Wednesday - August 6, 2014 Pre-conference workshops

7:30am-5:00pm **Registration** – Texas Foyer

7:30am-8:30am **Networking breakfast** – Texas Foyer

8:30am-4:30pm **All day workshops**

Texas III

Group Concept Mapping and Interaction Analysis for Team Science Planning and Evaluation

Mary Kane (*Concept Systems*) and Michael Huffman (*Concept Systems*)

Group Concept Mapping is a widely used tool to articulate team research priorities and enhance research design, implementation, and evaluation. Ideal for seeking and valuing the voices of research team members in research design, it has proven value in articulating the priorities of the community in which research takes place. GCM connects the knowledge of stakeholders with mixed methods to yield community or team-specific frameworks on issues of relevance.

This workshop is for researchers and evaluators with some familiarity with Group Concept Mapping or team strategy development for research. As an intermediate level training, this workshop links the philosophy and practice of Group Concept Mapping to community based participatory research and team science. It extends and builds upon basic GCM skills and practices, and introduces functional interactive analysis- a new application of network analytics to the GCM methodology. Through the use of small group exercises, practice and lectures, participants will learn skills for successfully engaging communities and teams, and systematically collecting and representing group wisdom. Participants will explore decision-making processes for finalizing the map output, and review approaches for producing results that increase the maps' utilization. Individuals attending this workshop will be able to apply their learning to projects that require team model and research design construction, and incorporate stakeholder participation and group conceptualization.

Keywords: Group Concept Mapping; Team Science Design; Evaluation; CBPR; Functional Interaction Analysis; Group Wisdom; Participatory Research

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Texas VII

Framing the Work Space: an Alphabet of Components for Great Team-work

Derek Wade (*Kumido*) and Jasmina Nikolic (*University of Belgrade*)

This workshop will guide participants through implementation of a systems approach, based on a particular framework, that encourages team synthesis of individual expertise into holistic outcomes under tight time constraints. This framework has demonstrated repeated success in improving processes, teams, and outcomes in a variety of transdisciplinary contexts. Participants will experience many of the joys and challenges inherent to transdisciplinary work as they form, produce, analyze and complete a team project through use of the framework components.

Participants will use problem definition and kanban1 workflow collaboration, combined with incremental success criteria, to solve issues of transdisciplinary team approaches during simulation of a new research center needing to improve its translational research infrastructure and processes. Through case study, technique briefing, group exercise, and debrief, participants will explore:

- Components of a 'framed' collaborative network: roles, flow, emergent problem definition, iterations, incremental outcomes, and reflective improvement
- Problems for which the principles of the framework are best suited: complex/chaotic domain interactions and the need for intra-team coordination
- Identification of misapplication of traditional methodologies to complex/chaotic interactions vis-à-vis 'analysis paralysis,' siloed work, and linear, additive outcomes vs. synergistic work
- Problem definition via emergent vs. deterministic processes

Keywords: Group Concept Mapping; Team Science Design; Evaluation; CBPR; Functional Interaction Analysis; Group Wisdom; Participatory Research

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8:30am-12:00pm Half day workshops

Texas V

Using Team Science to Teach Team Science Skills With Team-Based Learning (TBL)
Wayne Mccormack (*University of Florida*)

What better way could there be to teach team science skills in the classroom than having students actually use them while they learn? Team-based learning (TBL) is a structured collaborative learning method that uses a specific sequence of individual work, group work and immediate feedback to motivate students to increasingly hold each other accountable for coming to class prepared and contribute to discussion. TBL focuses classroom time on the application of knowledge through problem-solving and decision-making in a team setting. This "TBL 101" hands-on workshop will provide the single best introduction to TBL, and will be conducted in the TBL format. Participants will be asked to prepare in advance by reading a short paper about TBL. During the workshop, participants will be strategically divided into teams, take a readiness assurance test, and then solve a series of application exercises by engaging actively with their team members. The structure, process, and essential characteristics of an effective TBL module will be emphasized. By the conclusion of this workshop, the participant will be able to:

1. explain the key components of a successful TBL module;
2. outline how they would construct a TBL module from a set of objectives;
3. describe how they might convert a session they already teach into a TBL module; and
4. illustrate how to transform a small group into a productive learning-team.

The workshop will conclude with a discussion of how and why TBL works, and evidence for improved learning using TBL in a variety of academic settings.

Keywords: team-based learning; team learning; team training

Texas VI

Using HUBzero to Create "Hubs" for Online Collaboration

Michael McLennan (*Purdue University*)

The HUBzero® Platform for Scientific Collaboration is an open source software package used to create web sites for research, education, and scientific collaboration. Some call them “science gateways,” or “collaboratories.” We call them “hubs” for the community. So far, HUBzero has been used to create more than 50 such hubs across a wide range of scientific disciplines, including nanotechnology, bio-fuels, environmental modeling, volcanic activity, earthquake mitigation, microelectromechanical systems, cancer research, pharmaceutical engineering, and STEM education, to name a few. All together, these sites have served more than 1,000,000 visitors from 172 countries worldwide during the past year alone. In June 2011, the National Science and Technology Council’s Materials Genome Initiative for Global Competitiveness highlighted one of these hubs, nanoHUB.org, as an exemplar of “open innovation” that is critical for global competitiveness. In August 2011, HUBzero won the Campus Technology Innovators Award for IT Infrastructure and Systems.

Participants of this workshop will learn how to leverage the features of HUBzero to create new “hubs” for their own communities. Researchers in Team Science will learn about the various communities that exist and the capabilities that they are using, and also gain an understanding of data that these hubs collect, which can be used for team science research in various areas.

During this workshop, participants will access a virtual machine representing a brand new hub and explore the features of that hub. Each hub includes many features for collaboration, such as: 1) the ability to create user groups with blogs, wikis, calendars, and discussion forums; 2) private project areas for data exchange, with to-do lists for task management; 3) lightweight data sharing in a social network with the ability to "like," comment, and repost data; 4) community "wish lists" for brainstorming features; and 5) question-and-answer forum with incentives for participation. This workshop will walk participants through various features with hands-on exploration of the functionality. It will present case studies of communities that have leveraged or perhaps even shunned various features. It will describe the data collected by various hubs and how it has been and could be leveraged for detailed studies of user interaction. For more details about HUBzero, visit http://hubzero.org.

Keywords: collaboratories; web platform; brainstorming; data sharing; data management; communication; teams

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1:00pm-4:30pm Half day workshops

Texas V

Lessons from the DIA2 project for undertaking cyberinfrastructure-based team science

Aditya Johri (*George Mason University*), Krishna Madhavan (*Purdue University*) and Mihaela Vorvoreanu (*Purdue University*)

The purpose of this workshop is to engage and train those working in team science, large scientific projects, or planning to undertake projects that involve a large team related to cyberinfrastructure in social sciences. We have developed the workshop from our own experiences of a project spread across four institutions and with over a dozen team members. Our project DIA2, has designed an information portal (http://www.dia2.org) that allows researchers and scientists to browse and search public data from the National Science Foundation to understand what research has taken place in specific areas and to find collaborators. In this workshop we will focus on methodologies including systems approaches as well as conducting evaluation and understanding team dynamics. This workshop will be practical in nature. We hope to provide attendees real-world lessons, pitfalls, and documentations that can be useful to them in their project. The materials will also be available online after the workshop.

Keywords: Workshop; cyberinfrastructure; Social Science

Texas VI

Evidence-based Guidance for the Successful Praxis of Team Science

Holly Falk-Krzesinski (*Elsevier*)

Team science initiatives are characterized by cross-disciplinary collaboration focused on complex problem-, project-, or product-oriented research. Over the last decade, academia has generated an upsurge in team science initiatives, while external funding agencies in the United States and around the globe have made more collaborative and team-based science funding opportunities available. Studies on research centers funded by the National Science Foundation (NSF) and National Institutes of Health (NIH) have demonstrated that team science initiatives entail significant coordination costs. As a result, team science takes more time, at least proximally, than individual research; however, studies have also demonstrated a distal payoff in terms of research acceleration. Consequently, it is imperative that team science leaders and practitioners understand the most effective practices for productive team science. Through a combination of lively lecture and interactive small group activities, this workshop will arm participants with a collection of evidence-based tools and resources for implementing effective practices in team science in the areas of team assembly and composition; trust and communication; expert discovery and collaboration; interdisciplinary grantsmanship; and networking.

The workshop will:

- Provide an overview of team science, from empirical research to practice;
- Offer evidence-based insights and techniques on team science leadership;
- Demonstrate tools and resources that promote collaboration, communication, trust, and conflict management in science teams;
- Engage participants in a real-world case study discussion;
- Describe specific strategies and tactics for grantsmanship to support team science; and,
- Use the online TeamScience.net tool and Team Science Toolkit in practical, interactive experiences.

Keywords: Science of team science; Praxis of team science; Collaboration; Evidence-based; communication; Trust; Tools; Team Science toolkit; TeamScience.net

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5:00pm - 6:00pm Welcome Reception

Thursday - August 7, 2014 Conference (Day 1)

7:30am-4:15pm **Registration** – Texas Foyer

7:30am - 8:30am **Networking Breakfast** – Texas Foyer

8:30am - 9:00am **Opening Session** (Zilker Ballroom 1-2)

9:15am - 10:15am

Panel discussions

Texas V

The insider, the embedded, and the independent: Three perspectives on Interdisciplinary Collaborative Astrobiology Research

Arsev Aydinoglu (*NASA*), Rich Gazan (*University of Hawaii*) and Estelle Dodson (*NASA*)

Background. The research has become more interdisciplinary and collaborative to tackle complex problems. The NASA Astrobiology Institute (NAI) was established with such a framework as a virtual institute in 1998. Today, the Institute funds 15 distributed teams with 800 researchers in 140 different organizations. The distributed nature of the teams, in addition to highly interdisciplinary nature of the astrobiology research (which simply studies the origins, evolution, distribution, and future of life), depicts a very complex research network. The objective of this panel is to provide three perspectives detailing interdisciplinary collaborative work in astrobiology research to have a more comprehensive understanding and engage in a discussion with the SciTS community.

Flow. First perspective represents the funding agency and describes the socio-technical dimensions of building operational research communities and ensuring their sustainability. It addresses the collaborative requirements for the NAI Cooperative Agreement Notice (CAN), the composition of the funded teams, support given by the NAI during and after the project, Focus Groups and the social strategy behind the funding cycles. Second perspective is from a researcher embedded into the NAI who has been brought to study the interdisciplinary collaborative practices across the astrobiology network and to report back to the management. In this talk, the specific attention is given on the challenges and facilitators of interdisciplinary collaborative research in distributed teams and synergy (or lack thereof) between NAI Central and the astrobiology community. Final perspective is delivered by an independent researcher evaluating the outcome of this interdisciplinary endeavor. Through bibliometric analysis and visualization tools that is created based on unsupervised learning algorithms, final presentation focuses on the network topology of astrobiology research. The findings reveal interdisciplinary relations, monodisciplinary clusters, hidden connections, etc. that can be utilized by not only the funding agency but also the principal investigators.

Significance. We believe that team science is a multi-faceted topic. Through three different perspectives (the insider, embedded, and independent), methodologies (policy, qualitative/interviews, and quantitative/bibliometrics), and focuses (agency, agents, and products), we provide an in-depth analysis of an emerging domain. The pitfalls, best practices, tools will be beneficial to SciTS scholars, funding agencies, and researchers in teams.

Keywords: interdisciplinary research; scientometrics; visualization; collaboration technologies; distributed teams

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Texas VI

Team Science: Report from the Trenches

Anil Srivastava (*Open Health Systems Laboratory -OHSL*), Yassi Moghaddam (*International Society of Service Innovation Professionals -ISSIP*) and George Handy (*Activity for Innovation and Economic Growth - AIEG*)

At the core of Open Health Systems Laboratory (OHSL) is the idea of international team science and the belief in Virtual Organizations as Sociotechnical Systems (VOSS) to approximate the experience of a physical campus. Over the years, OHSL has created several international team science consortia spooning the globe which continue to work as autonomous research collaborations. In the process, OHSL has also reached out to other organizations working towards the same end—vibrant and needed international science and research collaborations.

In this panel presentation, three different organizations join the panel to discuss their experience and what it took them to create sustainable team science collaborations. The panelists are:

1. Anil Srivastava, Open Health Systems Laboratory (OHSL), to discuss their experience in creating (a) ICTBioMed: International Consortium for Technology in Biomedicine—which includes tightly couple high performance life science computing centers working on big data to knowledge projects in India (Centre for Development of Advanced Computing), Poland (Poznan Supercomputing and Network Center), Sweden (Chalmers Institute of Technology/University of Gothenburg) and USA (University of Notre Dame and Internet2); (b) International Consortium on Rescuing and Repurposing of Drugs for Cancer; and (c) Oral Cytology Global Network covering Germany, India, South Africa and the United States.

2. George Handy, Activity for Innovation and Economic Growth (AIEG), will describe his work of creating Network for Polish-American Cooperation on Cancer Research and Treatment consisting of 27 projects and activities include 15 cancer research projects, 3 research support projects and 9 activities.

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3. Yassi Moghaddam, International Society of Service Innovation Professionals (ISSIP), will present her work on global service science which in partnership with IBM Almaden Research Laboratory has created a global network of activities like (a) Internet of Things and Regenerative Medicine as part of the strategic vision of the “Prescription for Poland”© as a pilot grand challenge and the corresponding roadmap for this initiative implementation is directed by the "Prescription for Poland"© Experts Network; and (b) building several other communities of practice to promote service innovations for our interconnected world in Education & Research, Big Data & Analytics, Globalization, Innovation Tools & Methods, etc.

Keywords: team science; global collaboration; virtual teams; sociotechnical systems; oncology

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Paper presentations: Information Sharing via Networks - Texas VII

Session Moderator: Steve Fiore

Belief Networks in Interdisciplinary Research Teams

Lorien Jasny (*University of Maryland*)

Beliefs are not held in a vacuum; individuals create mental models that structure their beliefs. What do these structures look like, how much variance is there across scientific disciplines working on the same inter-disciplinary project, and how do individuals' models change as they work in an interdisciplinary team? This project quantifies and compares the belief networks among participants in the interdisciplinary project teams hosted by the National Socio-Environmental Synthesis Center (SESYNC) and measures how these structures change over the period of collaboration. Using a Bayesian formulation of the Informant Accuracy Model, we are able to quantify the agreement between individuals’ responses. A second network is made up of the comments individuals make either directed at another participant or to the group at large during their discussion. This data is analyzed using the Relational Events Model. After the meeting concludes we re-issue the questions to observe how individuals’ mental models change after the team workshop, and which positions in the discussion network are correlated with significant belief change. This paper presents preliminary findings from 6 different 3 day team meetings held at SESYNC in February, 2014.

Keywords: Networks; Beliefs; Interdisciplinary research

The Role of Knowledge Brokers in Interdisciplinary Team Science

Dorothy Sutherland Olsen (*Nordic Institute for Studies on Innovation, Research & Education - NIFU*)

Although interdisciplinary research and team science have been studied for many years, there are still gaps in our knowledge related to the practice of team science. The concepts of knowledge flows (Allen 1977; Owen-Smith & Powell 2004), knowledge integration (Klein 1990) and boundary crossing (Palmer 1999) have been used to describe how knowledge is created and shared in research, but the practice-based studies are sketchy suggesting that interdisciplinary collaborations take time and that teams need to develop trust and respect for each other. In this paper the concept of "knowledge brokering" is used to explore learning processes in case studies within nanoscience and medical imaging. The cases provide a range of examples of how individuals or groups function, not only as go-betweens, but as translational go-betweens. The implications for research management and research policy are discussed.

Keywords: Knowledge-broker; Interdisciplinary teams; Translational learning

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National Heart, Lung, and Blood Institute (NHLBI) Population Studies Workshops, Facilitating Team Science

Lorraine Silsbee (*National Heart, Lung, and Blood Institute, NIH*)

Introduction: HLBI-sponsored population studies play a major role in reducing the burden of cardiovascular, pulmonary, and blood diseases and sleep disorders. Supporting the entry of junior investigators into this field is essential for continued success. Three workshops were held to stimulate new research ideas among early career investigators and to further explore opportunities for use of previously collected data in large NHLBI-supported cohort studies. The goals of the workshops were: 1) to make data from NHLBI-sponsored population studies more accessible to investigators not currently involved in the long-term studies, 2) to increase opportunities for collaborations, and 3) to provide tools for each workshop participant to draft a manuscript proposal or ancillary study using data from one or more of the population studies presented.

The 2-3 day workshops were held in 2008, 2010 and in 2013. The first workshop included three studies, and subsequent workshops covered two studies. Criteria for cohort study inclusion were sample size > 4,500 participants, ability to share data outside the study, and opportunities for additional collaboration through publications and ancillary studies.

Description of Methods: Notification of the workshops was distributed via email. Early career investigators who held actively funded NIH career development awards and actively funded investigators in the areas of epidemiology, biostatistics and prevention were identified across NIH Institutes through the NIH RePORT Expenditures and Results system (RePORTER). Schools of public health and relevant associations and health organizations identified through internet searches also received notification via email.

Applicants submitted a CV, career development statement and a one-page draft manuscript proposal idea. Prior to the workshop, applicants were contacted by study investigators to determine the feasibility of their proposal and to provide redirection, if needed.

The structure of the workshops was similar. Each included an overview of study publications and ancillary study policies, guidance on how to access and use the study data sets, discussion of analytic challenges and, importantly, identification of opportunities available for further scientific collaboration. The presentations were followed by small breakout groups on pre-defined topics where participants received detailed feedback on their study-specific research ideas from senior investigators.

Summary of Findings: Workshop attendance ranged from 47 – 62 participants. Metrics include the number of publications and funded grant proposals by participants utilizing data from the presented studies. Challenges in tracking workshop outcomes were identified and an improved tracking system was implemented. To date there have been 32 publications related to the featured studies by workshop attendees; 9 first author papers; and 12 publications co-authored by two or more participants of the same workshop.

The workshops brought together new research ideas from early career investigators with experienced investigators who provided guidance and mentorship. The workshops successfully fostered new collaborations between participants and experienced investigators. Improvements were made to each workshop in outcome tracking and workshop organization. Although this model was used by a federal funding agency, it could be adapted by research centers to explore new scientific questions and as a vehicle to pair early career and senior investigators to facilitate the development of team science.

Keywords: Early career; Research collaboration; Professional development

10:00am - 10:30am Networking Break

10:30am - 12:00pm Future Directions Keynote Address

(Zilker Ballroom 1-2)

Future Directions Keynote Panel: Training, Citizen Science and NeuroDynamics

Session Moderator: Kara Hall

The keynote panel will address future directions for the SciTS field, including issues related to training, citizen science, and neurodynamics. On-going challenges and new opportunities will be highlighted.

Training: Team Science Training across the nation is happening at two levels - the individual and organizational levels. The drive for change within organizations to adopt team science approaches comes from various sources depending on the institution. For some, change is being driven by the organizational leaders and at others it is the individual scientists who are recognizing the need to and/or the opportunity that working collaboratively brings. Successful training at both levels will result in organizational cultures where collaboration not only recognized and rewarded but is woven into the fabric of the organization. Issues related to individual skill development, leadership, organizational self-reflections, and strategies for success will be discussed.

Citizen Science: Citizen science introduces a paradigm shift for science as well as for our conceptualizations of team science. Zooniverse houses the largest collection of online citizen science projects, ranging from discovering exo-planets to hunting for cures for cancer. These citizen science projects aim to engage the public in scientific research by asking them to participate in data analysis that remains too difficult for computerized methods. The development of specialized forums and communication tools allow communities and teams to form and establish new tasks or projects that sometimes appear frivolous though may result in extraordinarily serious applications. Efforts to study interactions between citizen scientists and with professional scientists across projects as well as efforts to empower teams within the project communities to do real research beyond data analysis and to take stewardship of the Zooniverse platform will be discussed.

Neurodynamics: Organizations and work groups are becoming increasingly reliant upon teams, as complex tasks usually require cooperative, interactive teamwork between individuals. Though teamwork is so thoroughly ingrained in daily life, current measures and methods for assessing and optimizing team performance are often limited to subjective reporting and qualitative observations, and are rarely evaluated in real-time. Moreover, existing measures only consider *external* parameters. To address the need for objective, real-time means of assessing team processes, a new measurement platform has been developed. This platform is based on Electroencephalogram (EEG) and Electrocardiogram (ECG) data that can unobtrusively measure a team's cognitive and emotional states. A new field of Team NeuroDynamics and the new opportunities it presents for the SciTS field will be discussed.

