in the operating theater; the surgeon no longer has physical proximity to the patient and the rest of the surgical team. This requires reliance on verbal communication critical with the team during surgery—a situation that often leads to miscommunication, frustration, possible errors leading to poor surgical outcomes, and at times a very "loud surgeon behind the console!". We report the first pilot feasibility study of verbal and non-verbal communications & team interaction during RAS.

Methods: Intra-operative observation protocols and processes were developed and set in place based on predetermined criteria. Three-network cameras recorded simultaneous capture (console surgeon, operative table, anesthesia and technician). Each team member (lead surgeon, assistant surgeon, bed side assistant, and anesthesiologist and scrub nurse) was given a lapel microphone before the start of the procedure. All environment recording was synchronized with real intraoperative video feed. Questionnaires on team familiarity and cognitive load were collected at the end of each procedure. Observer studied a variety of combinations of surgical scenarios and team-compositions to develop a detailed understanding of communication patterns.

Results: We recorded 11 RAS procedures, with combinations of 2 unique surgeons, 3 assistant surgeons, 2 physician assistants, and 7 scrub nurses. All people present in the OR (staff and patient) gave consent to participate in the study. One procedure could not be recorded due to equipment malfunctions. Some small portions of audio recordings were lost due to interference or participants inadvertently muting the microphones transmitters. Preliminary analysis of the data showed that the combination of the 4 videos (3 cameras and intraoperative feed) and 4 audios allows for a first of its kind opportunity to uncover both verbal and nonverbal interactions during RAS.

How the research advances the SciTS field: While team communication issues have been studied in the OR, the study of non-verbal interactions during (RAS and non-RAS) surgeries has been neglected. Also, the literature regarding communication during RAS has been sparse. This methodology shows a feasible methodology to combine the study of verbal and non-verbal communications in RAS while utilizing interdisciplinary specialties to evaluate surgical safety.

Poster 20: PACE Continuous Innovation IndicatorsTM—A Team-Based Approach for Evaluating Progress in Cancer Care

Authors: Silvia Paddock (Rose Li and Associates, Inc.), Lauren Brum (Rose Li and Associates, Inc.), Kathleen Sorrow (Rose Li and Associates, Inc.), Samuel Thomas (Rose Li and Associates, Inc.), Susan Spence (Rose Li and Associates, Inc.), Catharina Maulbecker-Armstrong (German Ministry of Health), Clifford Goodman (The Lewin Group), Michael Peake (University of Leichester), David Grainger (Eli Lily and Company) and Rose Li (Rose Li and Associates, Inc.)

Abstract: Objective: Understanding the current state of cancer research and treatments is complicated by the large amount of data and the lack of a common framework to evaluate progress. To address this gap, Eli Lilly and Company's Patient Access to Cancer care Excellence (PACE) initiative used a team-based approach to develop the Continuous Innovation IndicatorsTM, a flexible, scientifically rigorous tracking system designed to quantitatively measure innovation in cancer treatments over time. The Indicators allow diverse stakeholders, including clinicians, scientists, policymakers, and patient advocates, to identify and illustrate unmet needs and challenges in cancer treatments. The resulting platform provides a knowledge framework that helps its users to establish a scaffold of the evolving "evidenceome" of cancer treatments. Intuitive visualizations of this framework can facilitate discussions on incentives for continuous innovation in cancer research.

Methods: The Indicators employ a team-based approach to curate the vast literature evaluating the success of cancer treatments. A distributed team of analysts generates discrete Pieces of Evidence from published references that classify treatments and capture outcome measures and statistics in a consistent format. These Pieces of Evidence then become the units of analysis for the calculation of Evidence Scores (E-Scores), a novel measure of progress based on available evidence. A cloud-hosted relational database enables collaboration among analysts in any location and linking of multiple data sources. Crucial to the success of this endeavor is the use of blind duplicate scoring by multiple reviewers to ensure the integrity of the results; if discrepancies arise, an additional analyst mediates the final results. The Indicators' dynamic data management approach allows users to easily integrate new information while reconciling the results on a given treatment with prior evidence.

Findings: A team of analysts curated data from approximately 10,000 literature records to generate a flexible and innovative platform for evaluating the success of treatments in 12 solid cancers. A public version of the Indicators is available at http://paceoffice365-public.sharepoint.com/. The Indicators allow the user to visualize areas of unmet need and to compare E-Scores over time. The Indicators can incorporate the values and priorities of different stakeholders, facilitating a better understanding of how different values affect the interpretation of progress in cancer research.

How the Research Advances the SciTS Field: PACE developed the Continuous Innovation Indicators to become a common knowledge framework and facilitate productive discussions on the future of cancer research and treatments. The Indicators can also be used as a model for a team-based approach to build useful scaffolds of the "evidenceome" of treatments for other diseases, fostering discussions on future funding and research priorities. PACE invites interested organizations to contact the corresponding author regarding potential partnerships and collaborations.

Poster 21: Design and Implementation of the Enhanced Recovery Program

Authors: Bhavesh Amin (Detroit Medical Center, Wayne State University), Ali Sabbagh (Detroit Medical Center, Wayne State University), Nida Aftab (Detroit Medical Center, Wayne State University) and Vinay Pallekonda (Detroit Medical Center, Wayne State University)

Background: The Enhanced Recovery Program (ERP) is an initiative that implements a series of best-practice evidence-based interventions throughout the perioperative period of surgical care (Gustafsson et al 2012). ERP practices are aimed at optimizing patient recovery by decreasing post-operative complications, decreasing length of hospital stay (LOS), decreasing healthcare costs, and overall increasing patient satisfaction. The ERP initiative is designed to enhance the interaction between the health care provider and the patient during the overall recovery process. Studies have shown ERP to decrease LOS and result in fewer complications as compared to control groups (Kehlet et al 2002, Adamina et al 2011, Kalogera et al 2013, Miller et al 2014, Greco et al 2014).

Objectives: To implement a standardized Enhanced Recovery Program involving multiple specialties in the inner-city setting via the collaboration of multidiscipline health care teams in order to improve patient outcomes in the perioperative period.

Methods: The Anesthesiology and General Surgery departments in conjunction headed the ERP initiative with guidance from the Michigan Surgical Quality Collaborative. The idea was discussed with a multidisciplinary team and upon great interest a small research team was assembled to conduct a literature search regarding current ERP data. One department at a time a multidisciplinary team consisting of administration, nursing, physical therapy/occupational therapy, pharmacy, social work, case management, and surgical and anesthesia services was built. Upon presenting our process to additional surgical specialties and other stakeholders we were able to recruit specialty services including OB-GYN and Urology. The ERP process was designed at one Detroit Medical Center (DMC) hospital and then presented to the respective departments at three sister DMC hospitals sites (Sinai-Grace, Detroit Receiving, and Huron Valley). Through a collaborative approach, specific leaders or “champions” were chosen to represent all members of each health care discipline in order to collaborate as a multidisciplinary team to standardize ERP processes so that a system wide approach for perioperative care could be taken across the entire Detroit Medical Center at Wayne State University.

Results: As the ERP initiative moves forward, we believe that we have avoided the majority of potential barriers due to our innovative and collaborative process. To illustrate this progress a survey was sent out to all stakeholders (147 people) presented with the ERP implementation process, which consisted of five questions. Ninety two stakeholders responded within the time frame allotted. Approximately 55% of respondents had never heard of ERP prior to our team building process. 100% of respondents answered ‘yes’ when asked if they liked the ERP multidisciplinary approach. 97.8% of respondents agreed the ERP team building process was organized. 93.3% of respondents identified our approach as efficient. 84.4% of respondents replied they would be confident in taking our team building process to other institutions interested in starting an ERP.

Conclusion: ERP consists of twenty-five evidence-based interventions and our process sets out to assess the situation, align multidisciplinary stakeholders, and apply the ERP process in an efficient manner. The limiting factors identified by our colleagues at other institutions have been related to project organization and staff buy-in. Creating a process targeting the entire ERP with minimal pushback and maximal organization is imperative. We believe that strong teamwork, standardization, and low variability of implementation are essential to high value care.

Effective health care processes are designed to assist and guide productivity and we believe our approach has simplified the ERP team building process and allowed us to identify and address any potential barriers to implementation. As our ERP journey continues we are confident that the initiative we are progressing on will help us assist our health care colleagues in improving perioperative patient care.

Poster 22: Surgical Mentorship During Robot-assisted Surgery: Is the Surgeon Really with the Program?

Authors: Khurshid Guru (ATLAS Program, Roswell Park Cancer Institute), Somayeh B Shafiei (University at Buffalo), Mohamed Sharif (Roswell Park Cancer Institute) and Ehsan Esfahani (University at Buffalo)

Objectives: To elucidate the cognitive performance metrics of robot-assisted surgical mentor during robot-assisted surgery. To identify if viewing operative performance of surgical trainees is similar to performing robot-assisted surgery for a surgical mentor.

Design: An IRB approved study enrolled 51 robot-assisted surgical procedures performed by single surgeon (KG) between 2013 and 2014. A 20-channel wireless EEG recording device was used to monitor brain activity using an ABM X 24 neuro-headset during all surgical procedures. During each task participant's cognitive engagement, mental workload and mental state were evaluated via wireless electroencephalography (EEG) recordings. Two key portions of interaction between trainee and robotic surgeon mentor while performing prostatectomy & cystectomy were included in the analysis: Extended Lymph Node Dissection (eLND) (n=21) and Urethro-vesical Anastomosis (UVA) (n=19). Live, intraoperative exchange between robotic surgeon mentor and trainee in field notes, NASA—TLX based subjective evaluations were also measured.

Results: Lymph Node Dissection: As the trainee surgeon felt that the procedure was more challenging (High Mental and/or Physical Demands), he was more frustrated and had to put more effort and his perception of his performance was worst. Meanwhile the mentor surgeon's workload was increased (continuous concern and more attention) towards the trainee's performance. Urethro-vesical Anastomosis: Whenever the trainee felt the procedure was challenging (High Mental, Physical or Temporal Demands), the expert was paying more attention (Higher MS, lower Distraction). As the trainee felt more operative challenges, the expert also felt it was both mentally and physically demanding. However, it did not affect the perception of expert on trainee frustration, effort and performance level.

Conclusion: Utilization of cognitive performance metrics during live intra-operative mentorship can provide insight into studying team behavior and interaction during complex demanding surgical performance. Further research is required into use of cognitive performance metrics to assess the relationship between performance, mentorship, and its educational impact.

Poster 23: Engineering Solutions to Health Problems: A Workshop to Develop and Sustain Clinician-Engineer Collaborations.

Authors: Karen Demby (NC TraCS), Shawn Gomez (University of North Carolina, Chapel Hill) and David Peden (University of North Carolina, Chapel Hill)

Purpose: The workshop was designed to develop and support collaborations between clinicians and biomedical engineers with the thought that clinicians have many ideas that would advance diagnostics and therapeutics (problems) in both compelling and practical ways and that engineers would have the expertise and tools to design and create solutions to those problems.

Methods: A planning team was assembled that developed high level objectives for the workshop and recruited participants. Clinical and engineering faculty were recruited primarily by personal communication, with the notion that participants should all be 'grant seeking' individuals. Essentially, anyone selected could potentially serve as a principal investigator. Participants were selected based on their interest and expertise in four theme areas: mobile health, clinical devices, rehabilitation, and wild card (various other significant areas that did not fit into the other themes).

Results: Seventy-One clinicians and engineers were recruited and divided into eight groups, with two groups for each theme area. Within the contexts of these theme areas, lists of needs were created, prioritized, and, over the course of the day, specifications for solutions were generated. There is the potential 10-15 projects to develop from these activities. Plans are to follow up with these groups quarterly over the next 12 months to monitor the needs for CTSA services, to determine how well collaborations are working, and to connect the health and effectiveness of collaborations with activities of the workshop.

Poster 24: Transdisciplinary Team Science in the Advancement of a Patient Education Tablet Application

Authors: Vicki Shah (University of Illinois at Chicago), Carolyn Dickens (University of Illinois at Chicago), Adhir Shroff (University of Illinois at Chicago), Vicki Groo (University of Illinois at Chicago), Diana Wilkie (University of Florida) and Andrew Boyd (University of Illinois at Chicago)

Background: Transdisciplinary research involves hard and deep intellectual work and effort, calling for a continuous process of deliberation and exchange of information. Ideas from each participant are so thoroughly interwoven that their specific contributions tend to be obscured by the joint product.[1] In this study, collaboration between different professions has been an essential aspect in the creation of a patient centered tablet application, My Interventional Drug Eluting Stent (myIDEA). Patient anti-thrombotic medication adherence following the placement of a drug eluting stent (DES) is a challenge, as one out of seven patients with a DES stop taking their medication within thirty days.[2] Non-adherence to anti-thrombotic medication leads to a nine times greater risk of death.[3] Collaborators from the University of Illinois at Chicago (UIC) College of Applied Health Sciences (AHS), College of Nursing (CON), College of Medicine (COM) and College of Pharmacy (COP) as well as patient advocates worked together to create an application that would teach DES patients about medication adherence and its importance. This transdisciplinary team of collaborators were chosen as they portray the people who are involved in the patient's post-procedure success in real life.

Team Dynamics: Scheduling Working with so many different collaborators from different professions provided scheduling challenges. We started by giving collaborators six weeks advance notice for a meeting time. Initially all meetings were scheduled via email, but up to 22 email were required for a single meeting. We moved to Doodle, an online scheduling program, was used to set a time and date for meetings, trying to simplify the process which then totaled 9. Some users preferred not to use the Doodle website, complicating the scheduling. Collaborators who had long commutes or were not in state were given the option to call. The impact of having missing collaborators was that they were not able to give full feedback on critical aspects of the discussion. There were many important points that were analyzed about patient medication adherence which benefited from having all perspectives. However, records of important points made during the meeting discussed during a make-up time for their input. Scheduling a single time for all collaborators was impossible.

Team Communication: The patient advocates traveled from all over Chicago to get to UIC. The patient advocates were IRB trained to collaborate on interpretation. Multiple perspectives from health disciplines and patients were useful to provide insightful analysis. Collaborators from COP, CON and COM were able to talk more about how to put the application to use in a clinical setting. The collaborator from COP spoke about how medication and retention rates could be correlated to the participant voice recordings. Over three years, we built upon the idea of transdisciplinary teamwork and the patient advocates became more comfortable about giving their opinion freely in the presence of those with health expertise in the field. The feedback given from each collaborator and patient advocate was essential and tremendously useful.

Conclusion: Creating a transdisciplinary team was critical in designing a patient education application about medication adherence. The same team helped design and interpret a patient-centered research study. In terms of working with so many collaborators, we found that it was better to give a six weeks notice for a meeting, understanding that not everyone could attend. Being flexible with everyone's schedule was also pertinent. We ensured separate meetings with anyone not able to attend the larger meeting time. In a multifaceted health care challenge such as medication adherence, scheduling and communication are two critical aspects to creating a successful transdisciplinary team to ensure all voices are heard and incorporated in the app and study design.

Concurrent Session 1

Novel Face-to-Face Research Networking Approaches 1:30–3:00 pm

Paper 1: Affinity Research Collaborative to Study Neurodegenerative Diseases

Authors: Gyungah Jun (Boston University), David Coleman (Boston University), Katya Ravid (Boston University) and Lindsay Farrer (Boston University)

Objective: The Evans Center for Interdisciplinary Biomedical Research (the Evans Center) in the Department of Medicine at Boston University (BU) established a program to encourage BU investigators from multiple disciplines to assemble Affinity Research Collaboratives (ARCs). A group of investigators from several departments in three Schools on two BU campuses established the Protein Trafficking and Neurodegenerative Disease ARC to explore the role of vesicular sorting and other proteins involved in the intracellular trafficking and processing of key substrates that contribute to pathogenesis of Alzheimer's disease (AD) and other neurodegenerative disorders. One aim of this ARC is to understand genetic and biological processes leading to the generation of the toxic form of amyloid-beta peptide and the accumulation of hyperphosphorylated tau, which are central to AD pathogenesis. The unique and powerful aspect of the ARC is its ability to validate any findings using independent approaches of genetics, cell biology, model systems, and neuropathology.

Methods: Since December of 2009, a total of 28 scientists participated in the ARC from 7 BU departments including Medicine (9), Biochemistry (6), Biology (2), Pharmacology & Experimental Therapeutics (3), Neurology (1), Psychiatry (1), and Biostatistics (1). Nine of these members were at the rank of Assistant Professor, thus providing opportunity in networking with senior investigators and researchers from different disciplines. In addition, 20 trainees including 12 pre-doctoral students and 8 post-doctoral fellows were directly involved in the ARC-related research. ARC members meet once a month to discuss ongoing research progress and learn details of a research area presented by one of the members.

Findings: As of November 17, 2014, the ARC-related research has yielded 28 funded grants to Boston University, Boston Medical Center and the BU-affiliated VA Hospital totaling $5.05 million (annual direct costs), 72 peer-reviewed articles, and 42 abstracts presented at national or international meetings. The ARC organized a symposium that included presentations from six trainees in distinct laboratories and a key-note speaker. Two particular projects highlight successful interdisciplinary collaboration. In one project, ARC genetic epidemiologists identified a novel AD gene, PLXNA4, which has not been previously implicated. After in-depth evaluation of genetic findings together at the ARC meetings, three independent ARC laboratories examined a potential function of PLXNA4 on amyloid-beta production and tau phosphorylation as well as neuropathological effect on autopsied human brains. This effort quickly generated results showing that the full-length PLXNA4 isoform increased tau phosphorylation, had no effect on amyloid-beta production, and significantly correlated with AD-associated pathology and clinical dementia rating. In another project, a collaborative study on behalf of the International Genomics Alzheimer's Project led by ARC members identified genetic variants near MAPT (encoding tau protein) with AD among subjects lacking the APOE $\varepsilon4$ allele, which about 80% of late onset AD cases are absent with the APOE $\varepsilon4$ allele. Subsequent evaluation revealed that these variants regulate alternative splicing of MAPT and an adjacent gene (KANSL1). After discussing in the ARC meetings, ARC neurobiologists conducted mRNA GeneChip experiments to understand role of the novel gene KANSL1. This effort demonstrated that silencing KANSL1 in neuronal cells enhanced expression of genes in semaplexin and ephrin-eph signaling pathways by stimulating tau phosphorylation, suggesting that loss-of-function mutations in KANSL1 may accelerate tau phosphorylation through plexin or eph signaling.

Impact: Interdisciplinary approaches in the Protein Trafficking and Neurodegenerative Disease ARC made important translational impact by providing new potential evidence-based targets for preventive and therapeutic interventions for AD and neurodegenerative diseases. The ARC significantly contributed to scientific community by facilitating team science and for others to lean from, such as 1) encouragement of carrying out researches proposed by early investigators, 2) development of topics for workshops and mini-symposia that bridge between disciplines, 3) active engagement of senior investigators from multiple disciplines, and 4) infrastructure at the Evans Center (http://www.bumc.bu.edu/evanscenteribr/) for guidance and funding support.

Paper 2: Temporary Colocation and Collaborative Discovery

Authors: Sen Chai (Harvard University) and Richard Freeman (Harvard University)

Abstract: Our understanding of how collaborative relationships form remains relatively thin. I assess a specific vehicle that fosters the formation of collaborations by studying how temporarily colocating at conferences affects attendees' research trajectory. The lack of empirical evidence on the impact of conferences on participants has fueled a heated debate. On the one hand, researchers are advised to attend conferences to further their careers, but there are obvious trade-offs of diverted funding and potential productivity loss while away from the bench. I use difference-in-differences regressions on a sample of attendees from Gordon Research Conferences and most similar matched researchers, and several different cuts of the data to address endogeneity of better researchers selected to present, existing co-authors attending together and choosing to go to a conference. My results suggest that even after a transitory period being colocated, long-term collaborations between conference attendees increase with especially strong effects for those who have never published together beforehand. Conditional on collaborative ties forming, I find collaborative outputs between conference attendees draw more from the knowledge space of the conference and are also more highly cited. Conferences also enable attendees who have never been cited by other attendees to showcase their research as evidenced by increases in within-attendee citations. Given the cumulative nature of research, these findings imply that over time conferences can have a significant impact in steering the research path of attendees, from the works that they cite and build upon to the colleagues with whom they collaborate.