12:00pm - 1:30pm Lunch on Own

1:30pm - 2:30pm Paper presentations

Team Structure and Innovation - Texas V

Session Moderator: Steve Fiore

Inside the academic pin factory: creativity in science

You-Na Lee (*Georgia Institute of Technology*), John Walsh (*GT*) and Jian Wang (*Catholic University-Leuven*)

Increasingly scientific work takes place in a setting that more closely resembles a small factory, rather than an individual's lab bench, with knowledge as the product. Just as firms create a new product and gain profits from this, academic research teams create novel output and gain recognition. This change of science from a traditionally distinct domain to firm-like organized product-creation activity highlights the importance of structuring work teams. In this paper, we analyze the effect of team size and cognitive and functional diversity on creativity. Furthermore, we unpack two facets of creativity in science, i.e., novelty and impact. We find that increasing team size has an inverted-U shaped relation with novelty. On the other hand, team size has a continually increasing relation with the likelihood of a high-impact paper. We also find that the size-novelty relationship is largely due to the relation between size and knowledge heterogeneity. While knowledge heterogeneity has a significant impact on novelty, it does not have a direct effect on impact, net of novelty and size. Finally, we find the effect of division of labor on creativity is contingent on knowledge heterogeneity, such that division of labor has a more negative effect on novelty and impact in high heterogeneity teams than in low heterogeneity teams. These results suggest group-level tradeoffs between the benefits from heterogeneity and specialization in terms of idea generation and the costs in terms of integration. This study develops our understanding of team science and highlights the need for a governance approach to scientific work. We also advance the creativity literature by providing objective bibliometric measures that distinguish novelty from impact, and illustrate the distinct team-level drivers of each.

Keywords: Team science; creativity; knowledge heterogeneity; division of labor

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What's your innovation backbone?

Morton Tavel (*Innovation Business Partners*)

Innovation at the organizational level is a quintessential team process, requiring both a social interaction and a transfer of knowledge between team members. This dual interaction makes the process of innovation potentially describable by a network model in which nodes are team members that share their knowledge and use their social skills to aggregate that knowledge so that it ultimately solves some problem or creates some innovation. We have studied this process using several network models, one of them being a network whose nodes are inventors and whose links (the interactions between nodes) are the inventions on which they co-invented. One of our goals is to separate out the roles of the social forces and the knowledge components that influence the efficiency of the network. By studying the topology of the network and by applying well known network metrics, such as betweenness centrality and clustering, we have been able to identify key members (nodes) of the network that are responsible for its coherence. We call these key members, the "Innovation Backbone" because they appear to form a skeleton substructure that holds the network together and provides a conduit for communication across the organization. We believe that members of the Innovation Backbone, because of their singular social skills, can play an important role within an organization that goes beyond the role they play in the network structure through which they are discovered. In this presentation, we will give examples of some organizational networks, indicating what can be learned from their topology and Innovation Backbone.

Keywords: Networks; Organizations; Team Assembly

The Science of Team Science: Exploring Principal Investigator Leadership Style and Team Collaboration Satisfaction

Stephenie Kennedy (*Mary Babb Randolph Cancer Center, West Virginia University*) and Reagan Curtis (*West Virginia University*)

This study examined the relationship between the leadership style of principal investigators (PIs) of interdisciplinary research teams at academic health science centers and the collaboration satisfaction of their team members. Two stage sampling was used. One hundred NIH-funded principal investigators at eight regional health science centers completed a team identification form, identifying their teams as interdisciplinary and providing the names and emails of team members. An online survey instrument that included a basic demographic questionnaire, the Bolman and Deal Leadership (Others) Survey, and the Collaboration and Transdisciplinary Integration Survey was then sent to team members. The sample used for analysis included 170 individuals from 38 teams at 7 institutions. Team members identified that the PIs used all of the frames, but were more likely to use the human resource and structural frames. The pattern of frame use resulted in the identification that PIs were more likely to adopt a multi-frame leadership style rather than the no, single, or paired

styles. Nearly 53 percent of teams identified that their satisfaction with collaboration was good to excellent, but the areas of team meeting productivity and conflict resolution were identified as potential areas of improvement. An analysis of variance was completed and demonstrated that there was a significant difference in collaboration satisfaction; the political frame differed significantly from both the symbolic and human resource frames. Additionally, team members' reports were significantly different between leaders using the multi-framed style and the no frame style. The effect size for this sample was small and indicated that five percent of the variance could be explained by leadership. Most teams were composed of six to ten members and led by experienced PIs.

This research contributes to team science by exploring both collaboration and leadership in interdisciplinary teams. This study addresses one of the gaps in the literature regarding individual factors by qualitatively characterizing leadership of interdisciplinary teams. In addition it identifies the need for leaders to improve their skill sets in the areas of conflict management and meeting productivity.

Keywords: Leadership; Collaboration; Interdisciplinary research teams

Bibliometric/Big data – Texas VI

Session Moderator: Scott Leischow

Challenges and Opportunities of the UCSD Map of Science-Library of Congress Crosswalk

Robert Light (*Indiana University*), Jaimie Murdock (*Indiana University*), Colin Allen (*Indiana University)* and Katy Börner (*Indiana University*)

Numerous classification systems have been devised to manage different types of information. From the Dewey Decimal System and Library of Congress Classification Numbers to International Patent Classification to more modern ontologies, each is crafted by different groups to cover different entities with different goals. This creates substantial challenges when scientists from varied domains attempt to form teams and combine their resources and data. This paper examines the process of creating a crosswalk from one classification system to another. It will further discuss challenges and opportunities that arise when trying to study collaborations between researchers in philosophy and the sciences.

Specifically, we discuss the process of constructing a cross-walk from the UCSD Map of Science the Library of Congress classification system. We then proceed to use this cross-walk to exemplarily overlay 792 selected volumes from the Hathi Trust public domain book collection onto the UCSD Map of Science to understand how philosophy monographs on animal psychology are distributed over the landscape ofscience.

Keywords: Science of science; Classification systems; Digital humanities; Interdisciplinarity; Science mapping

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Assessing the Translational Characteristics of three CTSAs: a Scientometric analysis

Charisse Madlock Brown (*University of Iowa*)-and David Eichmann (*University of Iowa*)

Translational science, a methodology that bridges gaps between fundamental and applied science, has gained attention by both the medical research community as well as government funding agencies. Both groups identify a need for coordinated efforts to assist researchers in translating basic science research to clinical for the end goal of improving patient care. The signal-to-noise ratio problem is a significant impediment – identifying what of basic science can or should be translated is a difficult task for clinicians(1). The National Institutes of Health launched the Clinical and Translational Science Awardees program in 2006to support medical institutions across the country, with translation a clearly major component. This work presents the translational characteristics of three research institutions: The University of Iowa, a 2007 awardee; Northwestern University, a 2008 awardee; and Indiana University School of Medicine, a 2008 awardee(www.ctsacentral.org). We identify whether highly connected individuals are basic science or clinical science researchers. We also indicate the composition of co-authorship groups. Our intention is to highlight areas of concern in terms of how authors collaborate in such a way that is easily reproducible. We use data from the VIVO ontology-based profiling data from each university. We classify the departments in each university into three categories: basic, clinical, or other. The University of Iowa network has 873 authors. The Indiana University network has 823 authors. The Northwestern University network has 727 authors. We use the HITS algorithm to identity well connected first authors, and well connected secondary authors. This algorithm uses an iterative process to find those with high authority scores who would be first authors who are connected to those with high hub scores who are connected as secondary authors to many first authors with high authority scores. This is a popular technique to find important nodes in a wide variety of networks. We also use the Blondel community detection algorithm to identify groups of researchers who work together frequently enough to be considered a community of connected authors. The Network Workbench Toolkit (http://nwb.cns.iu.edu/) was used to run the analysis. Our results indicate that in the medical institutions of the universities studied there are very small percentages of basic science researchers. The proportion of well-connected basic scientists for all universities is 10% or less. Having so few highly connected basic scientists means clinicians may not be sufficiently influenced by scientists who can expand their knowledge base to improve healthcare. The average proportion of basic science researchers at the community level is also small. Given the importance of translational medicine we believe these numbers are too low. In our presentation we will discuss our results in more detail and give a more comprehensive view of the related issues.

Keywords: Translational science; Network analysis; Co-authoship

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Automatic detection of figure element reuse in biological science articles

Daniel Acuna (*Northwestern University*), Paul Brookes (*University of Rochester Medical Center*) and Konrad Kording (*Northwestern University*)

The output of science is largely communicated through articles, and while article texts have been analyzed at scale, their figures have received little scalable attention. The most basic relationship between figures is the re-use of their parts. Tracking the use of figure elements promises to be important for understanding how scientists collaborate and share ideas, both appropriately and potentially inappropriately. A broad range of methods in computer vision is scalable to large databases. Moreover, through PMC Open Access Subset, large sets of papers along with their figures are becoming openly available. In this study, we thus aim at detecting figure element reuse by adapting algorithms that are (1) fast, (2) memory efficient, (3) accurate, and (4) relatively robust to modifications of the copies such as changes in contrast, rotation, and scaling.

A fast and accurate method for copy-move figure element detection needs to be adapted to the particular demands of large databases of scientific figures. Here, we extend a typical move-copy image element detection algorithm that works well with natural scenes . In short, our algorithm extracts features in high entropy regions, clusters them, and looks for clustered matches with good affine transformations (i.e. translations with potential rotation or scaling). In the scientific literature, in particular, images are usually arranged in panels with additional text annotations, titles, and labels. We thus added a post-processing step to remove such common matches using the correlation between the gray scale and binarized images of the patches, which removes most text and graph pieces (e.g., arrows, lines, and bars). An article is tagged as having figure element reuse when 4 or more key points survive the end of the process. The final algorithm is relatively fast (1 articles takes around 10 seconds to analyze using non-optimized code) and the matches are accurate and robust to modifications such as contrast, rotation, and scaling.

To test our approach, we obtained figures of 71 articles from the PubMed Central Open Access Subset, randomly chosen from journals whose name contained one of the word parts “biol”, “med”, “biochem”, “cancer”, ”immune”, “mole”, “pharma”, “genes”, “endo”, “cell', or “onco”. We manually label articles for figure element reuse, which we treat as the ground truth. Our algorithm obtained a precision of 0.53 and recall of 0.83 (F1 score = 0.64), which is a relatively good performance given the diversity of figures analyzed. Many parameters in our algorithm are not tuned to particular kinds of figures or fields, opening the door for future improvements on a per field basis.

Understanding figure element reuse promises to open new avenues for the study of team science, such as team structures and their impact on the way ideas are communicated through figures.

Keywords: figure element reuse in science; “big data” science of science; computer vision

Evaluation of Team Formation, Process and Function – Texas VII

Session Moderator: Noshir Contractor

Applying Social Network Analysis to Evaluate the Evolution of Interdisciplinary Research Teams

Pamela Bishop (*University of Tennessee*)

Evaluators of collaborative research programs face a daunting challenge of measuring not only the productivity of group members in terms of scholarly products, but also the types of collaborative activities that lead to those products. This presentation will discuss the use of network analysis methods to evaluate the growth and productivity of several interdisciplinary research groups over a three-year period. It will focus on (1) how to look at the patterns of change in group composition of time, (2) what the patterns of connectedness look like across disciplinary and geographic boundaries, and over time, and (3) to what extent network characteristics of productive research group members correlate with productivity. The presentation will highlight the lessons learned from this evaluation, and how the process fits into the science institute’s overall evaluation program.

The National Institute for Mathematical and Biological Synthesis (NIMBioS) is funded through a National Science Foundation award and located on on the University of Tennessee campus. The institute draws a diverse cadre of researchers from around the world to take part in interdisciplinary working groups, workshops and conferences to find creative solutions to pressing problems from animal disease to wildfire control. A need exists to evaluate the mechanisms through which researchers at the center are interacting to produce scholarly research in order to fully understand the reasons behind group productivity. This paper attempts to evaluate these mechanisms using network methods where research group participants indicated the nature of their collaborative relationships with other group members before and after each meeting with their groups over a period of about two years.

Several network measures were applied to evaluate growth over time, including size, density, complexity, and centralization of the full network for each group at the each administration of the survey. Average numbers of cliques that have developed, as well as average effective network size were also used. Cross-disciplinary and cross-geographic collaboration were evaluated by examining densities of interactions within and among self-reported disciplinary areas. The relationship between network position (degree centrality and betweeness centrality) and productivity was examined to determine the network characteristics of productive center members and research groups as well.

This paper should be relevant to a diverse audience interested in research evaluation, team science, bibliometrics, network analysis methods, and/or longitudinal evaluation.

Keywords: network analysis; interdisciplinary research; bibliometrics; longitudinal evaluation

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Team Formation & Maintenance Strategies among Newly Formed Interdisciplinary Teams

William Pluta (*Columbia University Medical Center*), Zainab Abedin (*Columbia University Medical Center*), Boyd Richards (*Columbia University Medical Center*), Nancy Reame (*Columbia University Medical Center*), Harold Pincus (*Columbia University Medical Center*) and Henry Ginsberg (*Columbia University Medical Center*)

Introduction: Establishing and sustaining new interdisciplinary teams is a core challenge of team science. Stokols and colleagues note that understanding the complex, multiple political and societal factors involved in sustaining teams can help decision-making around strategic investments in team science.1 We examined how small planning grants can serve as a catalyst for new team formation when group members with minimal experience work together on complex research projects.

- What formation/maintenance strategies did newly formed interdisciplinary translational science teams adopt?

- How can successful team formation/maintenance strategies be promoted?

Methods: Participants included 12 (of possible 14) physician-scientist principle investigators who had won institutionally sponsored planning grants ($25000) to support the formation of new interdisciplinary teams. Semi-structured interviews were conducted 2 to 4 years post-funding. Questions focused on (a) outcomes, (b) adherence to grant selection criteria, and (c) strategies for team formation/maintenance. We utilized Chi's approach for quantifying qualitative data.2

Results: Ten of 12 teams were found to be still functioning 2 or more years after the grant. Through a process of coding using principles of grounded theory, we identified twelve strategies regarding team formation/maintenance in the interview transcripts. Seven strategies were congruent with the principles of successful teams found in the Science of Team Science (SoTS) literature and will not be a significant focus of our presentation (e.g. issues around leadership).1

Our presentation will focus on five linked strategies that are not consistently emphasized in the core SoTS literature.1,3 These include: (a) balancing critical discourse around research questions with efficiency, (b) balancing tension between clinical and research role and goals, (c) leveraging expertise of interdisciplinary trained investigators, (d) identifying projects that will consistently engage the entire team, and (e) promoting research projects and programs. For each strategy, we will briefly describe the strategy, present instances of the transcript that support the strategy, report prevalence in the sample, and propose a grant design principle that may support wider adoption of the successful strategy. By way of illustration, we elaborate here on the strategy "identifying projects that will consistently engage the entire team". This strategy addresses the challenges of engaging an interdisciplinary team around a narrow clinical research question.

For example, one group examined the role of how a dietary supplement that had been proven to be successful for one problem and population, could be transferred to a new problem and population. A second team brought together a sophisticated group of clinician-researchers to develop an artificial organ. While both teams came together around the clinical issues, the researchers generally did not coalesce around multiple research questions. After the initial planning stages, some team members had a much reduced role in the research project.

Conclusion: Planning grants can promote the formation of new interdisciplinary research teams. Fine grained analysis provides important information around how teams can be scaffolded during the formation stage in order to promote maintenance. These findings can be used to inform future large-N survey studies.

Keywords: Planning grants; Interdisciplinary Teams; Team formation; Team strategies

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Network Analysis of Cancer Research Collaboration in a Statewide Cancer Coalition

Scott Leischow (*Mayo Clinic*) and Janet Okamoto (*Mayo Clinic*).

Research on cancer remains a high national priority, and one reflection of that priority is the implementation of statewide cancer coalitions that are federally funded and that include the translation of research into practice. In the state of Arizona, the state cancer coalition has brought together stakeholders in the cancer community, and as part of that coalition created a 'research' committee' that is designed to foster increased communication and collaboration among those conducting cancer research. In order to better understand the nature of that collaboration and foster increased cancer research collaboration, we implemented a network survey in 2007 to characterize the Arizona cancer research community. The specific focus of that research was to assess communication and collaboration in three research domains: Discovery (research to identify new potential prevention and treatment options), Development (creation of new medications or other treatments derived from the discovery process), and Delivery (research on the implementation of new evidence-based approaches.

Two papers were published from that study*, and those results showed that the University of Arizona held a strong position in all three domains, and other cancer research organizations had expertise in mostly in either the discovery and delivery areas, with little focus on development. Similarly, network centrality was positively related to discovery and delivery cancer research in the organizations, but development was not.

We are now in the process of implementing a follow-up survey to cancer research research organizations within the Arizona Cancer Coalition in order to assess the current state of communication and collaboration. Our goal is to assess change over time among the research organizations, and to use the new information in order to strengthen the translational cancer research efforts in

Arizona. The results of this new research will be presented relative to the last survey.

Keywords: Collaboration Tools; Research Collaboration; Cancer; Coalition; Network Analysis

2:30pm-3:00pm Networking Break

3:00pm-4:30pm Paper presentations

Training - Texas V

Session Moderator: Michelle Bennett

Science of Team Science in Research on Learning

James Dietz (*National Science Foundation*), Gregg Solomon (*National Science Foundation*) and Sarah-Kathryn McDonald (*National Science Foundation*)

We examine science teams in the area of cognitive science research and research and learning in science, technology, engineering, and mathematics (STEM) education as funded by the National Science Foundation. The Research and Evaluation in Education in Science and Engineering (REESE) program was established in 2006 with the aim toward fostering multi-disciplinary research through the formation of teams of researchers from the learning sciences, education, cognitive science, psychology, other social sciences, and the natural sciences and engineering with the express notion that many of the most pressing national problems in education in STEM settings would benefit from solutions derived from multiple perspectives and disciplinary traditions.

In this paper, the authors first review some of the theory on research productivity and social research networks as well as recent work on the Science of Team Science. The authors then examine the relation between the interdisciplinary nature of REESE research projects using the theoretic model put forth by Dietz and Rogers on “scientific and technical human capital” and the role that multidisciplinary research plays in research production and the content of research on learning. Analytically, we investigate the composition of REESE teams over time, the nature of the research they draw on and the research they produce (and who cites that research). Our preliminary findings suggest that (1) Teams representing more disciplines produce more interdisciplinary work which is cited in a larger variety (greater number) of journals and has a higher citation rate (consistent with our theory). For this we make use of an interdisciplinary index based on the work of Porter et. al. via the Web of Science. And, (2) the most productive teams tend to have membership that includes disciplines in each of the following three categories (a) education research or learning sciences, (b) psychology and/or cognitive science, and (c) disciplines in that natural sciences and engineering. [We hypothesized this because these fields represent the three major conglomerations of fields that seem to offer possible solutions to research problems in our domain]. Human and social capital and citation data are taken from the systems of the National Science Foundation as well as the Web of Science and are analyzed using simple measures of correlation, ANOVA and/or multiple regression.

The REESE program is like many US government science programs in that it rests on a program theory that promotes multiple and interdisciplinary research solutions by encouraging partnerships among researchers in different disciplines. Our research is an initial exploration of this common, but untested, government policy hypothesis. We have learned a considerable amount through this research about the nature and complexity of collaborations between those in the social and cognitive sciences and those in natural science and engineering fields. We believe the methods we use and the measures (i.e., indices) developed will be of use to other researchers who wish to investigate team science outputs and outcomes.

Keywords: Multi-disciplinarity; social capital; human capital; cognitive science; learning research

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Applying Science of Team Science Research to Undergraduate and Graduate Education

Maura Borrego (*Virginia Tech*)

The purpose of this presentation is to translate the findings of team science research to provide actionable recommendations for teaching team skills to undergraduate and graduate students. Although the SciTS field is focused on professional scientists, all scientists begin their training in formal educational settings such as graduate and undergraduate degree programs. Effective team training at earlier points is likely to result in more effective teams that free training and research resources to focus on more advanced team science issues (for example, fewer basic training needs). This work will also provide an additional means for academic team science researchers to demonstrate the value of their research to their colleagues.

First, the author conducted a systematic review of 104 articles published 2007-2012 describing engineering and computer science student team projects in higher education settings. The systematic review addressed the following questions: What professional skills have engineering educators sought to develop through team projects? What challenges in facilitating and assessing engineering student teams have engineering educators sought to address? What literature has been used to inform development of teamwork and related professional skills in engineering students? This analysis found that engineering faculty members addressed a variety of outcomes through team projects, including teamwork, communication, sustainability, and global/societal design context. They sought to avoid social loafing and conflict while building trust among team members to ensure equal effort. However, few of these articles meaningfully engaged team science literature, or even the technical terms that team researchers use to describe the constructs.

Based on the challenges most frequently identified by the faculty authors of the 104 articles, the author selected five constructs from industrial and organizational psychology to review: social loafing, interdependence, conflict, trust, and shared mental models. The review of each construct includes basic definitions and key research findings, examples of how the principles can be applied in education settings, and pedagogical recommendations based on the research. Examples of pedagogical recommendations include: assigning smaller teams, more complex projects, providing clearer expectations, considering the implications of group vs. individual grading schemes and peer evaluations, including various social and team building activities, and allowing time for group processing and reflection.

Since the version of this work directed at a faculty audience has already been published as a journal article, the SciTS conference presentation will focus on recommendations for team science researchers to translate and disseminate their work to educators. This will include discussion of what types of professional teams are most relevant to educational teams and how outcomes such as profit and productivity can be translated to education.

Keywords: design; education; effectiveness; engineering; project teams

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Developing the Team Science Information Workforce

Suzie Allard (*University of Tennessee*)

In today's research environment there is a growing need for coordinated data curation, digital preservation and data management at all stages of the research and lifecycles. Scientists studying complex problems, such as climate change and the rise of chronic diseases, often produce mass amounts of data, require access to others' data, and need interdisciplinary approaches to data access and management. This necessitates a team science approach. Team science can be defined as "collaborative efforts to address a scientific challenge that leverages the strengths and expertise of professionals trained in different fields". Information sciences have embraced an interdisciplinary paradigm, but a focused approach to information science education is needed in order to reflect the increasingly intricate collaborative involvement in sustaining data services.

The introduction of team science brings its own set of new challenges to information professionals. Information professionals naturally fit into the role of data managers, and in fact have increasingly become parts of scientific teams specifically with the role of curating data. However, collaboration between librarians and researchers can be hindered by many factors, including scientists' ingrained habits, attitudes and preconceptions, as well as information professionals' frequent lack of scientific subject knowledge. There still remains the tendency for librarians and other information professionals to be perceived not as integral team players in scientific research, but as passive observers offering only remote support to data-driven science.

This paper introduces the project "Team Science" which is being introduced to educate students to become integral, central parts of research teams throughout projects and to anticipate the data and information needs of researchers rather than the more traditional role of simply responding to requests for data and information services. Team Science trained data specialists will become, as it has been termed, "embedded librarians" in these large-scale teams. Team Science will produce students with the communication skills to negotiate diverse, distributed teams and the expertise to handle data and information throughout the entire research and data lifecycles, from planning through preservation to analysis, and who can effectively work with interdisciplinary teams of researchers. The project focuses on three aspects of information professionals' roles in team science:

1. Data Management and Curation
2. Interpersonal/Interorganizational Skills
3. Situational Knowledge

This paper will introduce the foundation for the project and discuss the framework that has been established.

Keywords: Training; Situational Knowledge; Communication

Team science and transferable skills development

Tjerk Wardenaar (*Rathenau Instituut*) and Peter Van Den Besselaar (*VU University Amsterdam*)

A large share of PhD-qualified workers in a country's labor force is seen as an indicator for a developed knowledge economy. The number of PhD holders worldwide has been growing for decades: for example, the number of science

PhDs has grown nearly 40% each year between 1998 and 2008. Consequently, most PhD graduates will have a career outside academia .

The sharp rise in PhD holders attracts (increasing) criticisms on current PhD training trajectories: is the knowledge economy actually benefiting from this growing number of PhD holders? Can PhD holders contribute to the grand societal challenges that contemporary societies face? The key to answering these questions is in the skills that are developed during the PhD training trajectory. Are those skills too restricted, and mainly relevant for academic research, or are skills that come with PhD training transferable to other (non-academic) contexts within the knowledge society? However, there are not many studies on skill development in PhD training trajectories – and those that exist do not point in the same direction.

Criticisms on traditional trajectories has spurred interest in alternative PhD training trajectories. In line with a growing belief that transdisciplinarity is essential for innovation, alternative PhD trajectories emphasize collaborations with different disciplines and with non-academic stakeholders. Do such collaborative trajectories have a positive effect on the development of so-called transferable skills?

In this paper we compare skill development in different contexts. We distinguish between academic skills, communication skills, valorization skills and professional skills. We have a sample of about 180 PhD students in climate change research in the Netherlands and the UK. About 50% are/were in traditional PhD-trajectories, and the other 50% in large transdisciplinary team science projects. Do these different trajectories result in different skill profiles? How do these different profiles look like? And, does the development of broader and transferable skills leads to less development of academic research skills?

Keywords: Transferable skills; skill differences; learning in transdisciplinary teams; PhD trajectories

Organizational and Institutional factors - Texas VI

Session Moderator: Kevin Crowston

A Framework for Evaluating Institutional Initiatives that Promote Scientific Convergence

Matthew D Wood (*US Army Engineer Research & Development Center*), Igor Linkov (*US Army Engineer Research & Development Center*) and Matthew E Bates (*US Army Engineer Research & Development Center*)
Interdisciplinary collaboration and alignment across disciplinary boundaries is required to successfully achieve goals of today's innovation efforts in science and technology. "Convergence" is the term that has been used to describe this growing need for collaboration between different fields of inquiry to tackle inherently interdisciplinary problems of ever-increasing complexity. Funding and research institutions have a key responsibility in providing the environments, tools, manpower, and other mechanisms to facilitate this collaboration. While these organizations intend to help form new teams and support existing ones to address key research challenges, the manner in which these institutions think about, develop, and evaluate these collaboration mechanisms can often be ad-hoc. For instance, while groups like NSF and the NIH will host workshops and panels to develop recommendations for future research funding initiatives, the way that these recommendations are developed into funding lines or evaluated for inclusion in a Broad Agency Announcement may consider the problem to be answered without thinking about the most effective collection of expertise to solve that problem or whether the funding mechanism encourages researchers from the discipline of interest to collaborate.

We propose an evaluation framework using multi-criteria decision analysis (MCDA; Linkov & Moberg, 2011; Belton & Stewart, 2001) to provides a structure that institutions can use to evaluate different actions to promote convergence based on:

- the objective(s) which the institution would like to achieve, e.g., solving problem X
- the criteria which contribute to achieving objectives, e.g., the collections of disciplines hypothesized as useful for solving the problem or current technological constraints that limit current progress
- and metrics that quantify the effectiveness of an alternative in addressing the criteria and objectives. Alternatives are actions which promote convergence, e.g., a research center with colocated scientists.

The talk will outline the process for structuring an MCDA with the goal of evaluating alternatives for promoting interdisciplinary collaboration to solve scientific and technological challenges, provide a hypothetical case study to illustrate the framework, and give suggestions for specific problem and institutional contexts where the framework may be deployed.
Keywords: convergence, decision making, funding agency, science policy, workplace design

Self-Organization of International Research Teams: Role of Institutional Factors

Inga Ulnicane (*University of Vienna*)

International research collaboration has played an important role in knowledge production for centuries (Beaver & Rosen 1978) allowing researchers to benefit from joining high quality highly specialized expertise to solve complex scientific issues but also encountering challenges of increased transaction costs involved in reconciling diverse management styles, organizational cultures, employment and funding systems (Georghiou 1998). While today international scientific collaboration is increasing due to many scientific, technological and economic reasons (Wagner 2008) and is often seen by policymakers and research organizations as a good thing that has to be promoted, very little is known about how international research teams form and organize, i.e. how do scientists identify potential partners from other countries and how do they choose their common research problems and forms of interaction. To address this research gap, this paper undertakes an in-depth analysis of how successful international research teams form and organize and what factors facilitate their emergence and functioning.

To obtain a rich and nuanced empirical material on formation of international teams, this paper draws on an extensive study combining multiple research methods and data sources to study long-term (more than 10-25 years) international collaborations in an emerging field of nanosciences and technologies among researchers based in Germany, France, the Netherlands, Belgium and the United Kingdom. It integrates organizational, publication, project, CV and interview (61 semi-structured interviews with collaborating scientists) data to undertake multiple longitudinal case studies including within-case (process tracing) as well as cross-case (contextualized comparisons) analysis.

The empirical evidence reveals considerable self-organization of international scientific community where relevant partners and collaborations are identified via international academic conferences, associations, scientific literature and cross-border mobility. Self-organization of successful international teams is facilitated by a number of institutional factors such as autonomy of researchers to choose their collaborators, research topics and format of interaction, open organizational culture, reputation of research organizations for high quality highly specialized expertise, active collaborative and communicative environment, support for international mobility and recruitment as well as diversity of funding sources. This study reveals that factors facilitating self-organization of successful international teams are similar to ones enabling creative research accomplishments (Heinze et al 2009; Hollingsworth 2006) and that creation of international research teams is supported not only by dedicated internationalization strategies and policy measures but also indirectly influenced by institutional factors conducive to research creativity. Thus, this paper advances understanding of formation and organization of international research teams analyzing a detailed material and rich insights on an important but so far little studied process of self-organization of scientific teams, which provides basis for further theory development of team science.

Keywords: international research teams; research collaboration; self-organization; institutional factors

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Discipline and Promotion: Interdisciplinarity in Faculty Evaluations

Eliza Evans (*Stanford University*) and Daniel McFarland (*Stanford University*)

Many scholars, research institutions, and funding agencies view interdisciplinary research as transformative, progressive, and full of potential. As a result, universities and funding agencies often encourage faculty members to engage in boundary-spanning research. Through interdisciplinary research centers, institutional seed grants, and large federal grant programs, faculty receive incentives and support for interdisciplinary research from both within and outside their home institutions.

Though these grants and institutional initiatives urge scholars to engage in interdisciplinary research, faculty are simultaneously on career paths that are defined by their disciplines and departments, not these interdisciplinary initiatives or institutes. Faculty have discipline-based appointments, go through disciplinary tenure reviews and promotion processes, and disseminate their work predominantly through discipline-based conferences and journals, all of which serve to reinforce disciplinary divisions, encourage disciplinary specialization, and guide career trajectories along disciplinary pathways. How does engaging in interdisciplinary work impact the disciplinary career paths of university faculty? Are scholars who do interdisciplinary work more or less likely to succeed and advance in their discipline-based careers?

To explore these questions, we analyze a longitudinal dataset that spans 15 years (1993-2008) at Stanford University. Using parametric survival analyses, we specify whether doing interdisciplinary research increases or decreases the likelihood that a faculty member is promoted during two different evaluations: the tenure review and the review for promotion to full professor. We focus on these moments of evaluation because they both define career advancement for individual faculty and serve as gatekeeping and legitimation processes within departments and disciplines. This allows us to explore not only the relationship between interdisciplinarity and careers for individuals, but also the variation in acceptance and incorporation of interdisciplinary work and scholars across different disciplines. We focus on both tenure and promotion-to-full evaluations so that we can identify changes in the relationship between interdisciplinary work and faculty career trajectories over the length of faculty careers. To measure the interdisciplinarity of faculty members, we use publication data from Thompson Reuter's Web of Science, complemented by data from faculty curriculum vitae. We construct measures of interdisciplinarity based on the home departments of authors on multi-author papers, the citation patterns within publications, and text comparisons among the abstracts and methods sections of a faculty member's published papers and those of the broader discipline.

By adopting individual scholars and their career trajectories as the focus of our analysis, we explore an important and under-theorized aspect of how interdisciplinarity does (or does not) occur in academia as a result of individuals' motivations, evaluations, and career outcomes. The literature on interdisciplinary scholarship often focuses on institutions, publications, and the organization of knowledge production. This gives little attention to individual scholars and their motives, in spite of the fact that faculty research is self-guided, and faculty themselves decide whether or not to engage in interdisciplinary research. Here, we consider the career outcomes that stem from these decisions and consider the impact that evaluations may be having on faculty desire and ability to engage in interdisciplinary research.

Keywords: tenure; faculty careers; interdisciplinary research; evaluation

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The Solicitation Situation: Examining the Language of Team Science in Federally-funded Research

Wayne Lutters (*University of Maryland, Baltimore County (UMBC)*) and Barbara Linam-Church (*University of Maryland, Baltimore County (UMBC)*

The future of the scientific enterprise inevitably trends toward computation and collaboration. As a result there is an increasing emphasis on team-enabled "big science." United States federal funding agencies routinely encourage multi-investigator, multi-discipline, multi-institution efforts. While there is an expanding body of literature that examines the dynamics and effectiveness of these projects, it is unclear how much of this science of team science informs the design, solicitation, review, and evaluation of funded team-science projects. What is the current state-of-the-art in conceptualizing team science across government agencies?

This paper presents the preliminary results of an extensive survey of contemporary solicitations (e.g., broad agency announcements, calls for participation, requests for applications/proposals) across multiple federal funding agencies, including DARPA, DOE, EPA, NASA, NIST, NIH and NSF, and the full range of their diverse programs. Culled from the Research.gov repository and sampled to maximize disciplinary diversity, each proposal was content coded for team science language, both explicit and implied, by a team of cross-disciplinary researchers. Particular attention was paid to contextual language use (e.g., when is different language being used to describe the same thing and vice versa?) and the emergent disciplinary and agency dialects.

The results reveal meaningful connotative differences in the use of key terms such as team, collaboration, coordination, interdisciplinary, and cross-institution. There is a tendency to under-define terms, leaving their interpretation up to the principle investigator and review teams. However, there are some key examples where the specific characteristics or configuration of the desired teams is outlined. Budget often serves as proxy for team complexity. While some larger initiatives do acknowledge the need for explicit engagement of team science mechanics with required sections for management, coordination, or collaboration plans there is little guidance for content or quality metrics. This study provides a baseline for the current framing of federally funded team science and a design space to explore best practices.

Keywords: team science; solicitations; language; terms; content coding

Team composition and Assembly - Texas VII

Session Moderator: Deanna Pennington

9-The Strength of the Strongest Ties in Collaborative Problem Solving

Yves-Alexandre de Montjoye (*Massachusetts Institute of Technology*), Arkadiusz Stopczynski (*Technical University of Denmark*), Erez Shmueli (*MIT*), Alex Pentland (*MIT*) and Sune Lehmann(*Technical University of Denmark*)

Complex problem solving in science, engineering, or business has become a highly collaborative endeavor. Groups of scientists or engineers are collaborating on projects but also using their social networks to gather new ideas and feedback. Here we bridge the literature on group work and information networks by studying groups' problem solving abilities as a function of both their within-group networks but also their members' extended networks. We show that while groups' performance is strongly correlated with its networks of expressive and instrumental ties, only the strongest ties in both networks have an effect on performance, as shown in Figure 1. Both networks of strong ties explain more of the variance than other factors such as measured or self-evaluated technical competencies or personality of the group members. In fact, the inclusion of the network of strong ties renders these factors non-significant in the statistical analysis. Our results have consequences for the organization of groups of scientists, engineers, or other knowledge workers tacking our current most complex problems.

Keywords: social networks; collaboration; groups; strong ties; complex problem solving

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The consortium sand-box: An emerging trend in biomedical R&D

Mark David Lim (*FasterCures - A Center of the Milken Institute*)

Most patient-directed biomedical inventions travel through a pathway filled with scientific, regulatory, adoption, and reimbursement obstacles. Some of these challenges are shared by multiple researchers, and can be addressed through the use of a widely accessible resource or tool. However, the majority of tools that can meet these needs have not been developed, as they require expertise from other research sectors and validation across multiple organizations. This would be an endeavor beyond the capabilities or resources of most individual researchers. One emerging framework for biomedical research partnerships is the consortium, which provides a neutral and temporary collaborative environment for multiple – oftentimes competing – organizations, leveraging the aggregated intellect and resources of a diverse group of stakeholders to create a widely-usable tool. The output of a successful consortium is typically a standardized resource that is collectively designed, developed, validated, and deployed to the broader scientific community.

Our presentation would focus on the reasons, impact, and landscape of biomedical research consortia. By analyzing 371 biomedical research consortia, we track the growth of consortia across the globe, providing insight on how this model of partnership continues to broadly advance basic and translational biomedical research. We would like to present our analysis into areas of research, disease-focus (if applicable), types of research, and the challenges that consortia face when bringing together multiple biomedical research stakeholders.

Our data is based primarily on desktop research and phone interviews on a selection of consortia; some of results are highlighted at http://fastercures.org/consortiapedia, with the quantitative analysis under review in a peer-reviewed journal. We find that the majority of consortia are initiated by a government agency and are focused on: advancing drug discovery, developing tools for oncology research, and advancing the use of biomarkers. This model of collaboration continues to emerge, particularly in an environment of across-the-board dwindling resources. While our data suggest that the increasing trend of research-by-consortia provides significant benefits to the scientific community, it still needs optimization before it can be fully integrated into the biomedical research pipeline.

Keywords: *Consortium, Biomedical research, public private partnership, multi-stakeholder collaboration*

Principles of scientific team formation and evolution

Stasa Milojevic (*Indiana University*)

This abstract is based on the published paper: Milojević, S. (2014). Principles of scientific research team formation and evolution. Proceedings of the National Academy of Sciences (PNAS), 111(11), 3984-3989. Understanding the distribution of the number of coauthors in a publication is of fundamental importance, as it is one of the most basic distributions that underpin our notions of scientific collaboration, collaboration networks and the concept of "team science". Previous studies uncovered important properties of the internal structure of teams, but little attention has been paid to principles that govern their sizes. In most fields teams have grown significantly in recent decades. More importantly, the character of team size distribution has changed over that time period. This study presents a model that successfully explains how team sizes in various fields have evolved over the past half century (Figure 1). The model demonstrates that teams form based on two principles: (a) smaller (core) teams form according to a Poisson process, and (b) larger (extended) teams begin as core teams but consequently accumulate new members through the process of cumulative advantage based on productivity.

Keywords: team size; modeling; cumulative advantage

Compositional, Relational and Ecosystem Influences on Team Assembly in Emerging Scientific Fields

Alina Lungeanu (*Northwestern University*), Sophia Sullivan (*Northwestern University*) and Noshir Contractor (*Northwestern University*)

Scientific teams are often at the root of innovative breakthroughs. As a result, understanding the mechanisms behind the assembly of scientific teams has recently attracted scholarly interest. A first step in this direction has been an examination of the compositional and relational mechanisms at play when scientific teams form. However, this research has overlooked the reality that teams are part of larger ecosystems of scientific teams, defined as a dynamic network of both individuals and networks of individuals (Poole & Contractor, 2013) that contain interlocking relationships among teams with common members. These interlocks help to generate knowledge and learning, and may directly affect how teams are assembled and how they performance. To address this oversight, we propose an all-inclusive framework that examines the assembly mechanisms of scientific team based on compositional (i.e., gender, expertise, and university affiliation), relational (i.e., prior collaboration, friend of a friend, and preferential attachment), and ecosystem (e.g., closure and team interlocks brokerage) perspectives simultaneously.

To achieve this goal, we develop a hybrid agent-based and system dynamics computational model that incorporates individual and system-level influences on team assembly. We choose an empirical setting that allows us to assess the magnitude of the various mechanisms we propose. Specifically, we examine scientific teams in the Oncofertility scientific field from its inception in 1993 until 2010. The emergence and evolution of a new scientific field represents an appropriate context to examine assembly of scientific teams since (1) scientific teams are often assembled on an ad-hoc basis reflecting the autonomous and individual choices of its team members and (2) the evolution of the field allows us to explore how individuals change their behavior when choosing their collaborators as the field grows and how the field as a whole influences individuals behavior.

Our results show that the factors we propose differ in the magnitude of their influence on forming a scientific team. In particular, when scientists decide whether to invite or accept a collaboration, the friend of a friend mechanism is the most influential. We also find that the institutional homophily mechanism is more important than gender homophily in choosing or accepting collaborations. Finally, when examining how the structure of the ecosystem influences the success of team assembly in a new scientific field, our results show that ecosystem closure and team access to diverse information are equally important.

Our findings provide a better understanding of scientific team assembly. The model we developed provides researchers with tools to conduct "virtual experiments" that can be used to (1) infer hypotheses about the effects of differences in compositional, relational and ecosystem characteristics on the evolution of scientific fields and to (2) model the effects of policy decisions, such as NIH program funding, on the evolution of scientific fields.

Keywords: networks and teams; team assembly; longitudinal study; co-authorship networks; scientific field evolution

5-00pm-7:00pm Poster presentations – Zilker Ballroom 1-2

Cross Cultural Team Science: How To Leverage Global Experience To Augment Clinical Research

Nancy Dianis (*Westat*) and Tracy Wolbach (*Westat*)

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 supports diverse program needs and provides logistical expertise to the COEs.

A total of 22 individual COE research activities generated compelling new data about non-communicable CVPDs. Six months into the program, additional funding was awarded for team science activities. Several COEs collaborated to answer new research questions. Four subcommittees were established to advance team science by offering all COE staff the opportunity to engage in global non-communicable CVPD research. The following describes the objectives and contributions of these four subcommittees.