Paper 3: Scientific Retreats as Stimulators of Translational Interdisciplinary Team Building

Authors: Damayanthi Ranwala (Medical University of South Carolina), Randal Davis (Medical University of South Carolina), Anthony J. Alberg (Medical University of South Carolina), Kathleen T. Brady (Medical University of South Carolina) and Perry V. Halushka (Medical University of South Carolina)

Abstract: Objective: In an effort to stimulate statewide interdisciplinary translational research team collaborations and innovative pilot projects among translational researchers and community stakeholders, our CTSA—the SCTR Institute—Pilot Project Program has initiated 'speed dating style networking' via biannual Scientific Retreats.

Description: The themes of the retreats are prioritized based on whether the topic is cross-cutting, has a large enough critical mass of local investigators, addresses unmet medical needs, is a significant burden in South Carolina and beyond, and will generate use of novel technologies and methodologies. The format of the retreats is to start the day with a nationally renowned keynote speaker addressing the key issues based on the theme, followed by 3-4 short scientific presentations from local investigators highlighting future research topics that require new collaborations. The presentation sessions are repeated 3-4 times during the day. The presenters represent different disciplines. The speed dating style networking sessions are held in between the presentations. The participants congregate at networking tables to meet each other and exchange ideas about potential future research pilot projects and creating new interdisciplinary research teams. The retreats are concluded with a SCTR Institute Pilot Project Program overview and how to apply for research funding for the new ideas/projects that are developed as a result of the retreats. The Pilot Project Program has issued special funding opportunity announcements based on the retreat themes or set aside funds to support innovative pilot projects that emanated from the retreats.

Summary of findings: SCTR Institute held a total of 11 retreats since 2009. The retreat themes included—Cardiovascular Diseases, Bioengineering & Regenerative Medicine, Telemedicine, Neurological Diseases & Injury, Biomedical Imaging, mHealth Technology, Obesity, Implementation Science, Comparative Effectiveness Research, Pain and Tobacco.

The retreats have had a statewide reach and an average of 75 attendees per retreat including participation from basic scientists, academic clinicians, clinician-scientists, community-based physicians, nurses, population scientists, community engaged individuals and trainees. The retreat format has proven to be very effective with an overall satisfaction rate of 80% or higher and in fostering new interdisciplinary team building and collaborations. Further, 63 pilot project applications have emanated from the retreats requesting pilot funding from SCTR Institute with 15 funded to date as new interdisciplinary team collaborations. Further, this research has led to extramural peer-reviewed funding. The pilot projects that emanated from the Neurological Retreat supported a successful NIH Centers of Biomedical Research Excellence (COBRE) application in stroke. The Bioengineering and Obesity Retreats stimulated investigators from two institutions and disciplines (bioengineer from the Clemson University's Human Factors & Ergonomics Research Institute and a clinician from the MUSC Weight Management Center) to collaborate on a proposal to investigate a bite counter (developed at Clemson) as a tool for weight loss that has already resulted in 4 peer-reviewed publications, a Small Business Technology Transfer (STTR) grant, and a pending NIH R01grant. The Telemedicine retreat resulted in two Duke Endowment grants (The Virtual TeleConsult Clinic and Remote Expert Assessment of Lung Cancer). The Obesity Retreat generated collaborative projects between MUSC researchers (pediatrics) and community organizations, including a school-based study focused on pediatric obesity that translated into policy changes regarding daily dietary guidelines in two school districts.

How the retreats advance the SciTS field: Post-retreat attendee's evaluation data show that some of the new team building and team collaborations would not have happened without the retreats.

A few quotes from the attendees in their own words: "The project overall has grown, and would not be where it is now, without SCTR's retreats and early help with the pilot funding support". In some cases where attendees may have had collaborations already developed, the retreats have further enhanced the collaboration and/or the pilot research work where they indicate the retreats "watered it and helped it grow". In summary, the SCTR Institute Scientific Retreats have stimulated the formation of new interdisciplinary research team.

Paper 4: A Field Experiment on Search Costs and the Formation of Scientific Collaborations

Author: Kevin Boudreau (London Business School), Tom Brady (Massachusetts General Hospital), Ina Ganguli (University of Massachusetts Amherst), Patrick Gaule (CERGE-EI), Eva Guinan (Dana Farber Cancer Institute), Tony Hollenberg (Beth Israel Deaconess Medical Center) and Karim Lakhani (Harvard Business School)

Abstract: Scientists typically self-organize into teams, matching with others to collaborate in the production of new knowledge. We present the results of a field experiment conducted at Harvard Medical School to understand the extent to which search costs affect matching among scientific collaborators. We generated exogenous variation in search costs for pairs of potential collaborators by randomly assigning individuals to 90-minute structured information-sharing sessions as part of a grant funding opportunity for biomedical researchers. We estimate that the treatment increases the baseline probability of grant co-application of a given pair of researchers by 75% (increasing the likelihood of a pair collaborating from 0.16 percent to 0.28 percent), with effects higher among those in the same specialization. The findings indicate that matching between scientists is subject to considerable frictions, even in the case of geographically-proximate scientists working in the same institutional context with ample access to common information and funding opportunities.

Concurrent Session 2

Citizen Science and Crowdsourcing 1:30–3:00 pm

Paper 1: Making a Place at the Table: Crowdsourcing Design for Citizen Science

Authors: Carol Boston (University of Maryland), Jennifer Preece (University of Maryland), Mary Lou Maher (University of North Carolina Charlotte), Kazjon Grace (University of North Carolina Charlotte) and Tom Yeh (University of Colorado Boulder)

Abstract: Goal: Bonney et al. (2009) note that members of the public have varying degrees of involvement in the design and operation of citizen science projects, ranging from contributory to collaborative to co-created. Very often, they have little say in the technology used to support citizen science projects. Researchers from three universities received NSF support to explore the effect of including the crowd (i.e., visitors to a nature preserve in Colorado) in the design of interactive social technology while collecting and sharing biodiversity data. The technology is deployed on three platforms: a smartphone app, a tabletop computer, and a website, known collectively as NatureNet (NN). This paper describes the mediated deployment processes that have shaped our ideas for crowdsourcing the design of NatureNet.

Methods: Design sessions, focus groups/interviews, surveys, ethnographic field studies, log data analysis.

Findings: University researchers correctly anticipated that a large interactive tabletop displaying visitor contributions in a public area (see Figure 1) would trigger interest in the task of collecting observations but overestimated the crowds' interest in commenting on others' observations and contributing design ideas. These early results prompted researchers to first focus on the participation of naturalists in shaping the design. Their extended engagement with the technology and deep understanding of visitors resulted in three major shifts in design: 1) development of structured and guided scientific activities and challenges for visitors; 2) new focus on facilitating Q&A between visitors and naturalists via technology; and 3) support for extending visitor engagement with the NN website. These design foci are consistent with recent citizen science research showing that the interactions and relationships between scientists and volunteers are key to fostering volunteers' long-term participation (Rotman, 2013).

Contributions: Exploration of the dynamics, communication, and resource issues associated with researcher-practitioner-crowd design teams in citizen science and strategies for increasing contributions from the crowd through a combination of place-based and virtual crowdsourcing (see Figure 2).

Paper 2: Participation Dynamics in Crowd-Based Knowledge Production: The Scope and Sustainability of Interest-Based Motivation

Authors: Henry Sauermann (Georgia Institute of Technology) and Chiara Franzoni (Politecnico di Milano)

Abstract: Crowd-based production of scientific knowledge is attracting growing attention from scholars and policy makers. One key premise is that participants who have an intrinsic "interest" in a topic or activity are willing to expend effort at lower pay than in traditional employment relationships. However, it is not clear how strong and sustainable interest is as a source of motivation in crowd-based knowledge production. We draw on research in psychology to discuss important static and dynamic features of interest and derive a number of research questions regarding interest-based effort in crowd-based projects. Among others, we consider the specific versus general nature of interest, highlight the potential role of matching between projects and individuals, and distinguish the intensity of interest at a point in time from the development and sustainability of interest over time. We then examine users' participation patterns within and across 7 different crowd science projects that are hosted on a shared platform, Zooniverse. The data set includes information on the daily activities of over 100,000 volunteers, resulting in over 32 million person-day observations.

A first set of analyses examines the scope of interest-based motivation. These analyses build on prior research suggesting that interest should be conceptualized as the relationship between a person and a particular object (e.g., task, project, topic), rather than as a general trait of the person or a general characteristic of the object. Consistent with the notion that interest is quite specific and that many project-person pairs fail to result in a match, we find that most members of the installed base of users on the platform do not sign up for multiple projects, and most of those who try out a project do not return. Even those individuals who participate in multiple projects appear more likely to choose projects in the same scientific field rather than in different fields. Thus, our results suggest that interest-based motivation tends to be quite specific. At the same time, some individuals appear to have an interest that generalizes across topics and fields. Interestingly, controlling for the general time trend, contributors who start with one project and subsequently enter new ones increase their overall level of effort on the platform, although we also observe some crowding-out of effort in the first project.

Building on the notion that a given person's interest in a particular object can develop and change over time, a second set of analyses examined the sustainability of interest. This dynamic analysis shows that interest declines rapidly, with a large majority of the participants who returned to a project (and thus were likely an initial match) dropping out within a few weeks. However, we also observe some contributors whose activity increases over time, especially when we analyze activity at the level of the platform rather than individual projects, thus taking into account switching into additional projects. Individual-level heterogeneity in both initial levels of participation and in the dynamics over time translates into a highly skewed distribution of contributions, with a small share of contributors driving most of the output of projects.

Overall, it appears that interest can be a powerful motivator of individuals' contributions to crowd-based knowledge production, as evidenced by thousands of hours of effort invested in the projects we studied. However, both the scope and the sustainability of this interest appear to be rather limited for the large majority of contributors, with many participating only in a single project and only for a few days. At the same time, some individuals show a strong and more enduring interest to participate both within and across projects, and these contributors are ultimately responsible for much of what crowd science projects are able to accomplish.

We discuss implications for crowd science organizers as well as policy makers. In addition, we consider how insights from the setting of crowd science may inform our understanding of ongoing changes in the area of "traditional" science, including increasing team size, increasing openness, and a growing role of internet-enabled collaboration.

Paper 3: Biomedical Citizen Science: Barriers and Opportunities for Success

Authors: Katrina Theisz (Kelly Government Solutions, National Cancer Institute), Jennifer Couch (National Cancer Institute) and the NIH Citizen Science Working Group (National Institutes of Health)

Abstract: The National Institutes of Health (NIH) Citizen Science working group is interested investigating the utility of and furthering the incorporation of citizen science methodologies into biomedical research in a way that maintains NIH's high level of scientific and ethical standards. The working group describes citizen science as a collaborative approach to research involving the public, not just as subjects of the research or advisors to the research but as direct collaborators and partners in the research process itself. Citizen science takes on many forms and involves a variety of approaches benefiting from the creativity and problem solving skills of the public and from citizen collected data and insights not obtainable through conventional approaches. This group investigates, shares best practices, and engages in discussion with other agencies and groups promoting citizen science in other fields. The working group is comprised of program officers, scientific review officers, and others from across NIH interested in furthering the adoption and incorporation of citizen science methodology into biomedical research.

In May 2013, the NIH gathered thought leaders and practitioners in the fields related to citizen science, with a particular focus on those whom had successfully run biomedical citizen science projects, for a think tank entitled, "Citizen Engagement in Biomedical Research." The key recommendation was that the opportunities were vast and the methods were solid, but the participants noted that NIH involvement in this sphere would bring a level of needed scientific rigor to the field. To dig deeper into some of the barriers of biomedical citizen science as well as one of the areas of opportunity, two workshops were recently organized; one to address the ethical, legal, and social issues of biomedical citizen science, and the other to explore the potential for biomedical research games. The outcomes and lessons learned from these workshops will be the focus of this presentation.

Impact on the SciTS field: Much research has been done and is being done on the efficacy and impact of size, scope, and transdisciplinarity of research teams (among many other levels of assessment and evaluation), but these types of evaluation are only just beginning in the field of citizen science and crowdsourcing, particularly in the case of biomedical citizen science. As more biomedical researchers accept and adapt these citizen science and crowdsourcing methods (and as more citizen scientists partner with researchers), questions arise as to the efficacy, privacy, and ethical nature of the research, as happens with all research involving human participants (most often referred to as human subject research), though in this case on a much larger scale. The hope of the authors, and one of the goals of the working group, is to develop a set of best practices for biomedical citizen science with the help of the citizen science and crowdsourcing community.

Paper 4: Hackathons for Team Science: How and When Do They Work?

Authors: Erik Trainer (Carnegie Mellon University), Chalalai Chaihirunkarn (Carnegie Mellon University), Arun Kalyanasundaram (Carnegie Mellon University) and James Herbsleb (Carnegie Mellon University)

Abstract: Scientists rely heavily on software, from small scripts that process data to large "workbench" applications that integrate visualization, simulation, and analysis. Because software is easily replicated and distributed, it can be collectively maintained and enhanced. In practice, however, even when qualified and motivated people are available, a lack of social infrastructure and users' unfamiliarity with the code base present barriers to contribution. To overcome these barriers, scientific communities are experimenting with hackathons, short-term intense events where teams of scientists from academia and industry, postdocs, graduate students, and software developers collaborate face to face to share and develop software. Prior research suggests that hackathons may be effective ways to attract and train new contributors, learn about technical details of users' needs, and create and enhance ad hoc teams. We know little about the immediate outputs of these hackathons, and we know even less about how to plan them to maximize the likelihood of success.

This presentation describes a multiple-case study to understand the steps a hackathon goes through as it evolves, and how these steps relate to success. Our results indicate that steps fall under three stages: a preparation stage marked by event logistics, task brainstorming, preparing tools or datasets, and learning about tools and research profiles; an execution stage marked by team formation, building solutions, knowledge sharing, and small talk; and a follow-through stage marked by stimulation of user engagement, reification of ideas, and maintenance of social ties. In this presentation, we elaborate on three different team formation strategies in the execution stage that suggest a tradeoff between technical progress and building community. This study sheds light on the practices of scientific teams working within extremely short time scales, unlike most other work that has focused on longer scale team science initiatives. This work also provides practical design guidance for scientific communities looking to carry out hackathons. Finally, it can support funders of research who see hackathons as promising investments in science but also want realistic expectations about their outcomes.

Concurrent Session 3

Gender and Science Teams 1:30–3:00 pm

Paper 1: Gender and Team Science: Improving Collaborative Effectiveness of Research Teams

Author: Holly Falk-Krzesinski (Elsevier)

Abstract: Both interdisciplinary research and collaboration in science are on the rise and there's empirical evidence that team science, especially when done by teams with diverse membership, produces more highly impactful research. And, despite decades of efforts, disparity persists between participation of men and women in science, including in collaborative endeavors. While major funding initiatives such as the European Union's Horizon 2020 program includes an explicit objective for, "gender balance in research teams," the scientific community, research institutions, and funders remain under-informed about how best to attain such an objective.

This presentation addresses gender issues in team science from the perspective of advancing and facilitating actions at the organizational level, where the main goal is to improve the diversity, capacity, and quality of human capital by creating a more responsive, effective and efficient research environment for people to develop and work. Literature related to gender and team science is reviewed, with a focus on evidence-based policy implications designed to guide how research institutions can improve the processes and practices that affect how team science is conducted. Findings regarding gender differences and diversity from the following research areas are highlighted: research collaboration , team productivity and performance, expertise recognition and evaluation of performance, and collaboration strategies and networks.

Paper 2: Why do Articles Written by Women-Led Teams Receive Fewer Forward Citations than those Written by Men-Led Teams? Evidence from MEDLINE.

Authors: Richard Freeman (Harvard University) and Sifan Zhou (University of Albany)

Abstract: Forward citation is widely used to measure the scientific merit of articles and in turn the research productivity of scientists. We study a sample of more than a million journal articles from MEDLINE published between 2002 and 2007, and find that articles written by women-led research team receive fewer forward citations than those written by men-led research team do. Observable gender differences in academic field, collaboration style, research experience, and journal impact factor explain two thirds of the citation gap. Further examination of who are citing men- versus women-led team reveals that: 1) women-led team receives fewer self-citations than men-led team does; 2) both genders are more likely to be cited by the same gender. Given that man is still the majority among life scientists and men publish more frequently than women, the gender homophily in citation will leave women at disadvantage in getting forward citations. Our study suggests that we should always be cautious in interpreting the number of forward citations, especially when the difference in it is small, when the economic decision at stake is large, and when a comparison between a minority and a majority is involved.

Paper 3: Team Science, Collaborations, and Mentorship: An International Approach

Authors: Lisa Frehill (National Science Foundation) and Katie Seely-Gant (National Science Foundation, Energetics Technology Center)

Abstract: Team science is a collaborative, cross-cutting approach to scientific research to explore new ideas and perspectives. Team science's collaborative approach can especially important in resource-intensive bench sciences to share increasingly expensive equipment and supplies in an era of tighter fiscal exigencies. Additionally, collaborative teams offer the possibility for the formation of multiple mentorship relationships.

As the science enterprise becomes increasingly globalized, it is important for researchers to gain international research experience as well as attain a level of global competence to more effectively work and collaborate in international environments. These international experiences can be especially important for women (Frehill and Zippel 2011 and George et al 2009) and researchers at Minority Serving Institutions (MSIs), at which resources are often more constrained than at larger research-intensive institutions. For example, a recent study by the American Council on Education found that Historically Black Colleges/Universities (HBCUs, a subset of MSIs), often lack the resources or capacity necessary to support robust study abroad programs (ACE and CIGE 2014). (MSIs vary greatly in the extent to which they are research-intensive, with some institutions within the popularly referenced Research I Carnegie category while others have more teaching-intensive missions.)

Just as international experiences are key for researchers in a new, globalized workforce, so are they also for students, who have traditionally used study abroad as a means of accessing international experiences. Such programs, however, usually emphasize language and general knowledge rather than science and engineering, as noted in a working paper by the Institute of International Education (Berdan and Johannes 2014). Learning how different scientists in different national contexts approach the inquiry process provides a breadth of experience that is not often available within the structure of most study abroad programs.

By participating in international research collaborations, both researchers and their students have the opportunity to form intercultural teams while also gaining valuable international experience. These teams also present the opportunity for multi-dimensional mentoring between faculty, their students, and foreign collaborators.

This paper reports on findings from an evaluation of the American Association for the Advancement of Science's (AAAS) Mentoring Women in International Research Collaborations (MWIRC) Project. The MWIRC program provided funding for 15 PIs at US MSIs to initiate research collaboration with an international colleague. PIs were required to include a graduate student or a postdoctoral scholar as a mentee. Multiple modes of inquiry were used in our assessment to understand the outcomes and experiences of the PIs and mentees within the collaborative team context. Phone interviews (mean time: 1 hour; qualitative semi-structured) with 14 of the 15 PIs, online surveys of PIs and mentees, review of PIs' original funding applications, reviewers' assessments, and other program documentation provided rich qualitative evaluation data.

The presentation's key findings highlight the benefits of PIs' team mentoring relationships formed over the course of the project including those with their international colleagues and the students and postdocs in their respective groups. Importantly the PIs' planning and execution of the collaboration were key in informing policy guidelines about forging successful teams in the international context. The paper's findings are also important to MSI research administrators for whom there may be challenges in retaining and supporting women and minorities in STEM research. The evaluation team and AAAS are drafting guidance for MSI administrators and faculty on strategies to engage in productive international team science collaborations based on the evaluation findings.

Paper 4: "Girls Rock, Yes We Do:" Improving Retention of Girls in Science Using a Diverse, Interdisciplinary Team Approach

Authors: Kathryn Clancy (University of Illinois, Urbana-Champaign), Ayesha Tillman (University of Illinois, Urbana-Champaign), Carla Hunter (University of Illinois, Urbana-Champaign) and Jennifer Amos (University of Illinois, Urbana-Champaign)

Abstract: STEM students and trainees need a liberal arts education. What's more, research suggests that such an education connecting science to society increases the interest and retention in science of underrepresented individuals, particularly girls. Our interdisciplinary collaboration of four women, two of whom are African-American, includes an engineer, an anthropologist, a psychologist, and an evaluation specialist. We work to integrate and evaluate social science perspectives and methodologies with bioengineering training in a girls' summer science camp for rising ninth graders through seniors in high school. This BioE camp is a track within the Girls Adventures in Math, Engineering, and Science (GAMES) camps offered at the University of Illinois.

Our objectives for our campers are 1) to provide a transdisciplinary perspective, 2) to retain these campers in science, as they are all female and one third girls of color, and 3) instill a sense in them of the importance of diversity and inclusion in science. Our campers spend each morning engaging in small group, team science activities that provide a social science perspective to the laboratory work with which they engage in the afternoons. Much of the work we do with the campers in the mornings revolves around issues of gender, race, and the historical context of science.