Epidemiology Subcommittee: The Epidemiology Subcommittee (ES) identified a unique opportunity to aggregate common variable data from 13 epidemiological research activities in 8 countries, creating a database that offers a unique resource from Asia, Africa, and Latin America study participants. Using a landscaping exercise, ES members determined eight common variables. The ACC harmonized the data and uploaded it into a database for the COE PIs and staff to answer additional research questions. Currently, ES members are using the harmonized COE data to answer research questions and draft manuscripts for publication.

Community Health Workers Subcommittee: The Community Health Worker's Subcommittee (CHWS), with membership from 8 countries, tracked efforts to incorporate community health workers into COE programs and investigated their role in improving health. A landscaping exercise to collect information on community health workers organized the data into a CHW Profile Matrix. Knowledge acquisition sessions were convened to develop a database of characteristics and skills of community health workers, the tasks they perform, and the unique contributions they make to health promotion and prevention. Currently, CHWS members are drafting three manuscripts.

Training Subcommittee: The Training Subcommittee (TS) compared research training efforts across the COEs and discussed ways to evaluate, improve, and expand existing training programs to meet local and regional needs. TS members from 10 countries planned three annual trainee meetings that included presentations by distinguished NIH faculty, poster sessions, case studies, and networking opportunities. TS members drafted and submitted a proposal to NHLBI to enhance their COE training programs. NHLBI funded the development of two webinars – one about health economics and one describing the process of verbal autopsy, and also funded 13 seed grant projects.

Pulmonary Subcommittee: The Pulmonary Subcommittee (PS) convened to address research questions about non-communicable pulmonary conditions that influence the quality of life and health of all populations by integrating data collected across the COEs. PS members elected to conduct a study of the lung microbiome in chronic obstructive pulmonary disease in Peru, Nepal, China, and Bangladesh. Data collection and DNA sequencing of the samples was completed, and study results were presented at the NHLBI-UnitedHealth Centers of Excellence Meeting in 2014.

The ACC facilitated the efforts of all the subcommittees by connecting scientists with common interests; providing forums and infrastructure for discussions; summarizing those discussions, and managing the data generated by each of the subcommittees. The harmonized data from the COEs provided databases to explore pertinent research questions. The ACC coordinated writing groups to draft manuscripts that share findings with other scientists.

Keywords: cross-cultural; international; clinical research; epidemiology; community health workers; training; subcommittee

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Revealing the Global Flows of Research with Natural Language Processing

Charles Gomez (*Stanford University*) and Daniel McFarland (*Stanford University*)

Academics hold the normative view that research ideas should be generated independently of the nation-state and assume that there is no influence from either the state or from the international system on their work (Johnson 1973; Freeman 1985). Instead, research uncovers objective “Truth” that would have been otherwise developed by researchers in any other state, independent of influences due to any differences in a state’s characteristics or pattern of international interactions. But does it? The collaboration and influence patterns among teams of researchers and their published works are discussed in current literature, but the role of the nation-states and the international system on what gets researched is overlooked. Today, an assortment of large-scale corpora and new computational linguistic techniques are making these questions testable. By analyzing these corpora for national patterns of linguistic differences, we have the potential to learn expand our understanding of international team science. In our work, we argue that an author’s affiliation nation-state can describe much of the latent structure in research topics studied over time and that this is independent of co-authorship and citations networks.

Using techniques from computational linguistics to identify clusters of words uniquely associated with a nation-state, we analyze nearly 60,000 political science papers from 1991 to 2011 present in the Thomas Reuter's Web of Science corpus with the technique of Partially Labeled Dirichlet Allocation (PLDA). We begin our focus with political science because political scientists are concerned with political life, and the starting point for any discourse is the nature of the state. The PLDA model assigns each nation-label a set of words (or research topics) uniquely associated with it. For example, if two researchers from Stanford University and one researcher from Oxford University wrote a paper together, then the paper is tagged with the labels "United States" and "United Kingdom," respectively. Labels help guide the algorithm to identify which clusters of words that are uniquely associated with nation-state X, Y, or Z. The list of all states represented in the corpus is referred to as the corpus's topics. For instance, after PLDA processes all papers in the corpus with the label "Canada," it uncovers clusters of words like "first-nations" and "multicultural" that are only associated with the topic "Canada." Once the PLDA model is trained to learn which distributions of topics is associated with which nation-label, we can measure to what extent each document borrows topics associated with other nation-labels (McFarland et al. 2013, p.618). Thus, we can measure to what extent each document borrows "topics" uniquely associated with other nation-states. Perplexity is traditionally used to measure, on average, how unexpected a topic is when associated with the prescribed label, in our case "nation label." The LDA model is often taken as the "baseline" truth for the "true" latent structure of a corpus. We find that the nation label PLDA perplexity model scores closely matches the LDA perplexity model scores, suggesting that much of the latent structure in the corpus is explained by the author's nation of origin as a label.

We are interested in characteristics that describe political, economic, and cultural differences between nation-states that might mirror how research topics flows between them. We identify styles of research by nation-state and study patterns of inter-state influence and referencing, as well as this structure's change. Our initial results suggest that contrary to those arguing that globalization is fostering a more open, flatter, and interconnected global research community, nation-states are increasingly pursuing their own research agendas and are less dependent on the largest academic powerhouse, the United States. What is most surprising is that research topics "flow" independent of co-authorship and citation patterns. Physical proximity, as well as economic and colonial linkages, largely dictates research topic flows between countries.

Keywords: networks; natural language processing; global team science; knowledge flow; research topics

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A Novel Network Architecture for Ascertaining and Monitoring Care Coordination

Nicholas Soulakis (*Northwestern University*)

Well-orchestrated, multidisciplinary care improves patient outcomes and decreases medical costs. Current initiatives in healthcare quality encapsulate collaborative medicine as “care coordination.” Although federal agencies such as the Centers for Medicare & Medicaid Services (CMS) actively encourage care coordination to reduce the number of preventable readmissions, the ability to define and measure it remains elusive. Determinants of important outcomes such as hospital readmission remain a topic of constant debate and investigation, but no comprehensive examination of successfully coordinated care teams exists. Challenges to this examination are manifold. Organic and eclectic teams of healthcare professional innovate on a daily basis to provide well-coordinated care but no platform for measurement and evaluation, outside of labor intensive studies such as analysis of reimbursement records or surveys, exists to capture the data elements necessary to quantify the magnitude, complexity, composition or intensity of care coordination teams. These teams can be very large, with diverse interactions, across days or weeks. Active management of care coordination requires strategically guiding follow-up care by aligning patient characteristics and the skills of the evolving healthcare team. This is currently a manual process. Furthermore, hospital protocols reinforce practice guidelines that are evidence-based and effective, but do not consider the local strengths of the personnel and organization. Patients engage their care teams on a variety of levels. Capturing patient interactions, which provide input to the care team, is elusive and not well studied. A solution to the lack of visibility into care coordination presents itself in the increasing penetration of health information technology among large healthcare providers. ‘Paperless’ providers, especially hospitals, employ modern clinical and administrative systems to exhaustively digitize healthcare interactions between patients and healthcare professionals. These records serve as the electronic chart for the episode of care. Healthcare professionals repeatedly access this digital repository as the authoritative source system to browse patient records before delivering routine care or making important medical decisions. Most large providers meticulously keep auditable records of this access to assure appropriate use of personal health information. Similar to “dark matter” in astronomy, access of patient records to inform regular care cannot be observed by simple review through a clinical system, but comprises a high proportion of the use of electronic health records. If we make the assumption that accessing or updating a patient record links a healthcare professional to a patient, we may begin to define a network architecture of actors and interactions that adds analyzable structure to a currently intractable problem of medical quality improvement. The goal of this project is to improve ascertainment and monitoring of care coordination. The long-term goals are to provide a platform for strategic guidance of medical collaboration for care coordinators as well as informed navigation of healthcare professional networks for patients.

Keywords: care coordination; healthcare service delivery; collaboration; medical quality; architecture; electronic health record

Identifying and Evaluating Care Team Composition for Heart Failure Hospitalizations

Young Ji Lee (*Northwestern University*), Matthew Carson (*Northwestern University*), Connor Skeehan (*Northwestern University*) and Nicholas Soulakis (*Northwestern University*)

Introduction: Heart failure (HF) is one of the leading causes of death in United States. Currently, about 5.1 million people in the United States have the disease, and it costs the nation an estimated $32 billion each year.1 Well-organized, multidisciplinary healthcare teams have been shown to maximize the potential of patient outcomes such as length of stay.2 Several studies reported the effectiveness of the team approach among HF patients; however, interpreting the results of these studies is challenging due to substantial heterogeneity in the

composition of the HF care team.3 The objective of this study is to assess the feasibility of characterizing distinctive components of HF care coordination.

Methods: We extracted data from the Northwestern Medicine Enterprise Data Warehouse (EDW) that houses both the administrative data as well as the clinical data repositories for Northwestern Memorial Hospital (NMH).

The research project was approved by Northwestern University Institutional Review Board. The cohorts were defined as HF patients who were admitted only once during the year of 2012 and all types of healthcare providers who interacted with the patient at least once. HF patients were defined using ICD-9-CM codes as described in the literature.4 The interaction between patients and providers were identified using both an access log and electronic medical records. To identify the composition of team members, we ran classification tree analysis using R, Weka

(as package in R) and Salford Predictive Modeler Version 7.0. The target variable was the length of stay (0: 7 days or less, 1: more than 7 days), and the provider role types were entered as predictors.

Result: We included a total of 548 patients and 5,113 providers for the analysis and 131 employee role types were identified. The mean of length of stay during the admission was 8.4 days (SD=8.9, range: 1~71). The classification tree generated 5 terminal nodes and the percentage of patients who were admitted for 7 or fewer days ranged from 27.4% to 100% in these five groups. Of the variables evaluated, a dietician, rehabilitation physical therapist, physician office employee, and radiology nurse in the care team was identified as a discriminator between short

LOS and long LOS groups. The ROC curve area for the tree model was 0.873.

Discussion and Conclusion: Although conclusions from a single study should be interpreted carefully, this study demonstrates an effective use of electronic health record data to identify and evaluate the composition of HF care teams. Further studies examining role types and responsibilities in greater detail are needed.

Keywords: Team Composition; Classification Tree; Care Coordination; Heart Failure

Analysis of Care Coordination Networks For Deceased Heart Failure Patients

Matthew Carson (*Northwestern University*), Young Ji Lee (*Northwestern University*), Connor Skeehan (*Northwestern University*) and Nicholas Soulakis (*Northwestern University*)

Introduction: Inpatient care is a complex endeavor that requires interaction and communication between several distinct classes of healthcare actors comprising a healthcare team, including physicians, nurses, pharmacists, physical therapists, and others. Understanding the function of these care teams is necessary to understand the inpatient care process. Care teams have traditionally been defined as the group of healthcare actors who input data into a patient's health record via EHR software, what we will define here as the explicit team. However, other healthcare providers interact with these records as well. This second group of actors, the implicit team, does not modify records but instead views them in a "read only" capacity for decision making and review purposes. These record accessions are captured by the computer systems used and comprise a second type of care interaction that has to date not been taken into consideration when evaluating the quality and effectiveness of care coordination teams.

Methods: We have created and analyzed a hospital inpatient care coordination network based on 27 shared heart failure patients with an average length of stay of 13 days, each of whom expired during their hospital stay. The data was extracted from the Northwestern Medicine Enterprise Data Warehouse (EDW) and was approved by Northwestern University Institutional Review Board ID# STU00088968. In this network, each node represents an individual actor of one of 26 types. An edge between two actors indicates that each has accessed at least one common heart failure patient record. Gephi (1) was used to visualize the network and the algorithm proposed by Blondel et al. (2) was used to identify network communities.

Results: We found that the five most common actor types were respiratory therapists (~18%), staff nurses (~17%), resident fellows (~16%), pharmacists (~8%), and physicians (~5%). Notably, we found that for these 27 patients, each actor had an average of ~73 common patient record accessions, resulting in a high average clustering coefficient (0.85) and short average path length (1.8). Additionally, we identified three communities of actors within this network (see figure 1). Actors within each of these partitions have a higher density of interactions with each other than with actors in other partitions. This analysis highlights the complex nature of inpatient care coordination.

Keywords: networks; care coordination; heart failure

Emerging Structure in the New Field of Innovation Science

Michael Beyerlein (*Texas A&M University*)

This poster will focus on the emergence of the new science of innovation. The field has grown in complexity, number of disciplines involved, geographic location of researchers, and in the past 40 years with acceleration of the patterns in the past decade. The patterns suggest that the field is growing in silos with little communication across the disciplinary boundaries involved. Identifiable silos include entrepreneurship, technology management, innovation studies, and general innovation which seem to span over a dozen disciplines.

A mixed pattern of collaborative and non-collaborative publication was identified through use of bibliometric analysis to examine publication patterns over time including co-author and co-citation networks. The term innovation has been defined in multiple ways. Here we will adopt one of the simplest because of its comprehensive nature: “A new match between a need and a solution” (Terwiesch & Ulrich, 2009). This view suggests innovation closes the gap through the processes of problem solving and invention. Such processes occur in every aspect of life, uncountable times every day. Innovation is a term more often applied to larger scale and longer term solutions.

A search using the Scopus database resulted in 24,267 journal articles in English with innovation in the title and 1,032 in German. Less than 933 in French, 593 in Spanish, and 585 in Chinese. Analyses described below were limited to English language articles. Nearly 2% of the articles appear in the journal Research Policy. Other significant outlets include Technovation (1.2%), International Journal of Technology Management (1%), and Technological Forecasting and Social Change (0.9%).

From 1897 until 1964, journal articles fluxuated in frequency from 0 to 10 per year. Then a pattern of continual increase began averaging about 50 per year for 10 years, 100 per year until 1985, 250 per year until 1995, then doubling about every five years with 2,832 publications in 2013. The proportion of innovation articles that appeared in each disciplinary field varies. About 20% are in the business field, 14% in social sciences, 12% in engineering, 8% in economics, and 8% in medicine. Smaller but notable concentrations appear in several science fields and agriculture.

Evidence of a silo structure is suggested when removing articles that address entrepreneurship (mentioned in the title, abstract, or keywords) from the total pool results in a reduction of only 152 articles on innovation, suggesting that entrepreneurship is a separate field. Removing “technology management” from the data set results in a reduction of 137 articles.

Finally, removing articles addressing “innovation studies” results in a reduction of 150 articles. These three silos are not insubstantial fields, for example, entrepreneurship shows 7,047 journal publications after omitting the term innovation. This preliminary set of findings suggests multiple fields are examining various facets of the field of innovation but isolating their work from what may be informative influence emerging from other disciplines.

A comparison of the three primary databases for bibliometric data (Scopus, Web of Science, and Google Scholar) show they index somewhat different sets of publications and report somewhat different metrics (Kulkarni, Aziz, ShamsI, & Busse, 2009). This may be primarily due to differences in the years or the journals covered by each database. A follow-up to the present study will include a comparison of the three databases to determine if the same pattern of evolution for the field of innovation science emerges across them all.

Keywords: Innovation; Science Evolution; Silos; Bibliometrics; Collaboration

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Assessing the Impact of Interdisciplinary Collaboration in Neuroscience Research Publications

Norman Azoulay (*Harvard University - Extension School*)

Collaboration has been identified by bibliometricians as having an integral role in research productivity and performance. Neuroscience research is a domain that stands out, as it is a multi-disciplinary field encompassing subject areas such as biology and psychology. This study aims to provide the academic community with evidence that collaboration between authors from different subject expertise is not only linked to higher productivity, but is also correlated to a significant increase in citations. This research investigates the impact of neuroscience researchers that collaborate both within the field of neuroscience and with external subject experts. I hypothesize that neuroscience articles written by authors with diverse expertise have higher readership/citations than articles written by subject experts within the same field. The current literature suggests that national and international collaboration have the highest readership since it has more potential to reach multiple regional audiences. However, in a field with multidisciplinary relevance such as neuroscience, closing the gap between subject areas leads to multifaceted understanding of problems and the creation of new applications. I challenge that for the field of neuroscience, collaboration between researchers from different backgrounds has more impact than international collaboration.

Keywords: Scientometrics; Neuroscience; Research Collaboration; Interdisciplinary Research; Scopus; Productivity; Impact; Citation Analysis; Communication; Publication; Research policies; Bibliometrics

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Adoption of research practices and collaboration: The case of research synthesis methods

Laura Sheble (*UNC chapel Hill*)

Background: Meta-analysis, systematic review, and related methods of research synthesis have displaced traditional methods of review in highly visible fields, including the clinical sciences and psychology. Whether, to what extent, and which components of research synthesis methods are adopted in different fields is influenced by research cultures, resource availability, and how research goals are framed. Adoption of research synthesis as a method of research review has implications for research practice: Teams of researchers may work on the distillation of a large number of potentially relevant study reports; multiple coders assess study relevance and data extraction; and broader varieties of skill sets may be needed to perform research syntheses.

Purpose: The goals of this study were to understand the contexts of engagement with research synthesis in Conservation Biology, Information and Library Science, and Social Work; and to identify whether and to what extent adoption of the methods have contributed to changes in collaboration patterns in each field.

Analysis: Levels of collaboration in and subsequent research use of research synthesis studies versus traditional research reviews were compared across journals indexed in the Science and Social Science Citation Indexes over three years, 2006-2008. The number of authors contributing to each publication is used to measure collaboration, and the number of citations received by a paper at five years post-publication, an indicator of subsequent research use. Van Elteren tests (1960) were applied to understand whether research syntheses were more collaborative and received more citations compared to traditional research reviews, while controlling for differences in publication year. A supplementary analysis of publication years of reviews and research syntheses in Social Work was performed to examine trends in the number of each type of publication, 2006-2010.

Findings: Research synthesis studies were more collaborative endeavors in Social Work and Information and Library Science, but there was no difference in collaboration levels in Conservation Biology. Research syntheses are cited more in Conservation Biology, about the same in Social Work, and less in Information and Library Science compared to traditional research reviews.

Discussion: Higher levels of collaboration were associated with research syntheses in Social Work and Information and Library Science, supporting the view that research syntheses require greater collaboration. Though no difference was found in collaboration levels in Conservation Biology, a greater number of authors generally contribute to both traditional research reviews (median: 31 (first, third quartiles: 2 : 4)) and research synthesis studies (median: 3 (2 : 4.25)). Traditional research reviews appear to be a highly prized – or at least frequently used – resource in Information and Library Science, which might be explained in part by the small number of review publications in the journal literature in the field. With limited resources devoted to reviewing activities, broader, less specific traditional research reviews may be a more pragmatic approach to collocating and interpreting past research. In Social Work, the number of research synthesis publications increased substantially, while the number of traditional research reviews decreased. In combination with the observation that each type of publication receives about the same number of citations, these trends suggest that research synthesis has become the dominant method of review in Social Work, but traditional research reviews are still useful to researchers – though in an increasingly narrow range of contexts. Research syntheses are used to a greater extent in Conservation Biology compared to traditional research reviews, suggesting that the field has adopted the methods and generally finds them to be more useful than traditional reviews.

Keywords: Research practices; impacts of innovation diffusion; research cultures; comparative method; meta-analysis

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Automatic detection of figure element reuse in biological science articles: methodological considerations

Daniel Acuna (*Northwestern University*), Paul Brookes (*University of Rochester Medical Center*) and Konrad Kording (*Northwestern University*)

The output of science is largely communicated through articles, and while article texts have been analyzed at scale, their figures have received little scalable attention. The most basic relationship between figures is the re-use of their parts. Tracking the use of figure elements promises to be important for understanding how scientists collaborate and share ideas, both appropriately and potentially inappropriately. A broad range of methods in computer vision is scalable to large databases. Moreover, through PMC Open Access Subset, large sets of papers along with their figures are becoming openly available. In this study, we thus aim at detecting figure element reuse by adapting algorithms that are (1) fast, (2) memory efficient, (3) accurate, and (4) relatively robust to modifications of the copies such as changes in contrast, rotation, and scaling.

A fast and accurate method for copy-move figure element detection needs to be adapted to the particular demands of large databases of scientific figures. Here, we extend a typical move-copy image element detection algorithm that works well with natural scenes . In short, our algorithm extracts features in high entropy regions, clusters them, and looks for clustered matches with good affine transformations (i.e. translations with potential rotation or scaling). In the scientific literature, in particular, images are usually arranged in panels with additional text annotations, titles, and labels. We thus added a post-processing step to remove such common matches using the correlation between the gray scale and binarized images of the patches, which removes most text and graph pieces (e.g., arrows, lines, and bars). An article is tagged as having figure element reuse when 4 or more key points survive the end of the process (see Fig. 1). The final algorithm is relatively fast (1 articles takes around 10 seconds to analyze using non-optimized code) and the matches are accurate and robust to modifications such as contrast, rotation, and scaling (see the example output in Fig. 2).