We used exit surveys to determine the extent to which our project increases their intention of pursuing science or engineering in college. In a preliminary analysis, we have found a trend towards our campers having an increased level of confidence in their ability to pursue a career in engineering in the two years we have offered our transdisciplinary program (2013 and 2014), compared to a past year when we did not offer it (2012) ($p \leq 0.06$ for 2013 and $p \leq 0.08$ for 2014). When comparing the Bionengineering track to other GAMES tracks, BioE campers reported an 8% higher interest pursuing engineering and confidence in engineering careers. The lessons learned by these first two pilot years will be used to improve upcoming iterations of the camp to continue to increase retention.

Interdisciplinary teams have become increasingly necessary to plan, implement, evaluate, and disseminate results of STEM educational programs. A large part of our approach has been to model inclusive, societally-focused science. As a collaborative team that is ourselves diverse in discipline and demographics, we provide an evaluative and autoethnographic perspective on team-based science. In this oral paper we advance our team's best practices and objectives: 1) discover egalitarian ways to support each other's perspectives and improve our program and research; 2) reflect on challenges and opportunities revealed by our diversity; and 3) engage with our diversity to explore new ways of producing research, publishing, and advancing our joint perspective.

Concurrent Session 4

Organizational Approaches and Design Strategies for Team Science 1:30–3:00 pm

Paper 1: Towards Developing a Research Capability Framework

Authors: Airong Luo (University of Michigan Medical School), Marcy Harris (University of Michigan, School of Nursing) and Barbara Mirel (University of Michigan, School of Education)

Abstract: Rapid advances of technologies, computational methods, and wider and faster network connectivity have created opportunities to address scientific problems with new sources and types of data, new research strategies, and new forms of collaboration. Studies on team science tend to focus on technologies and social practices that facilitate coordination and communication within virtual teams and organizations. However, virtual organizations are "not so virtual" (Lee, Dourish, & Mark, 2006). Concrete local organizations—and the resources and services they provide—are crucial for efficient and productive team science. Moreover, interaction with researchers in a virtual team only constitutes part of researchers' daily practices. At present, little research

systemically examines the dependencies that exist between collaborative research processes and the concrete technical and organizational capabilities and capacities required for researchers to participate in virtual collaborations.

Purpose of this study: To explore key factors that enable research capability in academic institutions; the factors provide the key structural dimensions of our proposed Research Capability Framework (RCF). Research capability is the competency to leverage human, organizational and technical resources and services for a purpose defined by research goals. We anticipate that RCF can be used as an artifact to promote mutual understanding and communication between researchers and service departments, to profile an institution's or a research group's current readiness, to guide planning, and to help institutions align strategy with requirements.

Methods: We conducted and analyzed 40 interviews with PIs and members of research teams at a university classified as "very high research activity" in Carnegie Classification of Institutions of Higher Education. We complemented the interviews with a case study of a highly productive research group that exhibited collaborations at various scales. Additionally we reviewed and synthesized literature to identify factors leading to successful research performance in collaboratories, and to determine if any existing capability models could be adapted for our research purpose. Our data sources also included interviews and analyses conducted by consultants contracted by the university and a capability list created by an enterprise architect based on nine research use cases.

Results: Our findings suggest that researchers engage in different resources, services, stakeholders and collaboration processes at different stages of a research project. Based on our findings and inspired by Community Capability Model for Data-Intensive Research (https://communitymodel.sharepoint.com), we developed RCF to provide a comprehensive view of enabling factors that shape researchers' requirements for the efficiency and effectiveness with which they can conduct their collaborative workflows. RCF is presented in Excel spreadsheets. "Research Profile" and "Collaboration Profile" tabs aim to profile research projects and identify configurations of different types of collaborations. Additional RCF tabs list factors that enable research capability. These factors include skills and training, data management plans, data and information management, openness, service discoverability, technical infrastructure, economic and business models, and governance, legal and ethical issues. Within each factor, there are a series of attributes ranked on a 1-5 scale, which represents researchers' descriptions of their levels of activity/ support. Our next steps are to refine and validate RCF.

Paper 2: Design Theory for Team Science

Author: Ben Shneiderman (University of Maryland)

Abstract: Responding to the immense problems of the 21st century will require devoted research teams with passionate leaders who are skilled at nurturing individuals, weaving networks, and cultivating communities. The growing evidence shows that designing research teams with raised ambitions to find practical solutions and seek foundational theories simultaneously have a greater chance of achieving both (ABC Principle: Applied & Basic Combined).

Future research heroes will be those who make innovative use of powerful web-based, social media, and visual tools to speed their work, find helpful collaborators, and promote their results to wider audiences. Then by blending science, engineering, and design (SED Principle), research teams are more likely to achieve high impact as they: (1) Choose actionable problems that address civic, business & global priorities, (2) Apply observation, intervention, and controlled experiments, (3) Form teams with diverse individuals & organizations, (4) Test prototypes with realistic interventions, and (5)Promote adoption & measure impact.

My hope is to accelerate current trends by re-designing research teams and re-shaping the research lifecycle. Evidence is growing that these design strategies can more rapidly expand human knowledge through refined theories, while solving societal problems. Science research teams could benefit from design thinking, design methods, and design research. This applies to team formation strategies, as well as work processes, and evaluation methods. Recommendations for change will be made for: students, young researchers, senior researchers, academic administrators, business leaders, government policy makers, professional societies, publishers, and journalists.

Paper 3: A Proposed Framework for Evaluation of Scientists Collaborating in Team-Based Research

Authors: Madhu Mazumdar (Icahn School of Medicine, Mount-Sinai), Shari Messinger (University of Miami Miller School of Medicine), Dianne M. Finkelstein (Harvard School of Public Health), Judith D Goldberg (New York University School of Medicine), Christopher Lindsell (University of Cincinnati), Sally C Morton (University of Pittsburgh), Brad H Pollock (University of California at Davis), Mohammad H Rahbar (University of Texas School of Public Health at Houston), Leah Welty (Northwestern University Feinberg School of Medicine) and Robert Parker (Harvard University)

Abstract: Criteria for evaluating academic faculty are traditionally based on a triad of scholarship, teaching, and service. Scholarship is often measured by first or senior authorship on peer-reviewed scientific publications and leadership (Principal Investigator role) on extramural grants, though some institutions have added a career path that emphasizes educational scholarship with somewhat different metrics. Scientific innovation increasingly requires collective rather than individual creativity, which traditional measures of achievement were not designed to capture, and actually undervalue.

We propose a framework for evaluating scholarly contributions to team science and highlight items of unconventional education and specialized service which need to be incorporated in the assessment of team scientists. Examples of non-traditional evidence and an approach for documenting such contributions in a quantitative and qualitative manner are provided. We use biostatisticians as an illustration, but the approach outlined is generalizable to team scientists across scientific disciplines.

We have three key recommendations to members of institutional promotion committees and departmental chairmen. First, evaluation of collaborative scientists' contributions to team-based scholarship and specialized contributions to education and service need to be assessed and given appropriate and substantial weight in promotion decisions. Second, evaluations must be founded upon well-articulated criteria for assessing the professional stature and accomplishments of team scientists. Finally, appropriate mechanisms to assess an individual's contribution to team science need to be developed specific to each field of study and implemented at the institutional level. Without these three essentials, we fear that contributions of team scientists will continue to be undervalued in the academic environment.

Paper 4: A Thermodynamics of Interdependence: Teams, Individuals, and Science

Author: William Lawless (Paine College)

Abstract: Introduction: Social objects (teams) are interdependent (Bell et al., 2012). But teams lack a mathematics of interdependence (e.g., Schweitzer et al., 2009). With the advent of computational teams (e.g., transportation, space travel; medicine, military), this lack has impeded the science of team science, precluding effective and efficient models of arbitrary combinations of humans, machines and robots. Instead, normative science reigns; e.g., traditional approaches to social models remove interdependence to improve experimental replication. But their god's eye view of reality assumes that signals observed by scientists model social reality (Rand & Nowak, 2013, p. 415). Admittedly not "a good representation of that world" (p. 416), the results simply restate social and religious norms: "The population does best if individuals cooperate" (p. 413; for teams, see Bell et al., 2012, p. 40). By ignoring norms, our thermodynamics of teams has led to breakthroughs (Lawless et al., 2015).

A team is a social object constructed to multitask when individuals cannot, requiring channels to communicate, coordinate and block information, generating team boundaries and noise. Measurement of social objects affect results, like quantum objects. But indirect field evidence indicates that the best teams minimize noise, making them opaque to science (Lawless et al. 2015); so do gangs as they generate entropy to suppress public notice (i.e., "dark" social networks). Poor team performers, in contrast, waste energy, requiring new resources to survive (e.g., mergers). The goal of multitasking becomes to control resources and team boundaries.

Multitasking is not rational. Humans often misjudge reality, engage in magical thinking, and refuse to work in teams. Machines are governed by signal detection theory (SDT); and while better than humans at detecting some signals, they cannot yet multitask autonomously.

Neither group improves on SDT. Assume reality consists of subjective and physical signals, redefined as imaginary and real (e.g., self-reports and behavior), construing social dynamics as vectors in 2-D space. In this Hamiltonian (countable) space, agreement follows the adoption of a plan to gain energy (where cos 0 deg equals 1), disagreement the uncertainty that spontaneously generates alternatives (cos 90 deg = 0). Competition (conflict) helps an audience process alternatives (e.g., competing scientific claims), determined by the free movement of individuals from one to another team (random exploration and stochastic resonance) as the winner determines resources and team boundaries.

A limit cycle illustrates the non-linear nature of interdependence arising from the inability of either team to capture the social reality of both sides of an argument (Lawless et al., 2015). To solve ill-defined problems by reducing illusions and challenging prevailing beliefs, conflict centers become social resources. Witness that authoritarian (consensus, minority control) regimes shutter conflict centers, impeding social evolution.

The thermodynamics of interdependence (SDT) precludes completeness, limiting the information collected by human, machine or robot scientists, constraining meaning and predictability. These models lack convergence, but more closely match social reality; i.e., incomplete social information causes uncertainty; individual movements control social and scientific reality (e.g., juries; scientific peer review). But uncertainty can be exploited to reduce team mistakes with metrics to improve team operations and governance. As an example, given , where LEP is the least entropy production for teamwork, MEP the maximum entropy production for team exploration, and sigma the standard deviation, as becomes a minimum in the limit, becomes a maximum, allowing the best team maximum effort to search its environment for solutions to its problems. But, when teamwork requires maximum effort, as it does under suppression, teams are no longer innovative, a breakthrough model of the Department of Energy before 1985 when DOE suppressed its scientists into supporting its use of cardboard boxes as DOE's primary container for solid nuclear wastes as protective of the environment, until DOE was challenged in public (Lawless et al., 2015; see figure below).