Many challenges were found during the development of the algorithm presented here, and in this poster we hope to discuss in detail ideas to improve the rate of false positives. We will discuss different approaches to discard the repetition of labels and texts through fast OCR algorithms. Also, we will discuss potential ways of removing false matches found in figures that show the slow temporal evolution treatments. Some special considerations for disciplines that rely on the presentation of different exposures levels in different panels will be presented as well.

Understanding figure element reuse promises to open new avenues for the study of team science, such as team structures and their impact on the way ideas are communicated through figures.

Keywords: figure element reuse in science; "big data" science of science; computer vision

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Knowledge synthesis in interdisciplinary research teams using model-based reasoning

Deana Pennington (*University of Texas at El Paso*), Nino Aditomo (*University of Surabaya*), Gabriele Bammer (*The Australian National University*), Antje Danielson (*Tufts University*), David Gosselin (*University of Nebraska-Lincoln*), Geoffrey Habron (*Michigan State University*), David Hawthorne (*National Socio-Environmental Synthesis Center*), Chris Meissner (*University of Iowa*), Rod Parnell (*Northern Arizona University*), Kate Thompson (*University of Sydney*) and Shirley Vincent (*National Council for Science and the Environment*)

Socio-environmental synthesis brings together different disciplines and stakeholders to generate integrated knowledge on the complex interactions between human and ecological systems with the objective of solving society's most challenging and complex environmental issues. Synthesis is the act of integrating knowledge, data, methods, and perspectives in the pursuit of a more comprehensive understanding of the problem at hand. It is at the heart of effective teamwork in addressing interdisciplinary issues. Yet even in settings designed to support it, interdisciplinary synthesis is elusive. Despite a 57% increase in socio-environmental-related undergraduate and graduate programs over the last 4 years, many, if not most, of the programs are functionally multidisciplinary and struggle to integrate across disciplines (Vincent et al. 2012).

The project Understanding, Teaching, and Employing Model-Based Reasoning in Socio-Environmental Synthesis (EMBeRS), funded by the National Center for Socio-Environmental Synthesis, is premised on the notion that design of team activities intended to generate interdisciplinary synthesis should be driven by learning and cognition theory (Pennington 2011). Model-based reasoning (MBR) theory posits that in certain problem solving tasks, humans reason by constructing an internal mental model of the situations, events, and processes, and that external information (linguistic, visual, etc.) can be used to facilitate construction of a mental model (Nercessian 1999). A wide variety of empirical findings support the notion that group work is enabled by the use of external representations. MBR provides a cognitive explanation for the widespread empirical observations that “boundary objects” (Star and Griesemer, 1989) and material artifacts (Hutchins 1995) are key components that link across expert perspectives. Studies of interdisciplinary research have shown that successful teams use many analogies and metaphors (Jeffrey 2003) and co-construct diagrams and other visual models (Pennington 2010). However, cognitive scientist Giere noted that while these generic processes are under investigation, how they play out in practice is likely to be substantially different in different scientific domains (2002). This has recently been supported by Ifenhaler’s (2011) work, which identified different structural and semantic features of knowledge structures across different domains. Hence, progress in understanding learning and reasoning processes in socio-environmental synthesis requires interdisciplinary effort from learning and cognitive scientists, and socio-environmental science educators. The EMBeRS project, comprised of eleven faculty and professionals from the learning, cognitive, social, and environmental sciences, is investigating how MBR and the use of external representations occurs in socio-environmental science teams and classes as a first step towards designing practices that facilitate interdisciplinary knowledge synthesis. These practices will then be evaluated through design-based research in undergraduate socio-environmental courses nationwide. We hypothesize that in interdisciplinary research teams, MBR enables successful integration of expert conceptual frameworks igniting the “embers” of the mind that leads to the innovative outcomes commonly observed in interdisciplinary teamwork. This poster will report on the initial findings of the EMBeRS project.

Keywords: boundary objects; material artifacts; team macro cognition; interdisciplinary ; teamwork

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Measuring the Arc of Team Scholarly Output for Comparison Across Disciplines

Karina Kervin (*University of Michigan*) and Thomas Finholt (*University of Michigan*)

Previous work on collaboration has used the number of peer-reviewed publications or citations as a proxy for successful research, but this approach has drawbacks. While the number of publications or citations is comparable within a discipline, comparing across disciplines can be misleading and disadvantages fields that measure success in other ways (2). As the prevalence of interdisciplinary collaborations increases, this practice makes comparing performance across disciplines difficult. My goal is to develop a scale that addresses this problem by indicating where, when, and how research results are presented.

Keywords: evaluation of team outcomes; interdisciplinary collaboration; scholarly output

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A System for Monitoring and Evaluating Enterprise-wide Research Activities

Suzanne Thompson (*Geisel School of Medicine at Dartmouth*), Brian Levin (*Dartmouth College*), Steven Andrews (*Geisel School of Medicine at Dartmouth*) and Amar Das (*Dartmouth*)

The current CTSA program requires participating academic medical centers to measure, monitor, and evaluate the impact of clinical and translational resources and services on research activity. Such efforts are challenging when research activity is not systematically captured electronically. To address this need, we have developed a web-based, open-source system called InSPIRE (Information Sharing Platform for an Integrated Research Environment). We have designed InSPIRE based on activity theory, an established framework for analyzing organizational work practices in terms of technical and social factors. We present the outcome of this multi-level design approach, namely an integrated system that allows investigators to find and engage a range of CTSA-supported resources (such as cores, funding, and training) and that permits research administrators to track, measure, and assess the use of those resources in real time.

Keywords: translational research, enterprise-wide software, activity theory, multi-level design approach

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An Analysis of NIH Funding of Team-Based Research Grants

Brooke Stipelman (*NCI*), Grace Huang (*NCI*) and Kara Hall (*NCI*).

As the largest source of federal funding for biomedical research, NIH plays an important role in shaping the way in which science is conducted. While there continues to be a growing interest in team based research approaches as a way to solve many intractable public health problems, little is known about the role that NIH plays in helping to fund these collaborations. This poster will highlight trends in NIH funding of Center/Network grants over the last 40 years. Descriptive information such as the type of funding mechanisms, average duration of grants and changes in funding patters over time will be presented. This poster will also include an analysis of multiple PI grants, a model that was adopted by NIH in 2006 in an effort to encourage scientific collaboration.

Keywords: NIH; Funding Patterns; Team-Based Research

Development of Effective Technology Evaluation Guidelines in the Field of Criminal Justice

Nancy Merritt (*NIJ/OJP*)

Technology plays an increasingly important role in today’s workplace. This is certainly the case in the criminal justice field where equipment such as body worn cameras; enhanced communication devices; improved protective technologies and improved methods of information sharing are routinely introduced to the field in an effort to increase safety and effectiveness.

Frequently the assumption is that any new technology or device will enhance mission effectiveness, or officer and public safety. While new devices are generally subject to rigorous lab testing prior to adoption, less attention has been paid to assessing the actual impact of these technologies in the field, or conducting meaningful needs assessments or cost benefit analyses prior to adoption. As a result, there is a dearth of evidence as to the effectiveness of new technologies as they are implemented in the field. Without this information it is difficult for budget conscious agencies to objectively determine whether a given technology will actually improve operations and, if so, how best to determine which device(s) will be most effective in a given context.

The National Institute of Justice, the research arm of the U.S. Department of Justice, seeks to develop guiding principles for the evaluation of criminal justice technology as implemented in the field. This is a challenging task that requires the facilitation of effective communication between social scientists; technologists, and practitioners; development of standardized procedural, contextual, and outcome measures; and effective methods for communicating objective, science-based findings to a broad and diverse audience.

Initial efforts in this area draw from the fields of human factors engineering; criminal justice technology; research collaboration; and evidence based criminology. However, there are undoubtedly other areas of measurement and evaluation expertise that could inform the development of these principles and evaluation teams. Through this session we will share our initial framework and seek the input of individuals from other fields who have dealt with these issues or are simply interested in exploring and contributing to the effort. These issues will undoubtedly take on increased importance in all fields as practitioners and consumers seek to minimize operational costs and increase productivity through the use of technology.

Keywords: communication; evaluation; guidelines; criminal justice; technology

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The Interrater Reliability of an Expert Panel in Evaluation Scientific Teams and Team Changes Over Time

Kevin Wooten (*University of Houston Texas*), Gwen Baillargeon (*University of Texas*), Allan Brasier (*Institute for Translational Sciences*)

While the use of expert panels is commonly practiced, there is considerable concern about cognitive bias, rater errors, politics, and inconsistency. There is relatively little research involving the reliability of expert panels using mixed methods and complex criteria. It is believed that the growth of team science will necessitate use of this methodology, thus making reliability studies crucial.

This poster shall explore the interrater reliability of an expert panel judging the performance of twelve multidisciplinary teams (MTTs) at an NIH CTSA site. Building on a recent report utilizing mixed methods in team evaluation, this poster will illustrate the panel evaluations by five experts ranging in discipline and constituent representation. Using data reduction techniques from numerous sources of data (e.g., progress reports, artifacts, process observation, surveys, bibliographic ratings, and team observation) panel evaluations of team performance along eight criteria (Table 1) will be explored. Four criteria involving research and scientific progress, and four criteria involving team maturation will be used, rendering a team categorization depicting teams an Exemplary Team, a Process Team, a Traditional Team, or as a Developmental Team. Changes in team type categorization over time (2011 and 2013) will be displayed.

Previous reviews of expert panel reliability in grant evaluation will be compared to the current study involving interrater reliability of 12 multidisciplinary teams using more complex criterion and multiple raters. We shall employ a modified version of Cohen's kappa coefficient, with consideration to contemporary psychometrics.

Keywords: expert panels; team evaluation; reliability; team evaluation criteria; mixed-methods

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Advancing Obesity, Physical Activity, and Nutrition Research Efforts at an NCI Designated Comprehensive Cancer Center

Stacie Scruggs and Karen Basen-Engquist

MD Anderson's Center for Energy Balance in Cancer Prevention and Survivorship (Energy Balance Center) was founded July 2012 to facilitate and conduct state-of-the-science research to understand the relationships between physical activity, nutrition, obesity, and cancer, and uses this knowledge to optimize interventions to decrease cancer risk and improve cancer outcomes. The aims of the center focus on 1) developing practice changing research, 2) increasing trans-disciplinary collaborations, 3) improving infrastructure for energy balance research, and 4) disseminating knowledge related to energy balance in cancer prevention and survivorship.

Methods: In order to facilitate collaboration the Energy Balance Center hosted the Energy Balance and Cancer Research Retreat in February 2013 to encourage researchers to discuss new ideas, obtain feedback on ongoing research, and to brainstorm ideas for future energy balance research. The retreat featured a keynote speaker, as well as a plenary session with panel presentations, interactive poster sessions on focused topics, and a reception/general poster session.

Results: The Energy Balance in Cancer Research Retreat was attended by 177 professionals, including 87 faculty members. From MD Anderson Cancer Center, 136 attendees represented 69 departments. Outside of MD Anderson, 11 institutions were represented.

Evaluation data reported that 93% of attendees were either satisfied or very satisfied with the retreat overall. Retreat attendees identified themselves as basic (22%), translational (21%), clinical (19%), prevention, population, behavioral scientists (47%), or interested, but not currently conducting energy balance research (11%). Attendees could endorse multiple responses with regard to the description of their research interests.

Evaluation data identified the following areas extremely useful activities for the Energy Balance Center to facilitate: retreats (68%), disseminating information about funding opportunities (67%), a directory of energy balance researchers (65%), opportunities to network with other energy balance researchers (65%).

Summary: Attendance and evaluation data suggest that professionals at MD Anderson Cancer Center and surrounding institutions will benefit from a systematic effort to facilitate collaborations related to physical activity, nutrition, obesity, and cancer. Identifying the faculty members active in these areas of research and building networks to develop future research projects will allow MD Anderson to develop a critical mass in order to advance scientific discovery.

Keywords: cancer; obesity; research; transdisciplinary team

An Analysis to Examine the Productivity and Impact of Training in the Transdisciplinary Research on Energetics and Cancer Initiative

Julia Michaloski (*NCI*), Martine Bottalico (*NCI*), Brooke Stipelman (*NCI*) and Kara Hall (*NCI*)

In recent decades, there has been an increasing emphasis on large cross-disciplinary science teams to address important public health problems. As investments in team science continue to grow, so does the need to understand the impacts and challenges associated with effective team science approaches. Stimulating cross-disciplinary team science research and maximizing its efficiency can accelerate discoveries and solutions in science. Training is an important component of a team science initiative, because it helps develop the competencies necessary to foster influential transdisciplinary collaborations (American Association for the Advancement of Science, 2013). However, there is little research on the benefits associated with these training programs. Therefore, the purpose of this study is to assess the outcomes of a group of trainees who were part of a large transdisciplinary team science initiative.

The study includes 83 trainees and early investigators who were part of the Transdisciplinary Research on Energetics and Cancer (TREC) initiative. TREC aims to integrate diverse disciplines through collaborations in order to stimulate effective research and interventions across the lifespan to reduce the obesity and cancer burden. Demographic information and career history were ascertained using information contained in CVs and online searches. Publication data was obtained through Medline and Web of Science. TREC included trainees at multiple career stages including junior investigators (37.3%), postdoctoral fellows (15.6%) and graduate students (33.7%). The majority of trainees had PhDs (74.6%), followed by MDs (7.2%), and master's degrees (4.8%). A range of disciplines were represented including Public Health (26.5%), Basic Science (21.6%), Psychology (9.6%), Exercise Science (8.4%), Nutrition Science (8.4%), Genetics (7.2%), Medicine (3.6%), 'Other" (3.6%). Analyses regarding career trajectory, publication history and future grant funding will be presented.

Findings from this study have implications for better understanding the outcomes associated with participating in a trandisciplinary training program.

Keywords: Transdisciplinary; Collaboration; Training; Early Investigators

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Outcome Evaluation of the TREC Initiative

Brooke Stipelman (*NCI*), Kara Hall (*NCI*), Grace Huang (*NCI*) and Jodi Basner (*Discovery Logic/Thomson Reuters*).

There has been an increasing emphasis on the use of large cross-disciplinary scientific teams to address complex public health problems. As investments in team science have grown, so does the need to understand the outcomes and impacts associated with this type of research approach. This poster reports some initial findings from a quasi-experimental longitudinal study conducted to compare bibliometric indicators of scientific collaboration, productivity and impact of the Transdisciplinary Research on Energetics and Cancer (TREC) Initiative and a set of traditional investigator initiated grants (R01s) in the same field. Publication data was obtained from each of the four TREC Centers and a set of 125 investigator initiated (R01) grants in the same field through MEDLINE. Implications for these results and future research directions from the broader TREC Outcome Evaluation effort will be presented.

Keywords: Transdisciplinary Research; Outcomes; Concept Clusters; Bibliometrics

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Exploring the impact of team science on research productivity: A multi-level bibliometric study of the Transdiciplinary Tobacco Research Centers (TTURC) Initiative

Grace Huang (*NCI*), Brooke Stipelman (*NCI*), Amanda Vogel (*NCI*), Janet Okamoto (*Mayo Clinic Arizona*) and Kara Hall (*NCI*)

The Transdisciplinary Tobacco Research Centers (TTURC) Initiative was established between 1999 to 2009 as a funding mechanism to facilitate an integrative and transdisciplinary approach across basic and applied research to reduce the disease burden of tobacco use. Investigators of the eight funded TTURC centers were encouraged to form cross-disciplinary collaborations and a shared conceptual framework that drew together discipline-specific theories, concepts, and approaches to address the complex and interconnected factors related to tobacco use. While there has been increasing evidence over the last decade to support the value of cross-disciplinary collaborations on research productivity based on bibilometric data of investigator publications, the majority of these studies have focused on the impact of investigator-level factors with few studies delineating the effects of interrelated factors at the higher organizational-institutional or policy levels.

In this poster presentation, we present results from multi-level regression models that were used to assess the impact of individual- and organizational-level factors on the overall productivity, impact, and reach of one's scientific research, as well as on the composition of publication team members. Individual-level bibliometric data and organizational-level archival data of investigators who were part of the TTURC Initiative (n=144), and a matched comparison group of investigators funded through traditional RO1 grants with similar research profiles (n=175) were used in this study. Preliminary findings suggest that towards the end of the 10 year TTURC Initiative funding period, TTURC-affiliated investigators were more likely to have achieved higher levels of productivity (average publications per year), and greater scientific reach (average adjusted citations), compared to investigators RO1-affiliated investigators. Implications of these and other findings on the effectiveness of large Transdisciplinary Center Initiatives to enhance team-based research and the advancement of science will be discussed.

Keywords: transdiciplinary research; bibliometric analysis; team science; transdisciplinary tobacco research center

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Clinical and Translational Activities Reporting Tool (CTAR)

Robin Champieux (*Oregon Health & Science University*) and Melissa Haendel (*Oregon Health & Science University*)

Increasing, research organizations are using research profiling systems and services to understand expertise, facilitate new collaborations, and make strategic resource decisions. However, the leading approaches and tools exhibit several crucial weaknesses:

• They rely almost exclusively on post-award research activities (e.g. peer reviewed papers that occur well after the research is completed);

• They exclude important scientific and scholarly products, such as research resources, poster presentations, data sets, and code;

• They describe research and scholarly activity via the application of a limited set of controlled vocabularies that do not take into account broader or narrower relationships, making it hard to detect broader researcher trends. They also do not provide the ability to apply domain specific ontologies that could further elucidate research activities, expertise, and relationships. For example, a researcher studying cardiomyocytes may not appear in the results for a search on heart disease research.

• They do not provide information about research activities and researchers in relationship to the translational (“bench-to-bedside”) spectrum.

The OHSU Library is collaborating with the Oregon Clinical & Translational Research Institute (OCTRI) to address these weaknesses. We are aiming to build a research profiling tool that will synthesize and analyze researcher and research activity data across a disparate set of internal and external data sources. We are currently working on a proof of concept that leverages MeSH, domain specific vocabularies, custom terminologies, and simple Natural Language Processing (NLP) techniques. By effectively identifying research activity topics and trends and their classification as clinical or translational, CTAR will provide better and timelier data to facilitate new and smarter collaborations.

Keywords: Research profiling; Collaboration; Ontologies; Translational

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Scientists and their Sublanguages: A Model of Cross-Disciplinary Conversation
Jessica Lahey (*Boise State University*) and Stephen Crowley (*Boise State University*)

This project takes a philosophical approach to the challenges of cross-disciplinary communication. Building on two previous philosophical models of communication, the resulting model suggests a way to avoid miscommunication within cross-disciplinary contexts. The current model was checked against data from the Toolbox Project (http://www.cals.uidaho.edu/toolbox/), a series of workshops designed to mitigate miscommunication within cross-disciplinary research teams; these examples of cross-disciplinary communication, combined with data from post-workshop surveys, lend insight to the current model.

This project combines the conceptual model of communication developed in Sperber & Wilson’s 1986 Relevance as well as that in Harris & Mattick’s 1988 Science Sublanguages and Prospects for a Global Language of Science to create another model that is specific to cross-disciplinary communication. The Relevance model relies on the notion of "cognitive environments," and holds that some aspects of the participants' cognitive environments must be shared for communication to be successful. We propose that Harris & Mattick's notion of “sublanguages” lends important insights into the concept of cognitive environments in the context of scientific communication.

The Relevance model has roots in the Gricean tradition, and so seeks to explain communication in terms of speaker and hearer interpretations using the concept of relevance. Roughly, a piece of information or idea is relevant if the hearer can combine that piece of information with facts she already knows to create more new information. Sperber & Wilson claim that the speaker is responsible for crafting utterances to be maximally relevant to his hearer, and that those utterances, therefore, have an implicit guarantee of relevance. The hearer, then, should assume that utterances are in fact relevant to her, and should interpret them so that they are maximally relevant to herself.

Our model applies the concept of sublanguages, which scientists in a given field use to communicate with one another, to that of cognitive environments. Specifically, we believe that these sublanguages create and display subtle but important differences in the epistemology, ontology, and etc. of scientists in distinct disciplines, i.e., differences in their cognitive environments that are shaped by their relative training. These sublanguages facilitate communication within a discipline, but, clearly, make communication outside of that field more challenging. Ideally, and as suggested by the Relevance model, in cross-disciplinary contexts scientists will avoid terms or concepts that they know are not shared by other participants in the conversation. This is not always possible, in part because the participants may not be aware that some concepts and terms are not shared or agreed upon by other members.

Our model, then, suggests that one means of avoiding miscommunication in cross-disciplinary contexts is to engage in a conversation that makes each scientist's sublanguage, tacit assumptions, and jargon explicit and clearly defined, thus ensuring that all members in a cross-disciplinary conversation are using similar sublanguages and are aware of the differences between their own and the other participants' worldviews. These findings are checked against and supported with data from the Toolbox Project.