Summary: By limiting rationality (prediction and replication), interdependence is a resource to address ill-defined problems (i.e., scientific questions). Unlike swarms, machine learning and game theory, in our model, teams can only be controlled indirectly to solve ill-defined problems (e.g., training).

Concurrent Session 1

Our Scholarly Recognition System Still Doesn't Work (Panel) 3:15–4:30 pm

Authors: Daniel Katz (Univeristy of Chicago & Argonne National Laboratoty), Amy Brand (Digital Science), Melissa Haendel (Oregon Health & Science University) and Holly Falk-Krzesinski (Elsevier)

Abstract: With a historical focus on individual disciplinary achievements, the scientific community has been slow to figure out how to adequately recognize and reward accomplishments by individuals that occur across disciplines and in the context of collaborative work. This is a serious impediment to fostering effective team science. This panel will discuss issues around scholarly recognition, specifically authorship, contribution, credit, and attribution as associated with the development of scholarly products. Current models of shared authorship and attribution are an obstruction to scientific collaboration. When there are multiple authors, we tend to rely on the order in which names are listed to determine the most significant contribution, when in fact there are no consistent name ordering practices from one field to another. Yet who gets credit for research and discovery has a tremendous impact on people's lives. It affects career advancement and tenure, as well as the

transparency and integrity of the permanent research record. Even in fields such as economics in which the author order is alphabetical and a supposition of relative contributions has been removed, it has been shown that one is more likely to get tenure or win a prestigious prize if your last name begins with a letter earlier in the alphabet.

How we apportion credit for collaborative works today is highly subjective, open to abuse, and often determined more by lab politics or seniority than by effort or contribution. Junior researchers and those making nontraditional research contributions such as data and code tend to lose out most on deserved recognition. As interdisciplinary collaboration and multi-authorship increase across all fields of research, we clearly need a better system for representing collaborative contribution to published works– film credits are one alternative model. If this initiative is ultimately successful, there will be fewer barriers to team science, fewer author disputes, and fewer disincentives for sharing data and code, for example, because those contributions will be more reliably recognized. Hence these efforts could positively influence both the cooperative culture of research, and academic incentive structures more generally.

"We will need to find better ways to do team science and reward it if we are to solve large overarching problems. Everybody on the team needs to get the same big gaudy championship ring…" [AG Gilman. Silver Spoons and Other Personal Reflections. Annu. Rev. Pharmacol. Toxicol, 2012]

This area is of interest to funding agencies such as NSF and NIH in the US, publishers, university administrations, and scientific researchers, and the science of science research community. Much work has been going on in this area, for example, a recent effort to develop an open standard for tagging contributor roles in multiauthor research publications. Project CredIT (projectcredit.net) formally launched in 2014 to address the groundswell of interest among researchers, funding agencies, academic institutions, and editors in increasing the transparency of research contributions, and in more fine grained attribution and associated credit tracking. The taxonomy is now being actively piloted. Another example is the concept of transitive credit, where similarly, all contributions to a product are registered, but in this case, quantitatively rather than qualitatively. Efforts in VIVO and eaglei have aimed to relate a person to the things they do and create in support of expertise finding and attribution. A Force11 working group has been created to bring some of these efforts together.

This panel will include relatively brief statements from some of the research projects and researchers in this area, followed by a substantive discussion between the panelists and the audience.

Confirmed speakers:

1. Amy Brand (Digital Science). Project CRediT: recording contributor roles, see http://www.nature.com/news/publishingcreditwherecreditisdue1.15033 and http://projectcredit.net for more details.
2. Robin Champieux (Oregon Health & Science University). Force11 Attribution Working Group: linking attribution research and implementation activities see https://www.force11.org/group/attributionwg for more details.
3. Holly FalkKrzesinski (Elsevier). Team science reward and recognition and publishers' role in clarifying attribution in a digital world. See Mendeley Science of Team Science (SciTS) , specifically subgroups "Credit_Promotion and Tenure" and "Authorship_Publishing Issues" (available via desktop client) for more details.
4. Daniel S. Katz (University of Chicago & Argonne National Laboratory). Transitive Credit: recording weighted credit for both contributors and resources, see http://dx.doi.org/10.5334/jors.be for more details.
5. Richard Malham (The Academy of Medical Sciences). Team Science policy project: examining researchers' incentives and disincentives to participate in large collaborative projects, focusing on how such contributions can be better recognized in career-relevant decision making, see http://www.acmedsci.ac.uk/policy/policyprojects/teamscience/ for more details.

Concurrent Session 2

Team Science and Federal Agency Experiences with Transformative Research (Panel) 3:15–4:30 pm

Authors: Avery Sen (National Oceanic and Atmospheric Association), Bhavya Lal (Institute for Defense Analyses), William Bonvillian (Massachusetts Institute of Technology) and William Valdez (The Consultants International Group, Inc)

Abstract: The capacity of team science to impact the efficiency and effectiveness of translational research performed by Federal agencies is dependent on developing new structures of cooperation, policies that promote team science, and the ability of Federal agencies to learn from successful experiences at other agencies that could be incorporated into their practices. The proposed session is made up of three presentations. The first two by Bhavya Lal and Avery Sen present original research rich in definition, modeling and empirical analysis as well as policy implications. The work originates in two recently minted doctoral dissertations and important publications soon to come. The authors have logged years of experience with analysis of public sector R&D programs. The third presentation (Bill Bonvillian) takes a close look at the two Federal agencies most widely known for their proven capabilities in translational research and innovation: DARPA and ARPA-E.

Presentation: #1: Translational Research: Separating the Myth from the Reality (Bhavya Lal) U.S. federal programs that fund translational research have proliferated in recent years, with both Congress and the Administration urging science agencies to fund more of it. However, there appears to be no firm understanding of the concept. Its definitions tend to be inspirational but vague. More importantly, there is no operational agreement on how to identify, fund, and evaluate such research. This presentation will help bridge this knowledge gap, and will examine translational research using qualitative case study, quantitative analysis, and text mining methods. Building on two reviews, the literature in the interdisciplinary field of the Science of Science Policy, and federal programs that support transformative research, I developed six propositions – three about those who conduct translational research, and three about translational research itself. The propositions were then explored using data from a translational research program created at the National Institutes of Health.

Presentation #2: Island+Bridge: Organization for Innovation for Transformation (Avery Sen)
Achieving radical societal outcomes demands institutions that allow groups of people to tackle large, complex problems. This paper explores the organizational factors at play in transformative innovation, as realized by three federal agencies designed to create it: The Defense Advanced Research Projects Agency (DARPA), the Advanced Research Projects Agency for Energy (ARPA-E), and the Advanced Technology Program (ATP, now defunct) at the National institute of Standards and Technology (NIST). Using a mixed methods approach, I develop a model of innovation based on the island+bridge metaphor for how these agencies work. The result is a descriptive and graphical account of organizational heuristics—managerial rules of thumb—at play at these agencies. By attending to the institutions of innovation, we can improve the efficacy of programs at any scale, such that even federal research programs that are small can increase their chances of creating changes that are big.

As Bennis and Biederman write of the many groups responsible for transformative innovation, everyone "is an island, but an island with a bridge to the mainland" (Bennis & Biederman 1997, p. 206). The island is the refuge for experimentation and failure, and the bridge is the conduit for the transfer of knowledge and technology. The island-with-a-bridge metaphor suggested by Bennis and Biederman seems to describe DARPA and its analogs. Though it is separated from operational concerns as a formal institution, DARPA, ARPA-E, and ATP are still intimately connected to the outside world though people. With regard to the science of team science, I focus here on one of the heuristics derived though interviews of managers at these agencies: herd nerds.

These agencies are, as one might expect, steeped in the culture of science. Managers, senior leadership, and researchers all share a passion for science and engineering, and have a great deal of experience in conducting research. These agencies draw upon the curiosity and experimentalism of those in scientific fields. They do not, however, focus on the science, per se. Managers take a transdisciplinary approach: attacking problems on multiple fronts. Program managers are entrepreneurs and translators (not subject matter experts). They see the big picture. They have the technical “chops” (i.e. technical skills) to understand and guide the work of the specialists, as well as a systems perspective that allows them to orchestrate how individual experts work together and how all of the pieces of their programs function as a whole.

From the perspective of this research, other accounts of “the DARPA model” underemphasize inter-personal, inter-organizational elements. The “Special Forces” model of innovation, recently advanced by former DARPA Director Regina Dugan and former Deputy Director Kaigham Gabriel, focuses on clear goals and measures and iterative planning and evaluation, but it does not underscore that setting and achieving ambitious goals is a social phenomenon that requires frank, frequent face time. Any model of transformative innovation should start to address the mechanisms of organizational learning and group cognition, as well as the sharing of knowledge and understanding among scientists, engineers, and stakeholders.

Presentation #3: Is Transformative Innovation Feasible in Public Research Agencies? Lessons from DARPA and ARPA-E (William B. Bonvillian)

Given challenges in the connected areas of technology, economy and energy, breakthrough innovation is understood to be a key public policy response. We examine the role and characteristics of two breakthrough-oriented R&D agencies, DARPA and ARPA-E.

We look first into DARPA as a model, asking a series of questions, such as: What about DARPA has enabled its success? Is DARPA’s success transferable to other arenas? Secondly, we look at ARPA-E, raising similar questions: Is ARPA-E designed to effectively emulate the DARPA model? Are there significant differences in the energy arena that inhibit or prohibit the success of this model? Are there new elements in the ARPA-E approach modifying and adapting the DARPA approach to increase ARPA-E’s chance of success? Do some of the less well-known features of DARPA, as noted, provide lessons for ARPA-E?

There is an additional question: What about DARPA and ARPA-E could be emulated by other organizations seeking to foster and effect transformative technological change? Both agencies represent a different model for technology advance. While standard model R&D agencies focus on research not technology or its implementation, rely on a peer review process for selecting awardees, and do not use what could be called a technology visioning step in their process, DARPA, and now ARPA-E, alter these rules. They focus early on developing a vision of new technologies, then on developing a research program to achieve that vision, and on using empowered program managers, not a peer review process, for award selections. Early successes at ARPA-E suggest the DARPA model may be dynamic and replicable. Features of this model may be of interest to other parts of the US R&D system. For example, several other DARPA clones have now been created, with others being considered. Japan is now actively considering a DARPA model to spur its faltering innovation system. Thus, review of the DARPA and ARPA-E rulesets may offer lessons to innovation ecosystems more broadly.