Keywords: Communication; Toolbox Project; Gricean Pragmatics; Interdisciplinarity; Philosophy

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The Team Science Toolkit: Integrating and Advancing Knowledge for Team Science
Amanda Vogel (*NCI*), Kara Hall (*NCI*), Brooke Stipelman (*NCI*), Sophia Tsakraklides (*Westat, Inc.*), David Garner (*Westat, Inc*.) and Elliot Grant (*Westat, Inc*.)

The foundations for the SciTS field have been laid in the context of multiple disciplines, including but not limited to Public Health, Management, Communications, Psychology, and Computer Science. In addition, the field has benefited from contributions from stakeholders such as investigators who have developed practical tools to enhance team processes and administrators who have developed policies to facilitate team science at their institutions. While this diversity has been fruitful for the development of the SciTS field, a related challenge is how to access the complete SciTS knowledge base, as conferences and journals typically reflect the boundaries around disciplines and fields, and there are limited opportunities for disseminating practical tools and strategies for team science. Overcoming this challenge is essential to unifying and advancing the SciTS field and expanding the availability of evidence-based tools and strategies for effective and efficient team science.

To help address the need for better knowledge dissemination and integration in the SciTS field, the National Cancer Institute (NCI) has developed the Team Science Toolkit (www.teamsciencetoolkit.cancer.gov). The Toolkit is a dynamic online knowledge management system that collects and integrates team science knowledge and resources and makes them readily accessible to the public.

Capitalizing on the collective knowledge of the SciTS community, the Toolkit allows any user to upload publicly accessible materials relevant to conducting, managing, facilitating, supporting, or studying team science. Given the SciTS field's rapid development, this user driven model creates and maintains a continuously evolving database of knowledge and resources. There are currently nearly 1000 resources in the Toolkit.

The Toolkit's resources address the interests of a wide range of team science stakeholders, such as investigators and community and translational partners; administrators at academic institutions, businesses, and other organizations; funding agency staff; SciTS scholars and evaluators; and those seeking to learn more about team science and the SciTS field. The Toolkit contains three main types of resources: (1) practical tools to enhance, support, or facilitate team science; (2) measures and methods for studying or evaluating team science; and (3) team science relevant publications and bibliographic citations, including scholarly publications and gray literature (e.g., unpublished technical reports). Additional resources in the Toolkit include background on the SciTS field and a list of key SciTS resources that is periodically updated by the Toolkit's editorial board.

Toolkit resources are organized by a set of common team science related goals, including: learn about team science, form new collaborations and teams, lead and manage teams, engage translational and community partners, work in virtual teams, enhance team performance, bridge disciplinary and professional differences, provide institutional support, access or provide training and education in team science, support team science through funding opportunities, and evaluate or study team science.

Users interact with the Toolkit via three main functions: Discover, Contribute, and Connect. The Discover function enables users to search the Toolkit for resources. Users may browse by type of resource or team science related goal, search by keyword, or conduct advanced searches for multiple types of resources relevant to multiple goals. The Contribute function enables users to upload new resources to the Toolkit. Users can also comment on resources already in the Toolkit, for example, sharing their experiences with a practical tool or measure. The Connect function offers ways to connect with other Toolkit users, including blog posts written by a rotating group of experts in team science and SciTS, a user-generated directory of team science experts, a linked listserv, and bulletin boards for user-generated news and events.

As a "one-stop-shop" for knowledge and resources for team science, contributed by a broad range of stakeholder groups, the Toolkit has the potential to unify the SciTS knowledge base, accelerate the development of our knowledge, and make this knowledge highly accessible to the team science community. It can reduce unnecessary replication of SciTS research and practical tools for team science, for example by enabling investigators and organizations to apply tools that have been effective related to implementing and facilitating team science in other settings, and by helping SciTS scholars to find, use and cite measures and instruments developed by colleagues. In addition, the Toolkit can stimulate innovation by enabling cross-fertilization of knowledge among the many groups contributing to the SciTS knowledge base, and by highlighting gaps in knowledge that point to future directions for the SciTS field. Through these means, the Toolkit can help to enhance the efficiency and effectiveness of team science, ultimately helping to maximize the scientific and translational benefits of team science initiatives.

Keywords: online resource; knowledge management system; knowledge dissemination; communications; SciTS field

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Applying and Exploring a Conceptual Model of Transdisciplinary Team Research

Kara Hall (*NCI*), Amanda Vogel (*NCI*) and Sarah Gehlert (*Washington University in St. Louis*)

Transdisciplinary (TD) team research has emerged as a promising approach to answer complex scientific questions and develop solutions to pressing public health problems. TD research teams bring together collaborators from multiple disciplines, fields and professions who engage in an integrative process to synthesize and extend their perspectives, theories, methods and translational strategies to create novel findings and translational applications.

Complexity in TD research teams – e.g., the number of collaborators and the range of expertise represented on the team – contributes to the potential added value of this approach. But this complexity also introduces challenges such as difficulties with group communication and management and conflicts related to epistemological and methodological differences.

A conceptual model for the TD team research process can help to guide effective TD team collaboration and ultimately support achievement of scientific and translational goals. This poster presents a four-phase model of the TD team research process developed by the National Cancer Institute's (NCI) Science of Team Science team and collaborators. The model proposes four key phases in TD team science, identifies key team processes and scientific benchmarks to be achieved in each phase, such as creating shared goals, externalizing group cognition, developing shared mental models and managing conflict.

The experiences of the Center for Interdisciplinary Health Disparities Research (CIHDR) at the University of Chicago, a highly successful TD research initiative supported by the

NCI, are then explored through the lens of the model, highlighting real-world strategies for success and examples of scientific products in each of the four phases.

Finally, practical tools and strategies to support key team processes and scientific benchmarks in each phase of the model are highlighted. Examples include collaboration agreements, training modules in team science competencies, and team diagnostic surveys. Each of these resources is publicly available on the NCI's Team Science Toolkit website, an online one-stop-shop for resources to support efficient and effective team science.

Keywords: transdisciplinary; cross-disciplinary; conceptual model; conceptual framework; case study

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The Toolbox at Ten: What do we know, What can we learn?

Chad Gonnerman (*Michigan State University*), Troy Hall (*Oregon State University*), Michael O'Rourke (*Michigan State University*), Stephen Crowley (*Boise State University*), Shannon Donovan (*University of Alaska-Anchorage*), Chris Looney (Wa*shington State Department of Agriculture*), Sanford Eigenbrode (*University of Idaho*) and J.D. Wulfhorst (*University of Idaho*)

Over the past ten years, the Toolbox Project (http://www.cals.uidaho.edu/toolbox/) has been running workshops designed to facilitate communication within cross-disciplinary collaborations, conducting 127 workshops for over 1,000 participants. For the majority of these workshops, a variety of data has been collected – details provided below. Members of the Toolbox Project have been working on data analysis, and while there have been significant insights, more could be done with the data the project has in its possession. This presentation outlines the available data and current methods of analysis, and invites the SciTS community to participate in a conversation about additional approaches to the existing data.

To simplify somewhat, a Toolbox workshop begins with participants using a Likert scale in responding to a number of statements about the nature of their methods of inquiry (i.e., research methods). Demographic information, such as the participant's gender, disciplinary background, and years of cross-disciplinary experience, is also collected. This is followed by a 60-90 minute discussion of issues arising from the statements. The workshop ends with participants re-scoring the probing statements. About two weeks after the workshop, participants also complete a post-workshop survey that concerns the experience. Thus, Toolbox workshops generate three major types of information: pre and post workshop Likert scores for each participant, transcripts of the workshop discussion, and post-workshop survey responses. The Toolbox Project has employed both qualitative and quantitative methods in analyzing all three sources of information.

To conclude, this poster will present some results of the data analysis conducted so far, focusing primarily on open questions regarding what further analysis could be conducted using the data resources described.

Keywords: Communication, Toolbox Project, Data Analysis, Open Questions

Education and Training for Team Science

Stephen Fiore (*University of Central Florida*), Catherine Gabelica (*Maastricht University*) and Kara Hall (*National Cancer Institute*)

Education and training are two general terms that are too often used with little specification as to what is meant in the literatures associated with interdisciplinarity and teams. The tremendous variety of settings in which education and training can take place leaves much room for error. Training can be used to describe an hour-long presentation on a given scientific topic or a method for managing conflict within one's team. It can also be used to describe a workshop spanning hours or days where one receives more intense exposure to, for example, new methods for visualizing complex data, or how to lead and manage members of a scientific team. Education might be used when discussing a guest lecture from a noted scholar, or to describe a particular course developed to teach team-based projects for working with students from different disciplines. It might also be used when broadly discussing a curriculum centered on interdisciplinary learning. These examples are meant to illustrate two fundamental distinctions that must be accounted for when trying to bring some coherence to discussions of training and education for team science. First is the content of the material to be learned. The examples above were purposely dichotomized to illustrate a fundamental distinction made in the literature on team training. Specifically, when team training research began to evolve, it was recognized that a distinction needed to be made between taskwork and teamwork. Taskwork is a label for the activities in which one engages that are pertinent to achieving the goals and objectives for which the team is formed (e.g., running a procedure for data collection, completing a particular statistical analysis). Teamwork describes the activities involved in interacting with members of one's team and that are necessary for success (e.g., communication; back-up behaviors). Second is the duration of the learning activity. The literature on training and education might discuss short courses lasting hours or days or entire curricula that might span months or years. Table 1 provides a rudimentary illustration of this breakdown. While it is certainly possible for an educational or training experience to teach both taskwork and teamwork, our point here is that it is important not to conflate these as the content has a direct bearing on the pedagogical approach. In this poster we use this distinction and build on earlier frameworks delineating the types of competencies and pedagogies for interdisciplinary scientific collaboration. We describe how this can be used to better conceptualize how to study which competencies are better learned, using which pedagogies, and across these varied environments.

Keywords: Disciplinary Discourse, Evaluation of Team Processes & Outcomes, Methodologies for Team Science Research, Organization/Management, Team Dynamics/Composition

Why the Science of Team Science Matters: The Evidence and a Path Forward

Tina Winters (*National Research Council*), Nancy Cooke (*Arizona State University*) and Margaret Hilton (*National Research Council*)

The National Research Council study titled "The Science of Team Science" was funded by the National Science Foundation to address the following questions:

• How do individual factors (e.g., openness to divergent ideas), influence team dynamics (e.g., cohesion), and how, in turn, do both individual factors and team dynamics influence the effectiveness and productivity of science teams?
• What factors at the team, center, or institute level (e.g., team size, team membership, geographic dispersion) influence the effectiveness of science teams?
• How do different management approaches and leadership styles influence the effectiveness of science teams? For example, different approaches to establishing work roles and routines and to the division of labor may influence team effectiveness.
• How do current tenure and promotion policies acknowledge and provide incentives to academic researchers who engage in team science?
• What factors influence the productivity and effectiveness of research organizations that conduct and support team and collaborative science, such as research centers and institutes? How do such organizational factors as human resource policies and practices and cyberinfrastructure affect team and collaborative science?
• What types of organizational structures, policies, practices and resources are needed to promote effective team science, in academic institutions, research centers, industry, and other settings?

The National Research Council appointed an interdisciplinary committee of fourteen individuals with the collective expertise and experience necessary to address the study questions. The study included three public events in 2013 and is now in the final stages of drafting a consensus report that will present the committee's findings, conclusions, and recommendations related to the study questions. The report will undergo a rigorous review process and is expected to be released in late 2014.

Keywords: Individual factors, Team dynamics, Institutional and organizational factors, Virtual collaboration, Leadership and management

Friday - August 8, 2014 Conference (Day 2)

8:00am - 9:00am **Networking Breakfast**

9:00am - 10:00am **Joint Keynote Speaker**

10:00am - 10:30am **Networking Break**

10:30am-11:30am **Flash presentations**- Zilker ballroom 1-2

Session Moderator: Kara Hall

Why the Science of Team Science Matters: The Evidence and a Path Forward
Stephen Fiore (*University of Central Florida*)

In 2013, the National Research Council convened an expert committee to: "…conduct a consensus study on the science of team science to recommend opportunities to enhance the effectiveness of collaborative research in science teams, research centers, and institutes." The committee has prepared a draft report, which is now under review, and the final report is expected to be released October of 2014. Among the questions under consideration are:
• How do individual factors (e.g., openness to divergent ideas), influence team dynamics (e.g., cohesion), and how, in turn, do both individual factors and team dynamics influence the effectiveness and productivity of science teams?
• What factors at the team, center, or institute level (e.g., team size, team membership, geographic dispersion) influence the effectiveness of science teams?
• How do different management approaches and leadership styles influence the effectiveness of science teams?
• How do current tenure and promotion policies acknowledge and provide incentives to academic researchers who engage in team science?
• What factors influence the productivity and effectiveness of research organizations that conduct and support team and collaborative science, such as research centers and institutes? How do such organizational factors as human resource policies and practices and cyber infrastructure affect team and collaborative science?
• What types of organizational structures, policies, practices and resources are needed to promote effective team science, in academic institutions, research centers, industry, and other settings?

Keywords: Disciplinary Discourse, Evaluation of Team Processes & Outcomes, Institutional Policies, Leadership for Effective Team Science, Methodologies for Team Science Research, Multi-level/systems approaches, Multi-team Systems, Networks, *Organization/Management, Team Assembly, Team Dynamics/Composition, Training & Professional Development*

Integration: 'You keep using that word. I do not think it means what you think it means'

Stephen Crowley (*Boise State University*), Michael O'Rourke (*Michigan State University*), David Stone (*Northern Illinois University*), J. Britt Holbrook (*Georgia Institute of Technology*) and Robert Scharff (*University of New Hampshire*)

In recent years, policy efforts advocating more aggressive disciplinary combinations that move beyond multi-disciplinary modes of collaboration have emerged that aim to restructure science, science education, science publishing, and science funding to promote interdisciplinary science. These efforts, including the recent, far-reaching and high-profile AAAS Arise 2 report, presuppose that disciplinary "boundaries" obstruct effective responses to complex real world challenges. That is, they presuppose that we can move past a science that operates through individual, disciplinary "silos" to wholly new ways of knowing that rely on what Arise 2, for example, refers to as "deep integration" across disciplines, and a "dismantling of disciplinary boundaries, rather than ad hoc collaborations, that could transform the scientific enterprise and deliver the potential to address previously intractable problems" (Arise 2 p.xii). Recommendations like these are made to radically modify the research ecosystem, changing funding streams, regulations, review processes, review criteria, etc. in the hopes of promoting, facilitating, and stimulating this deeper level of "integration" across disciplines. We see a real danger in the underlying understanding of science that motivates this approach in the first place.

The language used in the literature on interdisciplinarity and in efforts like Arise 2 that advocate policy change to promote interdisciplinary research has turned metaphors like silos, boundaries, and especially "integration," into operationalized terms as though there was some scientific theory of interdisciplinarity through which such terms could be so operationalized. There is no such theory. And if there was, it and its operationalized terms would fundamentally misrepresent how disciplines work qua disciplines. The danger in this misrepresentation is that it is being used to promote dramatic policy changes regarding the organization and funding of science.

While there is surely value in sciences and scientists improving communication and collaboration across disciplines, the metaphor of "integration" and the policy prescriptions that would be put in place in order to promote it are not the way to get there.

Keywords: Science Policy, Integration, Concept Analysis

A Model for Transformational Team Science Leadership

J Quyen Wickham (*University of Oklahoma*)

Interdisciplinary academic research necessitates Transformational Team Science Leadership that eschews traditional management methods for a contextually appropriate and transformational approach. Team Science outcomes must be expanded beyond the immediate goals of proposals and papers towards an evolutionary approach that contextually transforms faculty member assumptions of individual scholarship to epistemologies that embrace cross-disciplinary collaboration. Differentiating Transformational Leadership as described in business and industry is important; whereas Transformational Leadership has seen thirty years of success in business to create innovative and successful teams, its core elements (individualized consideration, intellectual stimulation, inspirational motivation, and idealized influence) must be redefined for the context of academic Team Science. Decades of research and practice in transformational teaching, as described by the pioneering work of Robert Kegan and Jack Mezirow, outline best practices for changing epistemological perspectives rooted in individual scholarship.

Transformational Team Science Leadership can shift team members' disciplinary ethnocentrism towards a shared epistemology of collaboration by supporting a contextually defined frame of reference for research faculty that promotes research collaboration while embracing core beliefs in the individual disciplines. These processes, described in transformational teaching, are grounded in a learning paradigm that embraces collaboration to engage and transform individual perspectives. By nurturing interdependent processes of discernment and critical reflection, elaborating existing and learning new frames of reference, and transforming points of view and habits of mind, transformational teaching provides a script for context specific Transformational Team Science Leadership. The leader creates a zone of safety that allows the team members to open themselves to the intersubjective experience involving intentions, values, and moral issues outside of their disciplinary experiences. As transformational teaching is currently embraced in higher education, research faculty leadership development programs can be readily modified from existing materials and applied to Team Science leadership.

This flash presentation will 1) describe how disciplinary ethnocentrism and individual scholarship drive habits of mind that are counter to collaborative research, 3) describe how transformational teaching and learning fits the need to develop a contextually-driven collaborative frame of mind, and 3) outline a rough plan for a Transformational Team Science Leadership development program that accounts for the context of interdisciplinary academic research. The audience will be challenged to consider transformational teaching and learning as a long view solution to Team Science leadership.

Keywords: transformational leadership, leadership, academia, higher education, interdisciplinary

Academic–Corporate Collaboration Contributes to Research Success

Sambath Chung (*Elsevier*)

Previous studies have shown that the trend toward collaboration is increasing, and that international academic collaborations contribute to research success as measured by citations per paper. However, this does not fully explain all the contributing factors for research success. In this study, academic-corporate collaboration is analyzed to determine its impact on research success, and is compared to international academic collaboration.

Keywords: Collaboration, Academic, Corporate, Research, Success

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The Toolbox at Ten: Where Next?

Stephen Crowley (*Boise State University*), Chad Gonnerman (*Michigan State University*), J. Britt Holbrook (*Georgia Institute of Technology*), Michael O'Rourke (*Michigan State University*), Liela Rotschy (*Independent Scholar*), Kyle Whyte (*Michigan State University*), Brian Robinson (*Independent Scholar*), Julie Klein (*Wayne State University*), Lynn Schnapp (*Medical University of South Carolina*), Tom Seager (*Arizona State University*), Steven Orzack (*Fresh Pond Research Institute*), Kara Hall (*National Cancer Institute*), Sanford Eigenbrode (*University of Idaho*), J.D. Wulfhorst (*University of Idaho*), Nilsa Bosque-Perez (*University of Idaho*) and Graham Hubbs (*University of Idaho*)

The Toolbox Project (http://www.cals.uidaho.edu/toolbox/) has now been running workshops designed to mitigate miscommunication within cross-disciplinary research teams for a decade. Over this time more than 125 workshops have been run with over 1,000 participants. A recent gathering of Toolbox Project team members and collaborators identified two issues of particular importance for the growth of the project.

First, while there is solid and growing evidence for the impact of the Toolbox workshop in the short term, we have not yet identified what if any long-term impact the workshop intervention might have. Second, while the workshop experience is typically regarded as positive, it is often the case that teams express an interest in complementary activities to build on the insights generated by the Toolbox workshop.

In this presentation we are seeking suggestions from the SciTS community about ways to both test and enhance the long-term impact of the Toolbox workshop. What are the best ways to identify the long-term impact of workshop type experiences and what resources are required to conduct such evaluations? (For example, could the work be done without requiring very large numbers of very similar teams?) Are there complementary activities that might be 'bundled' with the Toolbox workshop to bring about synergistic team impacts? If so, what are the best ways to manage the combination?

Keywords: Communication, Toolbox Project, Tool Development, Open Questions

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Identifying Cross-Disciplinary Pathways to Translational Science

Griffin Weber (*Harvard Medical School*)

The National Institutes of Health Roadmap places special emphasis on accelerating "bench-to-bedside" research, or the "translation" of basic science research into practical clinical applications, which today typically takes more than 20 years to occur. The nearly $500 million the NIH spends annually on its Clinical and Translational Science Awards (CTSA) program is just one example of the large investments being made to develop a national infrastructure to support translational science. However, tracking the impact of these major policy changes is challenging because although translational science has been described in many different ways, including the frequently used qualitative T1-T4 classification, consensus on a precise definition has not yet been reached.

I recently introduced a new quantitative and visual approach for measuring translation called the Triangle of Biomedicine, which maps the 22 million biomedical journal articles in the National Library of Medicine's PubMed bibliographic database to a triangle, whose corners represent research related to animals (A), cells and molecules (C), and humans (H). The position of an article on the graph is based on its topics, and translation is defined as movement of a collection of articles, or the articles that cite those articles, towards the human corner. This provides a way of determining the degree to which an individual scientist, organization, funding agency, or scientific field is producing results that have potential impact on human health, and calculating the amount of time it takes.

I received an NSF Science of Science and Innovation Policy (SciSIP) grant to extend this work to study interdisciplinary teams. Specifically, the project will answer two main research questions: First, to what extent does research outside of biomedicine impact human health through cross-disciplinary diffusion of knowledge? Second, do biomedical research teams that include investigators from other disciplines accelerate translation? For this study I have access to the entire Elsevier Scopus citation database, which contains more than 50 million journal articles across all fields. I am looking for collaborators with expertise in Science of Team Science to help me analyze these interdisciplinary teams in more depth.

Keywords: Triangle of Biomedicine, Scopus, Translational Science, CTSA

A Collaborative Research Project Model

Richard Fabsitz (*National Heart, Lung, and Blood Institute*), Jean Olson (*National Heart, Lung, and Blood Institute*), Mona Puggal (*National Heart, Lung, and Blood Institute*), Kara Hall (*National Cancer Institute*), Katherine Catevenis (*National Institutes of Health*), Grace Huang (*National Cancer Institute)*, Matthew Eblen (*National Institutes of Health*) and Robin Wagner (*National Institutes of Health*)

Collaboration and team science are increasing as science is getting more complex. Promotion of collaboration is deemed to be useful to address this increasing complexity and improve the scientific output of research projects. Arguably, one well-accepted measure of collaboration in research projects is co-authored publications. Identification and evaluation of factors that promote collaboration would be enhanced if a conceptual model were available on which to build an analytic framework. This paper proposes a model comprising multiple components that influence research project collaboration including the funding agency, the research institution(s), the study investigator(s), the study community, external investigators, trainees and writing teams; the study investigators are central to this model. Each of these components has multiple elements. The value of the model is in creating a framework for evaluation to determine what elements (characteristics, actions and policies) may promote or discourage collaboration. The availability of this model is intended to offer a framework to spur research in collaboration to identify those elements that are most effective at increasing collaboration with the goal of strengthening the research that is produced. This presentation will seek wide-ranging feedback on the model and collaborators to apply the model in a variety of research projects and settings.

Keywords: teams, research project, collaboration, model

Enhancing the Effectiveness of Team-based Research: A Dynamic Multi-level Systems Map of Integral Factors in Team Science

Kara Hall (*National Cancer Institute*), Brooke Stipelman (*National Cancer Institute*), Amanda Vogel (*National Cancer Institute*) and Grace Huang (*National Cancer Institute*)

In August 2014 we will begin development of a multi-level systems map of the complex and interacting factors integral to conducting team science. This map will be generated based on evidence from the literature and a participatory approach involving representatives from six stakeholder groups: funding agencies, professional organizations, journal editors, university leadership, investigators using team science approaches, and Science of Team Science scholars. This project aims to guide a long-term vision of how we can enhance the efficiency and effectiveness of team-based research in order to more rapidly address complex scientific and societal problems. The systems map will: (1) offer a comprehensive visual representation of the system of factors influencing team science processes and outcomes; (2) guide a research agenda based on a holistic understanding of the multi-level team science system including its key leverage points, and gaps in the evidence base for key factors and relationships in the system; and (3) contribute to the development of a system dynamic modeling tool that can be used to test possible interventions to enhance team science. This map serves as a companion to the anticipated (fall 2014) National Academies consensus study report on the Science of Team Science. It will also be used as an interactive tool to link users to resources in the Team science Toolkit, including measures for the study of team science, practical tools to enhance or support team science, and scholarly publications.

Keywords: system science; conceptual framework; effectiveness

11:45am-12:15pm Paper presentations

Boundary Spanning Ties in Multiteam Systems – Texas V

Session Moderator: Leslie DeChurch

Informal Boundary Spanning Ties in Multiteam Systems: A Theory of Accelerated Degeneration

Ralph Heidl (*Michigan State University*), John Hollenbeck (*Michigan State University*), Roger Calantone (*Michigan State University*), Clay Voorhees (*Michigan State University*), Andrew Yu (*Michigan State University*), Michael Howe (*Michigan State University*) and Daniel Chaffin (*Michigan State University*)

Organizations are increasingly relying on teams. These teams often work interdependently with other teams to form loosely structured multiteam systems. Multiteam systems retain the flexibility and responsiveness of single teams, while leveraging specialized functions of other component teams to solve highly complex problems. Structuring organizations as multi-team systems creates an environment that is conducive to the development of informal boundary spanning relationships between teams which can be both a virtue and liability. While informal boundary spanning relationships are instrumental to unlocking potential benefits of multiteam systems, they can also produce problematic between team processes.

We develop the "Accelerated Degeneration Theory" (ADT) to describes where, when, with whom or why informal boundary spanning ties in multiteam systems help or hurt the efficiency or innovative capacity of multiteam systems. Specifically, we propose that the number, nature, and distribution of informal boundary spanning ties in multiteam systems determines the extent to which this unique organizational form offers potential performance advantages over rigid bureaucracies and large inefficient large teams. We argue that there is an inverted-U relationship between the desired number of informal ties and performance in multiteam systems, but that the apex of this inverted-U shifts vertically and horizontally depending upon the (a) strength of formal boundary spanning ties, (b) strength of within team ties, and (c) degree to which ties are evenly distributed among team members. Implications of the Accelerated

Degeneration Theory in multiteam systems are further discussed in our presentation.

Keywords: Boundary spanning; Multiteam systems; Coordination; Networks

Mixed-methods Approach to Team Science – Texas VI

Session Moderator: Brooke Stipelman

A mixed-method approach to understanding team science: Working towards useful feedback

David Meyer (*Boise State University*)

The proposed presentation will summarize the project assessment and evaluation activities during the first three years of a five-year project addressing climate change in US agriculture. The goal of this presentation is to highlight the quantitative, qualitative, and social network assessment activities aimed at fostering appropriate collaboration across more than 90 researchers and students in seven disciplines from three universities. This presentation advances SciTS field by sharing some of the evaluation challenges within large-scale collaborative projects and developing ideas on how to provide more useful assessment and evaluation feedback to interdisciplinary teams.

This evaluation effort is designed to maintain an open and flexible approach and support participants as they build the new communities of understanding that define transdisciplinary efforts. This approach is consistent with Klein's (2008) recommendation that evaluation of transdisciplinary efforts "evolves through a dialogue of conventional and expanded indicators of quality" (p.S122). It is also consistent with a utilization-focused evaluation philosophy that provides meaningful feedback to program participants and other stakeholders (Patton, 2008). The quantitative, qualitative and social network approaches used to date are summarized below and will provide the content of this presentation.

Quantitative Data: Validated Scales of Transdisciplinary Integration: An annual survey of the project's transdisciplinary integration includes research faculty, staff, and graduate student participants. Based on prior survey research on transdisciplinary attitudes and behaviors (Masse et al. 2008), the data from a 37-item survey provides four statistically sound measures of: collaboration satisfaction, team trust, attitudes toward transdisciplinary research, and perceptions of project productivity. Preliminary results regarding geographic location and differences on these measures will be shared; future analysis will track change in these measures over the five year duration of the project and correlations with betweenness and degree centrality from the social network analysis data.

Qualitative Data For Improved Cross-Project Dialogue: The collected qualitative data focus on team processes and are intended to illuminate which project components/activities are working and which require modification. The presentation will summarize the qualitative analysis results of nearly 100 participant comments collected annually, highlight the project success and challenge themes, and review the strategies used to identify and implement appropriate solutions.

Social Network Analysis: During the project's third year participants were asked to retrospectively rate the quality of their interactions with others on the project during the previous 12 months using a four-point collaboration scale developed for this project that ranged from "no direct contact with this person" to "a strong integration of ideas, merging of perspectives, and growth of common understanding." Combined with other assessment measures, the proposed SNA approach helps illuminate the social and contextual factors (Hackman, 2012; Salazar et al., 2012) that may support or inhibit effective collaboration. The presentation will include preliminary SNA graphs of identity key information brokers within the project, color-coded by institution, discipline, or project objective area.

Keywords: utilization-focused evaluation; social network analysis; quantitative survey methods; qualitative methods; interdisciplinary teams

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A model for assessing readiness – Texas VII

Session Moderator: Amanda Vogel

Assessing Readiness: A Model for Understanding Individual Motivation and Deterrents to Team Collaboration

Gaetano R. Lotrecchiano (*George Washington University*), Trudy R. Mallinson (*George Washington University*), Lisa S. Schwartz (*George Washington University*) and Holly J. Falk-Krzesinski (*Elsevier*)

Background. Teams of researchers and scientists attempting to solve complex problems work with contributors possessing variable collaboration skills. Collaboration is a cooperative effort between two or more entities striving towards a common goal and is a major objective in many funded projects. The sustainability of many programs depends upon the continued successful collaboration between contributors, which may be influenced by individual readiness to enter into scientific teams. Collaborative readiness has been measured through both conceptual and organizational means in an attempt to understand team readiness for interdisciplinary and transdisciplinary endeavors and in light of scientific productivity. Contemporary issues associated with disparate groups, the ethics of collaboration and the organizational antecedents necessary for productive collaboration have also been received attention. However, to date no comprehensive assessment tool of individual readiness has been constructed that measures individual motivations to doing collaborative science. Such assessments require measurement of both motivators and deterrents to individual willingness to collaborate. This project provides the theoretical basis and framework for a hierarchy of indicators for individual readiness to collaborate in teams found in the team science and interdisciplinary collaboration literature.

Objectives. To construct an operative model and instrument by which individual-based motivators and deterrents to collaboration may be measured and analyzed.

Methods. A review of the team science literature was used to compile a list of motivators and deterrents to collaboration. The indicators identified were aligned with a collaboration theory that suggests four levels of formal integration (cooperation, coordination, collaboration, and coadunation) ranging from low to high. The 55 indicators represent a hierarchical spectrum of collaboration ranging from cooperation (low) to coadunation (high) level collaborative involvement. Items were scored using a 4-point Likert-type rating scale of impact on readiness to collaborate. Data will be collected from teams engaged in collaborative science.

Items will be analyzed applying a 1-parameter Rasch model using Winsteps® 3.80.1. The Rasch model transforms raw scores into log-odd probabilities that comprise linear (i.e., interval-level) measures. Rasch measurement provides logit values (calibrations) as estimates of item challenge and person ability. Negative logits indicate that the item is easier, or the person is less ready for collaboration, than average. Positive logits indicate that the item is more challenging (harder to endorse), or the person is more ready for collaboration than average. Responses will be evaluated for category threshold order, item fit and dimensionality (construct validity), item hierarchy targeting of items to participants, precision and reliability, and differential item functioning.

Results. We have developed a conceptual framework capturing the relationship between the Bailey and Koney model for collaboration and the individual-based motivators and deterrents identified in the team science literature, alongside a hierarchy of participant needs. This conceptual framework will inform the development of an assessment tool for measuring individual readiness in scientific collaborations.

Conclusions. Although, many authors have proposed models of collaboration, it has been difficult to translate these into instruments that objectively measure the degree of collaboration between entities. Our model aligns reported individual motivators and deterrents to collaboration to a hierarchical model for collaboration at the group level and fashions an individual level instrument that can be used to assess one's readiness to enter into or to excel to higher level collaboration.

Keywords: Readiness; Motivation; Collaboration; Deterrents

12:15pm-1:45pm Lunch discussion – Zilker Ballroom 1-2

1:45pm - 3:15pm Lightning and paper presentations

Tools – Texas V

Session Moderator: Gary Olson

The Virtual Learning Commons (VLC): Enabling and analyzing the flow of information across disciplines, communities, and institutions

Deana Pennington (*University of Texas at El Paso*), Aida Gandara (*Cyber-ShARE*), Nicholas Del Rio (*University of Texas at El Paso*) and Omar Ochoa (*University of Texas at El Paso*)

A key challenge in transdisciplinary research is identifying, understanding, and integrating methods, models and tools that could be relevant for a particular problem, but are described using disciplinary vocabulary. The goal of the Virtual Learning Commons (VLC) is to improve awareness and understanding of emerging methodologies and technologies, facilitate individual and group evaluation of these for innovative uses, and trace the impact of innovations across teams, disciplines, and communities, providing an opportunity to study inter- and trans-disciplinary knowledge exchange in real time. The VLC is funded by the U.S. National Science Foundation, and will be released in 2014.

The VLC is a Web-based social bookmarking site with support for semantic analysis of content. It makes use of Web 2.0 (Social Web) and Web 3.0 (Semantic Web) approaches to enable discovery of potentially relevant methods, models, and tool innovations, and networked learning about their function. It is founded on well-developed models of technology adoption, diffusion of innovation, and experiential learning.

This presentation will include a brief demonstration of the VLC followed by analysis and discussion of preliminary usage data, along with expected future work. The research advances the SciTS field by providing a new technical approach towards investigation of knowledge exchange across disciplinary, community, and institutional silos.

Keywords: networked learning; diffusions of innovation; Social Web; Semantic Web

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Research Networking to Enhance Multi-institutional Expertise Discovery and Collaboration

Holly Falk-Krzesinski (*Elsevier*), Daniel Calto (*Elsevier*) and Jeff Horon (*Elsevier*)

Research networking is facilitated through web-based expertise profiling systems—research networking tools (RN tools)—that aggregate research and scholarly information about faculty members and investigators to enable the rapid discovery and recommendation of experts to address new or existing research challenges and to facilitate new interdisciplinary collaborations. While most RN tool implementations focus on harvesting and displaying expertise from a single institution and across traditional academic organizational structures, this session will examine the flexibility of Elsevier's Experts Portal to deliver innovative multi-institutional, cross-sector, and international semantic expertise portals in partnership with universities and other research institutions. These multi-institutional expertise portals are a key to stimulating networking and collaboration across typical research silos.

Northwestern Scholars at Northwestern University was the first to implement a university-wide research networking tool, profiling faculty researchers across all of its schools, not just those in the STEM fields. Moreover, they organized their researchers by research centers/institutes and graduate programs to foster expertise discovery across institutional boundaries and promote broad interdisciplinary and collaborative research.

Using the same Experts platform, the Chicago Collaboration for Women in STEM portal represents the first instance of an RN tool focused on making discoverable members of an underrepresented minority group. A joint initiative of Northwestern University and The University of Chicago, it also profiles women researchers at two regional Department of Energy national laboratories, Argonne and Fermi.

The Solar Fuels Institute (SOFI) is a global research consortium of universities, government labs, and industry united around the goal of developing and commercializing a liquid solar fuel. The SOFI portal represents one of the first uses of a research networking portal to connect researchers internationally across a single initiative and demonstrate a research institute's collective expertise. Similarly, the Experts portal at MD Anderson Cancer Center includes profiles of cancer researchers from all of its sister institutions around the globe.

The Michigan Corporate Relations Network (MCRN) Expertise Portal is a statewide university research network specifically designed to connect corporations and SME's to relevant university-based researcher expertise and core facilities to promote innovative cross-sector research and grow Michigan's economy. The MCRN Experts Portal profiles researchers from five public research universities in the state and aims to build on findings that university-industry publications are generally of higher impact and university-industry patents are more likely to be successfully brought to market and drive revenues.

Like all public Experts portals, these sites are connected via multiple federated searches (SciVal Community, Direct2Experts, and CTSAsearch), offering the ability to expand the search for experts and collaborations even more broadly. And the Northwestern Scholars and Women in STEM implementations broadcast data in their profiles openly in RDF triplestore, VIVO-compatible format, which can be accessed freely through any SPARQL endpoint. This provides analysts and developers access to the rich profile information, enabling sophisticated collaboration and networking studies.

Collectively, these multi-institutional research networking portals serve as models for other institutions to extend expertise discovery and networks beyond their institutional boundaries to promote collaborative and global research.

Keywords: Research networking; Collaboration; Global research; Expertise discovery; Experts Portal

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Archival information as a collaboration tool: Assessing the potential of bibliometric and content analysis as a tool to aid research collaboration and organization in Tobacco Regulatory Science

Janet Okamoto (*Mayo Clinic*), Hongfang Liu (*Mayo Clinic*), Dingcheng Li (*Mayo Clinic*) and Scott Leischow (*Mayo Clinic*)

Bibliometric, content, and network analytic methods are increasingly being used in the assessment and evaluation of team-based research. These methods have been used, and are well-suited, for examining collaboration among research investigators, assessing transdisciplinarity and scientific reach of publications and journal citations, and investigating the scientific impact of team science research. However, these methods can also be used tools to identify areas of common interest and overlap in research focus, as well as to identify potential collaborators with specialized knowledge or skills. Research networking tools and recommender systems rely heavily on these methods. While these tools and systems are often utilized within an institutional context, they are currently less flexible for use within a research area that spans across multiple scientific disciplines and institutions. However, some of the greatest need to identify and organize research collaboration comes from researchers working in the same or similar research areas, where specialized or complimentary knowledge is primary and common institutional affiliation is of less importance. This need is often amplified in emerging and developing research areas, where multiple disciplines and topic areas are often merging together and knowledge of the expertise of investigators from different fields is often low.

Tobacco regulatory science (TRS) is such an emerging research area, bringing together researchers from various fields and disciplines to conduct research to support the FDA's Center for Tobacco Products (CTP) regulatory activities over tobacco products. The 2009 Family Smoking Prevention and Tobacco Control Act gave the FDA the authority to regulate the manufacture, marketing, and distribution of tobacco products to protect public health. In order to make evidence-based regulatory decisions and assess the impact of these decisions on public health, the FDA and NIH have partnered to fund a large investment in research related to tobacco regulation. This includes a large population assessment of tobacco and health (PATH study), 14 Tobacco Centers of Regulatory Science (TCORS), and close to 100 grants and grant supplements. Collaboration across projects and centers has been mandated for some grantees and will optimize innovation and dissemination for the entire TRS research enterprise. We examined publications of funded TRS grantees, as well as publications pulled from keyword searches based on the CTP's identified TRS research priorities, in order to better define the boundaries of TRS. Author-topic modelling and network analysis was also conducted using this publication data in order to identify common themes and investigator expertise. Content analysis of TRS grants was performed in order to describe current research projects and identify common areas of research interest across funded projects.

We propose that using this type of information as a tool to share with investigators, particularly early in a research initiative, could aid in research collaboration through identification of potential collaborators and formation of working groups around shared interests. With in-depth grant information, potential shared measures could also be identified. This work demonstrates that analysis of archival information, such as research publications and grants, using bibliometric, content, and network analytic methods shows potential as a low-burden tool to aid and support research collaboration and organization.

Keywords: Collaboration Tools; Research Collaboration; Bibliometric; Content Analysis; Network Analysis

Data-Enabled and Spontaneous Researcher Networking at an International Conference

Jeff Horon (*Elsevier*)

This case study explores the use of both data-enabled and spontaneous researcher networking activities among attendees at an international conference based in Seoul, South Korea, in an attempt to utilize knowledge from the Science of Team Science field and discern best practices in their application.

Data-enabled networking activities included an advance survey of all attendees to find participants willing to participate in networking activities, and then suggesting networking partners based upon methodological expertise, methodological needs, and common interests. Response rates and participant feedback will be discussed.

Spontaneous networking activities were also made available to attendees stopping by a physical networking space made available for the duration of the conference. Activities included live browsing of research networking tools and a system for making requests related to research and responding to the requests of others, based upon sociological theories of reciprocity. Participation rates and participant feedback will be discussed.

Keywords: Researcher Networking; International Team Science; Best Practices

Enabling Teams to Self-Assemble: The My Dream Team Tool

Raquel Asencio (*Georgia Tech*), Yun Huang (*Northwestern University*), Toshio Murase (*Georgia Tech*), Anup Sawant (*Northwestern University*), Leslie A. Dechurch (*Georgia Tech*) and Noshir Noshir Contractor (*Northwestern University*)

Knowledge about how teams assemble is important for understanding the consequences of their “assembly” on the relationships they develop, and their subsequent success or failure. Team assembly characterizes the mechanisms that influence the formation of a team (e.g., homophily; Ruef, Aldrich, Carter, 2003), external constraints (Guimera, Uzzi, Spiro, & Amaral, 2005), personal characteristics (Roberts, Hann, Slaughter, 2006), and the role of prior relationships among members (Hahn, Moon, Zhang, 2008). This study introduces an intervention, My Dream Team, designed to aid in assembly and allow researchers to directly observe the mechanisms people use when they form teams.

An important aspect of team assembly is the modality, or medium through which the team forms. My Dream Team is a type of modality, which affords a high level of agency in choosing teammates, as well as structured information about the pool of potential teammates. Whereas unstructured information provides various details about potential teammates (e.g. individual profiles), structured information systematically combines information to offer suggestions about what characteristics best fit together on the team. My Dream Team applies user preferences to make recommendations that aid in team assembly, and simultaneously allows insight into the reasons why people choose to form a team. In the current study we test the impact of the My Dream Team tool and other traditional modalities on the mechanisms people employ to assemble into teams.