We close with a look at a challenge faced by both DARPA and ARPA-E: technology implementation. Both agencies move technologies through the innovation pipeline to the prototype or small-scale demonstration stage. Neither agency has direct authority to enable commercialization of its potentially breakthrough technologies. DARPA often relies on procurement programs by military services to form initial markets, although that procurement is now being significantly cut back; ARPA-E has no counterpart to the services within DOE. How could these implementation hurdles be overcome?

Concurrent Session 3

Communicating Across Disciplines: Team and Organizational Level Perspectives

3:15–4:30 pm

Paper 1: The Communicative Constitution of Organizations: A Framework for Understanding and Troubleshooting Interdisciplinary Science

Author: Margaret Brooks (Arizona State University)

Abstract: Scientific breakthroughs are increasingly achieved by interdisciplinary groups, networks and organizations. At first glance, it is easy to see how the confluence of expert perspectives around a common problem provides fertile ground for innovative, groundbreaking research to flourish. The multi-faceted, multi-dimensional and multi-modal solutions engineered by interdisciplinary research groups have the potential to address and resolve important challenges on the individual, organizational and environmental planes of society. However, despite the benefits of this form of research, the field of interdisciplinary science is not without issue. Though interdisciplinary, collaborative team initiatives have gained prominence in the last decade the scientific community continually struggles with overcoming the challenges arising from this complex form of teamwork. As the problems and questions posited to these research groups become more complex, more federal funding is allocated to them, despite the fact that these initiatives often struggle to produce transformative benefits. This struggle is evident in the growth of literature directly addressing the challenges and obstacles facing multi-, inter- and transdisciplinary teams, written both by leading practitioners in the field and governmental agencies.

While it is clear that we should cultivate and develop the transdisciplinary intellectual orientation so as to enable emerging scholars to communicate and collaborate more effectively, the role of communication in the success of interdisciplinary work has not been explored in detail on a localized, contextual level. A theoretical framework from the field of organizational communication known as the Communicative Constitution of Organizations provides an insightful lens through which to consider the behavior and performance of interdisciplinary teams and organizations. From this perspective, an organization is not merely a container in which communication occurs. Rather, communication plays a constitutive, rather than merely informational, role in establishing relationships, developing trust, increasing collaboration, and sharing knowledge among interdisciplinary group members.

In the same way that a roof is comprised of overlying shingles or the skin of a fish consists of overlapping scales, an organization is not a standalone entity but rather comprised of relationships and communication interwoven so as to create an organizational infrastructure. This concept, referred to as imbrication, is a central component of the Communicative Constitution of Organizations framework. As multiple shingles and scales connect and overlap to form a roof or fish, interdisciplinary research groups are comprised of members whose communication interactions continuously create and recreate organizational expectations and structures. To examine organizations and groups as imbricated means that communication cannot be reduced to merely explicit, deterministic mechanisms. Instead, we need to understand how each shingle and scale, or each communication interaction, plays a role in creating, sustaining or changing larger structures and expectations for behavior. Such an approach requires researchers and participants to closely observe and analyze communication interactions and patterns, as well as identify and acknowledge implicit, tacit knowledge that subtly shapes reality in important ways for interdisciplinary group members. The qualitative, interpretive approach undergirding this perspective is a marked departure from the majority of quantitative, prognostic studies of interdisciplinary teams which currently dominate the team science research landscape.

This presentation will demonstrate the value of taking a Communicative Constitution approach to better understanding the challenges and obstacles facing interdisciplinary research groups. It will also share preliminary analysis results of a pilot study involving a multi-university team studying environmental nanotechnology. These results highlight the strengths of a Communicative Constitution approach in identifying challenges facing interdisciplinary research groups and inform suggestions for future data collection and analysis within the Communicative Constitution of Organizations framework.

Paper 2: Perceived Discontinuities and Continuities in Transdisciplinary Scientific Groups

Authors: Kevin Crowston (Syracuse Univeristy), Kathy Chudoba (Utah State University), Mary-Beth Watson-Manheim (University of Illinois, Chicago), Alison Specht (University of Queensland) and Carol Hoover (Los Alamos National Laboratory)

Abstract: To synthesize diverse bodies of knowledge, transdisciplinary teams comprising members from diverse backgrounds provide an appropriate range of expertise, knowledge, and experience (Edmondson, 2002). In order to obtain such range, such teams often contain members from multiple organizations. Team members have to collaborate across boundaries of discipline, organization, distance and even time to achieve their desired outcomes. Achieving integration across these boundaries can often be problematic.

Organizational discontinuity theory (ODT) (Watson-Manheim, Chudoba, & Crowston, 2012) provides a perspective for analyzing problems encountered by team members who span boundaries in the course of their work. Boundaries are important because they distinguish one domain or situation from another, ordering and simplifying the environment (Ashforth, Kreiner, & Fugate, 2000; Schneider, 1987; Schreyögg & Sydow, 2010). On the other hand, boundaries are also points where differences between team members become salient and potentially problematic. Boundaries, however, are not uniformly or necessarily problematic: members of dispersed teams can often adapt their processes to span these differences (Bjørn & Ngwenyama, 2009; Gibson & Gibbs, 2006; Orlikowski, 2002). ODT suggests that boundary is problematic when an individual perceives a change in information and communication flows that requires conscious effort and attention to handle (Watson-Manheim et al., 2012), termed a discontinuity. A corollary to discontinuities is the emergence of continuities that reduce or eliminate the attention and effort required to understand and manage the situation associated with problematic boundaries (Dixon & Panteli, 2010; Watson-Manheim et al., 2012). Individuals must make sense of the disruption caused by the discontinuity and change their work practices to address the problem.

To test the predictions of ODT and its application to team science, we conducted a study in the context of the “DataONE” (Data Observation Network for Earth) project. This project was executed by a mix of employed staff, compensated investigators and post docs, and a large number of volunteer contributors who attended twice-yearly 3-day meetings but otherwise worked independently (Michener et al., 2012). Having a range of people involved in the project provided a diversity of skills, but this diversity meant there were many boundaries across which knowledge needed to be synthesized. Despite the potential for problems created by these boundaries, the DataONE project was considered a success by its sponsor, the US National Science Foundation, as evidenced by the decision to renew the project funding (award 14-30508).

Data were collected from participant observation, interviews, and two rounds of survey. The demographic characteristics of DataONE members indicated the presence of several boundaries that could be problematic and result in discontinuities. An obvious pair of discontinuities were in institution and place, as nearly all participants worked on DataONE only part-time, in addition to their regular jobs at institutions around the world, and worked together face-to-face for only a few days a year. The demographic data also make clear that participants came from multiple disciplines. From the reports of perceived communication challenges, these boundaries did result in discontinuities. The most commonly reported tactics for dealing with perceived discontinuities among DataONE groups were ways to increase or improve communications, addressing the symptoms of discontinuities without directly addressing the discontinuities themselves. As well, some individuals (librarians in particular) served as boundary spanners between members of different disciplines. Data show that participants were generally satisfied with their

participation in the project and many expressed a desire to continue participation. The overall assessment of group members' ability to work together effectively was also high. These findings offer a basis for suggestions to improve the effectiveness of transdisciplinary synthesis teams for scientific research.

Paper 3: Let's Talk About It—How Dialogue Supports Integration

Authors: Michael O'Rourke (Michigan State University) and Stephen Crowley (Boise State University)

Abstract: The Science of Team Science has arisen, at least in part, in response to the difficulties of combining expertise from differing disciplinary cultures/worldviews. Many different approaches to this challenge advocate addressing it by means of dialogue. One common framework for describing valuable combinations of ideas refers to the result of such combinations as 'integration'. It seems reasonable then to ask what it is about dialogue that promotes integration. In this paper we present a preliminary analysis of the contribution of dialogue to integration; we draw on our experience with the Toolbox workshop protocol to provide a case study.

The Toolbox Project (http://toolbox-project.org/) has been running workshops designed to mitigate miscommunication within cross-disciplinary research teams for over a decade. During this period more than 150 workshops have been run with over 1,500 participants. A key element of these workshops involves guided dialogue amongst participants concerning aspects of good scientific practice.

The nature and impact of dialogue has come under consideration in a number of literatures (e.g., Michaels et al. 2008, Tsoukas 2009) in addition to work in Interdisciplinary methodology (see McDonald et al. 2009). We consider our project to be of a piece with McDonald and colleagues, although we seek to supply a more detailed account of how dialogue can yield integrative results in the context of a particular dialogue method.

After locating our own work with respect to this literature we proceed by developing the hypothesis that part of the power of dialogue is that real dialogue (i.e., the joint construction of meaning), appropriately focused, is isomorphic to the intellectual challenge of integrating differing worldviews.

Three phenomena that appear to be central to this process in the Toolbox context are: 1) The use of examples as boundary objects ; 2) The use of 'meta' discussion to identify areas where the group requires integration and to establish the standards for such integration ; and 3) The use of conflict to clarify group consensus or lack thereof . The paper will develop our views about the role of these three mechanisms and discuss to what extent the resulting insights generalize to other dialogue methods.

Paper 4: Diagnosing Differences among Disciplinary Worldviews

Authors: Brian Robinson (Michigan State University), Michael O'Rourke (Michigan State University), Chad Gonnerman (Michigan State University) and Stephen Crowley (Boise State University)

Abstract: The science of team science has arisen, at least in part, in response to the difficulties of combining expertise from differing disciplinary cultures/worldviews. One reason that ameliorating these difficulties has proved elusive is that we have a poor grasp of the features of differing disciplinary worldviews. This paper reports the results of using aspects of the Toolbox workshop protocol to diagnose differing disciplinary worldviews.

The Toolbox Project (http://toolbox-project.org/) has been running workshops designed to mitigate miscommunication within cross-disciplinary research teams for over a decade. During this period more than 150 workshops have been run with over 1,500 participants. A key element of these workshops involves the completion of 'questionnaire' concerning aspects of good scientific practice. Combining the results of these questionnaires with demographics of the participants has the potential to identify conceptual aspects of disciplinary cultures/worldviews.

A taxonomy of disciplines from the Digital Commons (http://digitalcommons.bepress.com/cgi/viewcontent.cgi?article=1008&context=reference) was used to structure the disciplinary information about participants. Specifically, we used the taxonomy to code the disciplinary self-identifications of 264 participants in 44 workshops into academic families. The participants in

the sample included graduate students, post-docs, and research scientists. Once the participants were grouped by academic family, a one-way ANOVA was conducted on the variation between academic families and answers to various Toolbox prompts. This was followed up by a post-hoc analysis using the Dunnett-Tukey-Kramer test.

Results of these tests suggest that currently: The Toolbox identifies philosophical differences between Social and Behavioral Sciences and other kinds of scientists. The Toolbox is not currently catching much in the way of philosophical differences between the Life Sciences and the Physical Sciences and Mathematics. Perhaps differences among the Life Sciences and the Physical Sciences and Mathematics do exist at the more fine-grained level of disciplines, but not at the level of academic families. Alternatively it might be that the main differences between Life Sciences and Physical Sciences and Mathematics are in subject matter and not in philosophical differences. There remains the possibility that some philosophical difference exists, but it isn't in the current Toolbox.

Concurrent Session 4

New Measures to Assess Readiness for Team Science 3:15-4:30 pm

Paper 1: Calibrating and Validating the Motivation Assessment for Team Readiness, Integration, and Collaboration (MATRICx) Model and Instrument and Its Applicability for Self-reflection and Intervention.

Authors: Gaetano R. Lotrecchiano (George Washington University, Department of Clinical Research and Leadership), Trudy Mallinson (George Washington University, Department of Clinical Research and Leadership), Tommy Leblanc-Beaudoin (George Washington University, Department of Clinical Research and Leadership), Jeremy Furniss (George Washington University, Department of Clinical Research and Leadership), Lisa Schwartz (George Washington University, Department of Clinical Research and Leadership), and Holly Falk-Krzesinksi (Elsevier and Northwestern University, School of Professional Studies)

Abstract: Objective: To complete a pilot study in preparation for calibrating and validating the Motivation Assessment for Team Readiness, Integration, and Collaboration (MATRICx) model and instrument and relate findings from data collections and analysis to a strategies for self-reflection and educational interventions that enhance collaboration readiness in individuals.

Methods: A review of the team science literature was used to compile a list of motivators and deterrents to collaboration that were aligned with a collaboration theory suggesting four levels of formal integration—cooperation, coordination, collaboration, and coadunation (Bailey & Koney, 2000; Gajda, 2004). This list informed the development of 55 indicators representing a hierarchical spectrum of collaboration (Bailey & Koney, 2000). Rasch analysis was used to investigate the rating scale structure, unidimensionality, and person-item fit of responses from 16 participants. Items were analyzed applying a 1-parameter Rasch model using Winsteps® 3.80.1 (Linacre, 2013).

Results: Preliminary Rasch analysis indicates that the rating scale is working as intended and steps proceed monotonically. Five items underfit the model; 11 overfit the model; these represent items for revision or deletion. Items calibrations reflect a hierarchical order from easiest to endorse items. "Easy items" reflect personal concerns for enjoyment and advancing own career; "challenging" items reflect fears and concerns related to loss of independence and promotion. Only 1 respondent misfit the model. Person reliability was .85 and person separation ratio 2.34. Principal component analysis indicates acceptable unidimensionality.

Findings: Preliminary results suggest that the MATRICx tool has promise for capturing readiness for collaboration in a way that usefully distinguishes both items and people. Refinement of misfitting items, deletion of redundant items, revising instructions so participants reflect about a particular collaboration, and further cognitive testing will be completed prior to a larger round of data collection and analysis.

Once outcome indicators of high impact are identified, these can serves as means for self-reflection and ultimate learning interventions that target specific motivational barriers to achieving desired collaboration along the degree scale. Utilizing an attitude-social influence-self-efficacy model (De Vries and Backbier, 1994; De Vries, et al., 1986) the relationship between how individual motivations or intentions determine behaviors and action plans can be organized. This model allows for motivational factors to be grouped into attitudes and social norms (Fieshbein & Ajzen, 1975), social influences (Ajzen, 1991, Ajzen & Madden, 1986), and self-efficacy expectations (Bandura, 1986). This organization of the MATRICx output provides a means by which to develop interventions and training opportunities that specifically address the individual, social, and functional requirements associated with achieving various degrees of collaboration (Koney and Bailey, 2000) along the MATRICx model scale (Lotrecchiano et al., 2014).

How the research advances the SciTS field: The MATRICx model and assessment provide a means by which we can measure individual motivation and degrees of collaboration on a correlative and parallel scale. The generalizable team science literature that informs the compilation of factors associated with why individuals choose or don't choose to collaborate provides the foundation for research that can measure, analyze, and contribute to sector-specific calibrations of the most significant factors affecting collaboration success between scientific stakeholders. Once identified within a particular teaming population (in this case health and biomedicine), interventions and training opportunities can be designed that target these most significant sector-specific factors. In addition to this outcome, the method associated with this research is generalizable to other sectors and can be reoriented to provide a means for isolating key factors that affect those sector's collaborative requirements and challenges and therefore can also serve as a means for self reflection in those sectors with specific learning interventions in mind.

Paper 2: Measuring Integrative Capacity in Interdisciplinary Teams: Scale Development and Testing

Authors: Maritza Salazar (Claremont Graduate University), Theresa Lant (Pace University), Daniel Slyngstad (Claremont Graduate University), Angela Demichele (Claremont Graduate University) and Jeffrey Fajans (Claremont Graduate University)

Abstract: The objective of this paper is to develop and test survey-based scales to measure integrative capacity in teams. Integrative capacity is defined as the capability of a science team to transform knowledge through social and cognitive integration and is essential for disciplinary integration (Salazar, Lant, Fiore, & Salas, 2012).

Survey items were developed and refined based on the theoretical model of integrative capacity and data generated from focus groups of professionals working in interdisciplinary science teams. Three steps were conducted with the aim of creating survey measures to identify and capture behaviors constituting integrative capacity in teams in conjunction with an NSF-funded project. Exploratory factor analyses were performed using independent online respondents (n = 200) and student project team members (n = 162). Then, a confirmatory factor analysis was performed on a sample of professional science teams (n = 206) at universities in California, New York, Texas, and Virginia.

Analyses reveal strong evidence for six types of socially integrative behaviors (SIBs) and three types of cognitively integrative behaviors (CIBs). The SIBs include visioning, suggesting ideas, coordination promotion, reflexivity, connecting others, and perspective seeking. The CIBs include knowledge consideration, knowledge accommodation/assimilation, and knowledge transformation.

The results suggest that the SIBs serve to create a supportive and collaborative context for idea sharing and novel idea generation, while the CIBs promote active

consideration and modification of team members' ideas to enable innovative knowledge transformation.

Given the need for team science to facilitate teamwork across disciplines in teams with highly specialized individual team members, understanding the specific components of integrative capacity will help assess and guide teams through the process of combining knowledge from disparate sources of expertise to generate new knowledge, as well as to avoid common pitfalls of collaboration between disciplinary diverse science teams.

Paper 3: Transdisciplinary Orientation and Its Relation to the Quality of Scientific Products

Authors: Shalini Misra (Virginia Tech), Lulu Cheng (Monsanto), Daniel Stokols (University of California, Irvine), Maritza Salazar (Claremont Graduate University) and Theresa Lant (Pace University)

Abstract: The collaborative success of cross-disciplinary scientific teams depends in part on the intrapersonal, interpersonal, and intellectual orientations individual team members bring to the group. Following Stokols' (2014) conceptualization of "Transdisciplinary Orientation", defined as the values, attitudes, beliefs, conceptual skills and knowledge, and behavioral repertoires that predispose an individual to collaborating effectively in cross-disciplinary scientific teams, we develop a new Transdisciplinary Orientation (TDO) Scale and test its internal consistency and factor structure. We validate the TDO scale by examining the relationship of individuals' self-reported TDO to the intellectual qualities of their scientific outputs and their past experiences in cross-disciplinary teams.

For Study 1, in which we tested the factor structure of the 12-item TDO scale (alpha=.91), we collected an online sample of academics (n= 150) from a variety of different disciplines throughout the US. Confirmatory factor analysis was conducted using the Maximum Likelihood Method with JMP 10.0.0. Strongest support was found for the two-factor correlated model of transdisciplinary orientation with two dimensions—Values, Attitudes, and Beliefs (VAB) and Conceptual Skills and Behaviors (CSB).

For Study 2, we invited faculty members (n=76) from a variety of academic departments at a large university in Virginia to complete a survey on factors that enhance the success of interdisciplinary teams. For each respondent, we randomly selected one research article published within the last five years (between 2009 to 2013) in which the respondent was the primary or lead author. Each article was reviewed by three independent and trained raters on a number of dimensions concerning the intellectual and integrative qualities of the article. In hierarchical regressions, using the average ratings of the three raters and controlling for the effects of age, gender, and number of years in academia, it was found that individuals' reporting higher TDO had more interdisciplinary research articles as judged by independent raters ($B=.34$; $p<.05$). Higher self-reported level of TDO was significantly and positively related to raters' appraisals of the potential societal impact of the study reported in the article ($B=.32$; $p<.05$). TDO score was positively and marginally significantly related to raters' evaluations of the creativity ($B=.28$; $p<.07$) and intellectual quality of the article ($B=.18$; $p<.08$). Past experience in interdisciplinary teams was found to be significantly and positively related to TDO ($B=.47$; $p<.05$). Educational and training strategies for the cultivation of TDO are discussed.

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- A user-generated collection of resources recommended by experts across disciplines
- Publically available resources such as practical tools to enhance research collaboration, measures for studying team-based research, and recommended readings
- A platform to connect with colleagues and stay up to date on news and events

How Can You Use The Toolkit?

You can use the **Team Science Toolkit** to:

- **Discover.** Learn from colleagues by exploring available resources to support your team science goals, and download them or link to them online.
- **Contribute.** Share your knowledge by uploading documents, links, information, or comments on resources that support the practice or study of team science.
- **Connect.** Join expert discussions on the blog, add your name to the expert directory, or stay up to date on news and events.

The Team Science Toolkit includes a wide variety of resources to help you conduct, manage, support, evaluate, or study team-based research. Use the Toolkit to find resources that support your goals.

www.**teamsciencetoolkit**.cancer.gov

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