Our sample consisted of 95 students participating in a semester-long team project at a Southeastern US university. Students formed 30 teams each with 3-4 members. First, students completed an online survey with measures of individual characteristics and social networks. Survey responses were then used to populate the My Dream Team tool. Students were given one week to form teams or be randomly assigned to a team by the experimenter. We classified the team types as follows: (1) appointed teams were composed of randomly assigned members, (2) blended teams consisted of members who self-organized (i.e., either organically or using the tool), and some blended teams included at least one member who was randomly assigned, (3) data-driven self-organized teams were composed of members who used the tool to form the team. The appointed teams provide a baseline of how team relationships form when no rules of attraction are at play. The remaining two categories reflect increasing degrees of agency, and in the case of the data-driven self-organized teams, an increase in the amount of information that was used to choose teammates.

We used Exponential Random Graph Models (ERGMs) to test our ideas. In ERGMs, the process of estimating model parameters is centered on the observed network; parameters are chosen so that "the most probable degree of reciprocation is that which occurs in the observed network" (Robins, Pattison, Kalish, & Lusher, 2007, p. 176). In comparing sampled network relations to observed network relations, if there is a close match, it may be possible to explain the emergence of the observed network.

We find that in data-driven teams, people are less likely (odds ratio=.58) to team up with others of larger age differences than people of the same age, and less likely (odds ratio=.45) to team up with people who are disparate on intercultural sensitivity (i.e., the enjoyment of, and willingness to accept cultural differences). In blended teams, people are more likely (odds ratio=1.90) to team up with others of the same gender. In data-driven and blended teams, people are more likely (odds ratio=167.3; 114.4) to form a team if they share a prior relation. As a benchmark, we find that mechanisms have no effect in appointed teams.

Additionally, we compared teams assembled via different modalities on the structure of the relationships that form as team members interact toward task accomplishment. We find that data-driven teams and blended teams have higher levels of communication ($F(3,29) = 4.27$, $p = .015$) and collective efficacy (i.e., belief in their capability to achieve the task; $F(3,29) = 5.82$, $p = .045$). These teams also talk more evenly ($F(3,29) = 4.50$, $p = .012$), and are balanced in their efficacy toward one another ($F(3,29) = 4.63$, $p = .01$) compared to other groups. This study advances our understanding of the mechanisms people use to assemble into teams, and by considering the modalities used in team formation, we move away from the traditional framework of considering inputs to the team only after team formation, as the groundwork for interactions and outcomes.

Keywords: Team assembly; recommenders; modalities; Exponential Random Graph Models; ERGM/p.*

Conceptual and Mental Models – Texas VI

Session Moderator: Julie Klein

Interdependence and signal detection theory: Individuals, teams, firms and systems

Bill Lawless (*Paine College*)

Introduction: Teams, firms and systems are interdependent (Bell et al., 2012). Despite its introduction in game theory seventy years ago, the theory of teams lacks a valid mathematics of interdependence (e.g., Schweitzer et al., 2009). With the approach of computational teams (e.g., transportation, medicine, military), the unsettled mathematics of interdependence is a barrier to the science of team science, precluding effective models and efficient applications for present and future teams composed of arbitrary numbers of humans, machines and robots. In its place, traditional (normative) science reigns. To counter normative science, we propose a new theory of team dynamics and, hopefully, a rigorous testbed for theories of team science based in part on the performance of publicly funded science teams (at the SciTS conference in DC last October, Federal agencies objected that this data was private; however, athletic teams are privately funded and their performance is public knowledge).

Traditional approaches to social models remove interdependence to improve experimental replicability. They assume a god's eye view of reality, implying that sufficient signals can be collected to model social reality (Rand & Nowak, 2013, p. 415). Admittedly not "a good representation of that world" (p. 416), the results restate social norms: "The population does best if individuals cooperate" (p. 413; for teams, see Bell et al., 2012, p. 40).

In contrast, we assume a team is a social object constructed to multitask when individuals cannot, requiring channels to communicate, coordinate and block information, generating noise as a byproduct. Measurement of a social object affects the result, like quantum objects. But indirect field evidence indicates that robust teams minimize noise (Lawless et al. 2013); so do robust gangs, but they also generate entropy to avoid public notice (i.e., "dark" social networks). Poor team performers, in contrast, waste energy, requiring new resources to survive (e.g., mergers). The goal with multitasking then is to control resources and team boundaries.

Multitasking is not rational. Humans can misjudge reality, engage in magical thinking, and refuse to work with each other. Machines are governed by signal detection theory; and while better than humans at detecting some signals, they cannot yet multitask as well. Neither group improves on signal detection theory. 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 cosine 0 deg equals 1), disagreement when uncertainty obscures a plan (cos 90 deg = 0); the latter represents the orthogonal interpretations that spontaneously arise in social situations. We claim that competition (conflict) processes information (e.g., competing scientific claims scientific debates; uncovering scientific deception), measured by the free movement of individuals from one team to another (random exploration and stochastic resonance), reflecting changes in resources and boundaries.

A limit cycle results that illustrates the (non-linear, non-rational) nature of interdependence arising from the inability of either side to fully capture the social reality of all sides of an argument (Lawless et al., 2013). To solve ill-defined problems by reducing illusions, conflict centers are a social resource.

Witness that authoritarian (consensus, minority control) regimes seek to prevent conflict centers from existing, impeding social evolution.

The physics of interdependence (Signal Detection Theory) precludes completeness, limiting the information collected by machines or humans, constraining meaning and predictability (e.g., unlike in 2012, from October 2013, President Obama's low approval has created predictable problems; cf. http://www.realclearpolitics.com/epolls/other/president_obama_job_approval-1044.html). These models lack convergence, but more closely match social reality; i.e., incomplete social information causes uncertainty; individual movement controls outcomes (e.g., juries). And they may be exploited to reduce team mistakes, offering metrics to improve team operations and governance (e.g., science involved in cleaning up Department of Energy nuclear wastes; in Lawless et al., 2013).

Summary: Interdependence is a resource to solve ill-defined problems (i.e., scientific questions). But it limits rationality (predictability and replicability). Unlike swarms, machine learning and game theory approaches, in our model, teams can only be controlled indirectly to solve ill-defined problems (e.g., training; Lawless et al., 2013).

Keywords: interdependence; mathematical models; uncertainty; irrational model; predictability

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Everything is Connected: Using Group Concept Mapping to Articulate Conceptual Relationships

Alyssa Goldman (*Concept Systems, Inc.*) and Mary Kane (*Concept Systems, Inc.*)

Group concept mapping is a mixed-methods conceptualization approach used by research teams to integrate and represent diverse perspectives on any topic of group interest. Group concept mapping is often advantageous in studying how individuals from various scientific disciplines collectively consider complex issues, particularly those relevant to collaborative strategy, planning and goal-setting.

The simple sequence of participatory steps (brainstorming, sorting and rating of ideas), followed by multivariate statistical analyses, yield maps that visually depict an emergent, hierarchical system of concepts that reflect the perspective of the team as a whole. Participants interpret the resultant maps to elicit understanding and approach consensus on the focal issue based on the team-authored conceptual framework. Maps are often the basis for subsequent action planning, decision-making, evaluation and model development.

To date, relationships between concept map elements (ideas, clusters, regions) are typically described based on their relative distance to one another on the map. Whereas proximity remains a key indicator of conceptual similarity, this paper introduces additional means for articulating relationships among map elements. Using an example from an interdisciplinary initiative, we illustrate how theory and methods from network analysis are well suited to quantifying relationships among concepts. We discuss how this secondary analysis can benefit users of the method in a team science context.

First, we review the standard group concept mapping participatory process and output. Next, we link features of the standard analysis (i.e. spanning analysis) to demonstrate additional relational insights that are derived from the same data used to generate a concept map. The spanning analysis also underscores the inherent variation in strength of conceptual relationships of a map, and leads us to consider how quantification of this variation can be considered an added value to concept map results. We then describe our application of network analysis to concept mapping data in order to generate a relatively simple quantitative output that can be used in conjunction with the standard results, supporting the conceptual framework and offering additional relational insights for planning and evaluation in complex research contexts.

Using our example project, we offer several potential applications to demonstrate how this relational analysis can practically benefit collaborative, interdisciplinary planning endeavors that use group concept mapping. We demonstrate how the quantified relationships allow researchers and team members to better understand the linkages and potential pathways of influence among the map's elements, thereby strengthening the ability of concept maps to facilitate systems thinking within a team. By more precisely measuring the extent to which teams perceive elements of the map as interrelated, researchers can gain a more comprehensive understanding of the dynamics that underlie a collaboration’s potential for success.

Keywords: Concept mapping; network analysis; systems thinking; group conceptualization

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What is the ‘integration’ in integrative interdisciplinary research? First steps toward a conceptual model

Stephen Crowley (*Boise State University*), Michael O'Rourke (*Michigan State University*) and Chad Gonnerman (*Michigan State University*)

Collaborative cross-disciplinary research (CCDR) is increasingly seen as crucial to solving the “grand questions” facing humanity at the beginning of the 21st century. Doing CCDR well then is a good idea, which in turn implies the

importance of thinking about what is involved in doing CCDR well. Such thinking is significantly more valuable if it gives rise to insights that can improve the practice of CCDR. In this paper we argue that philosophy is ideally placed to contribute to just this sort of practically valuable thinking about CCDR. We base our argument in part on our experience using philosophically framed dialogue to facilitate CCDR and in part on our developing theoretical understanding of key CCDR concepts (e.g., common ground, integration). Our focus in this paper is theoretical; since this focus draws on our empirical work we will offer a quick sketch of that material.

Our empirical work is part of the Toolbox Project, which originated in a NSF-sponsored Integrative Graduate Education and Research Traineeship (IGERT) project at the University of Idaho. This project involved students and faculty committed to CCDR and well-supported institutionally, but it encountered a critical but under-appreciated barrier to CCDR, viz., that students from different disciplines had difficulty working together in teams due to their distinct, tacit styles of doing science. The treatment, developed by the IGERT community in 2005, is the Toolbox workshop, a structured dialogue among team members about their styles of doing science. Philosophy of science provides the structure for these dialogues, illuminating the core commitments that frame different scientific styles. The response to participation in the more than 90 Toolbox Workshops has been overwhelmingly positive. This suggests, tentatively, that the Toolbox Project is on to something, and we explore that in our theoretical work.

Two key notions in the theory of CCDR are common ground and integration. Both are philosophically under-theorized. This is in part due an emerging consensus among CCDR theorists that these concepts are so plastic and contextual that there is little to be said about them at a theoretical level. We think that this is a mistake; both common ground and integration have core meanings that are worth theorizing. Such core meanings are largely procedural in nature. In this paper, we focus on integration. Integration is a notion that lacks any sort of theoretical account, to our knowledge; what there is a kind of “shell game” in which integration is cashed out in terms of synthesis which is cashed out in terms of unification and so on…. We argue that the way to avoid such a “shell game” is to begin as simply as possible with a model of integration as involving no more than relation. The next step in the process of theorizing involves enriching the basic notion sufficiently to make it do real work without focusing it so tightly that it fails to capture critical features of the phenomena in question. Our presentation offers both an initial definition and a sketch of the enrichment process.

Keywords: Interdisciplinarity; Toolbox Project; Conceptual Integration; Philosophy

Team Development Interventions for the Evolution of Scientific Teams: A Proposed Taxonomy for Consideration by Phase of Research, Phase of Adaptation, and Stage of Development

Kevin Wooten (*University of Houston Texas*) and Allan Brassier (*Institute for Translational Sciences*)

The purpose of this paper is to propose a taxonomy of interventions for the development of scientific teams. Reviews of the literature have all articulated the need for developing readiness interventions and team training. The current status of team science suggest that we should be able to diagnose and intervene in teams, with some sophistication about type of intervention appropriate for the context. This paper will consider interventions appropriate for the phase of research, the phase of team adaptation, and the stage of group development, involving goal setting, interpersonal relations, role clarification, and feedback, as well as team training interventions involving KSA training, team practice, and team feedback. A third area of interventions to be explored will be knowledge management, including acquisition, coordination, and sharing, mental models, transactive memory, and innovation. Last, this paper shall consider interventions involving team structure, involving team assembly and membership/disciplinarity.

Keywords: team development; team education; team building; team interventions; team evolution

Innovations in Applying bibliometrics – Texas VII

Session Moderator: Janet Okamoto

What do retraction notices learn about team dynamics and research collaboration?

Mark Luwel (*CWTS Leiden University*) and Thed van Leeuwen (*CWTS Leiden University*)

Part of a larger ongoing study, characteristics are presented of retracted papers in WoS.
With nearly 70% the 'Authors' are the dominant retracting party. However, in 10% of these retractions one of the authors disagreed with his co-authors'

decision ('Authors except one').'
One third of the retractions are due to fraud. However in 12% of the cases it is stated that only one author is responsible for the misconduct.
These quantitative results stimulate the debate about the underlying reasons for misconduct and publishing error-prone results and the interactions and cognitive distance between co-authors.

Keywords: retraction, fraud, collaboration, team dynamics, bibliometrics

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Measuring the evolution and output of cross-disciplinary collaborations within the NCI Physical Sciences–Oncology Centers Network

Jodi Basner (*Discovery Logic/Thomson Reuters*), Katrina Theisz (*NCI*), Nicole Moore (*NCI*), Unni Jensen (*Discovery Logic/Thomson Reuters*), C. David Jones (*Discovery Logic/Thomson Reuters*), Ilya Ponomarev (*Discovery Logic/Thomson Reuters*), Pawel Sulima (*Discovery Logic/Thomson Reuters*), Karen Jo (*NCI*), Mariam Eljanne (*NCI*), Michael Espey (*NCI*), Jonathan Franca-Koh (*NCI*), Sean Hanlon (*NCI*), Nastaran Kuhn (*NCI*), Larry Nagahara (*NCI*) and Joshua Schnell (*Discovery Logic/Thomson Reuters*)

Development of effective quantitative indicators and methodologies to assess the outcomes of cross-disciplinary collaborative initiatives has the potential to improve scientific program management and scientific output. This article highlights an example of a prospective evaluation that has been developed to monitor and improve progress of the National Cancer Institute Physical Sciences—Oncology Centers (PS-OC) program. Study data, including collaboration information, was captured through progress reports and compiled using the web-based analytic database: Interdisciplinary Team Reporting, Analysis, and Query Resource. Analysis of collaborations was further supported by data from the Thomson Reuters Web of Science database, MEDLINE database, and a web-based survey. Integration of novel and standard data sources was augmented by the development of automated methods to mine investigator pre-award publications, assign investigator disciplines, and distinguish cross-disciplinary publication content. The results highlight increases in cross-disciplinary authorship collaborations from pre- to post-award years among the primary investigators and confirm that a majority of cross-disciplinary collaborations have resulted in publications with cross-disciplinary content that rank in the top third of their field. With these evaluation data, PS-OC Program officials have provided ongoing feedback to participating investigators to improve center productivity and thereby facilitate a more successful initiative. Future analysis will continue to expand these methods and metrics to adapt to new advances in research evaluation and changes in the program.

Keywords: team science; cross-disciplinary; collaboration; prospective evaluation; program evaluation; bibliometrics; survey; metrics

Can bibliographic couplings inform the structure of large public universities?

Kevin Lanning (*Florida Atlantic Univ*) and Xingquan Zhu (*Florida Atlantic University)*

The academic structure of the typical American public university, in which each faculty member is assigned to a single department, and each department is assigned to a single college, provides only the roughest approximation to the structure of expertise within the university, and may impede collaboration between faculty members in different units.

In this paper, we explore an empirical approach to the problem in which a model of the entire university is based upon shared references, or bibliographic couplings. The data were obtained via support from the Elsevier Bibliometric Research Program, and include some 8000 papers authored or coauthored by FAU investigators and 108000 potential links or bonds in the form of the papers cited therein.

In contrast with network analyses based upon manifest relationships such as co-authorships, bibliographic couplings reflect latent relationships, and are indicators of potential rather than actual collaborations. We believe that, particularly in large and heterogeneous public universities, the discovery of these latent bonds may lead to new synergies between scholars and new collaborations in both research and instruction.

Keywords: Institutional structure; Bibliographic couplings; Public universities; Organization; Network

Analyzing the Frontiers of Science

Satyam Mukherjee (*Kellogg School Of Management, Northwestern University Evanston*), Daniel Romero (*University of Michigan*), Benjamin Jones (*Northwestern University*) and Brian Uzzi (*Northwestern University*)

We have witnessed an upsurge in the production of scientific papers. In 1950 there were approximately 26,000 papers indexed in Web of Science. In 2010 the number rose to 1.4 million. This suggests that the amount of scientific knowledge available to researchers is increasing at very fast rate. Since every scientist has a limited capacity to discover and process existing knowledge that is relevant to her research area, every scientific paper builds upon a relatively small subset of previous knowledge. An important question that remains largely unanswered is how to search for relevant knowledge when writing a scientific

paper. In particular, given that there is much more recent knowledge than early knowledge, how far back in time should we look for relevant knowledge?

In this work, we analyze approximately 18 million papers in the Web of Science database. We define two measures that characterize the distribution years between the time a paper was published and the time its references were published. We find that papers that reference recent papers, but also reference papers from a large variety of years, tend to have higher scientific impact than other papers. Furthermore, papers that follow this pattern of references also tend to reference more interdisciplinary and high impact papers.

To characterize how a paper draws together knowledge of prior work, we take two summary statistics from each paper. First, to measure how far back in time a paper looks for knowledge, we define the “reach” of a paper as the median time distance from the publication year of the paper and the publication year of its references. Second, to measure the variety of years among a paper’s references, we define the “breadth” of a paper as the coefficient of variation of the time distance among all pairs of references. The coefficient of variation measures the dispersion in time distance among pairs of references, while controlling for the average distance.

We study the relationship between a paper’s impact and its reach and breadth. Figure 1 presents the probability that a paper is a hit paper given its level of reach and breadth. Hit papers are defined as the top 5 percentile papers for a given year, as measured by the cumulative number of citations 8 years after publication. Our findings suggest a universal pattern: the highest scientific impact is achieved when recent work is combined with a large variety of work from the past. Finally, we test the robustness of our findings by testing whether it holds in other domains. We find that low reach and high breadth also leads to high impact work in the context of patents and US Supreme Court rulings. This provides evidence for the universality of our results.

Keywords: Scientific Impact; Reach & Breadth; Teams; Frontiers of Science

3:15pm - 3:45pm Networking Break

3:45pm - 4:15pm Paper presentations

Effects of Institution's Governance on research Teams – Texas V

Session Moderator: Kevin Crowston

The effects of institutions' governance on research teams

Peter Van den Besselaar

In earlier work, we investigated the effect of leadership, management and organization on performance of research teams (e.g., Verbree et al 2013a, 2013b, under review). Using two surveys (in 2002 and 2007) among biomedical research teams leaders, we found relations between group size, resource strategies, and leadership characteristics on the performance of the team. For example, medium sized and flat (non-hierarchically) organized teams tend to perform better, as do teams with a leader with a 'researchers identity', more than a 'managerial identity'. And, in terms of resource strategies, group leaders who draw on a diverse set of resources (funders) also tend to perform better. Performance was measured in terms of productivity, impact, and success with grant applications.

Based on the two surveys, we did a multivariate analysis (Verbree et al, under review) in which the about 250 teams were compared. However, in fact we have a multi-level problem, as the research teams are embedded in universities and public research organizations. The governance structure and leadership practices within those universities and organizations are expected to have an impact on the functioning and performance or research teams too.

In order to investigate this, we included in a third recent survey among the same population of biomedical research leaders also questions about the higher-level management and governance within the larger institution. Together with interviews held among higher management, this provides us about information about the governance and managerial environment the research teams are working in. Again, we measure team performance in terms of productivity, impact, and research grants. The response is about 500 (about 50%).

We are currently doing the data analysis, and the results will be presented at the conference. We will answer the question how governance and institutional management influences the performance of research teams.

This we feel is an important extension of our knowledge of managing, organizing and leading research teams, as effective team science may not only depend on team leadership, but also heavily on the organizational context.

Keywords: Academic leadership; leadership of research teams; university governance; team performance

Reputation as a motivation and Reward for teamwork – Texas VI

Session Moderator: Wayne Lutters

Sharing the spoils: the trouble with reputation as a motivation and reward for teamwork

James Howison (*University of Texas at Austin*)

One key difference between teams in science and teams elsewhere is the central importance of academic reputation as the primary reward for work in science. In this presentation I will draw on empirical and conceptual work to discuss how reputation as a reward is different from other rewards when it comes to collaboration, including rewards in the form of money, learning, enjoyment, and the use-value of shared artifacts (like software, data, or instruments). I will discuss how and when seeking to draw on a motivation for academic reputation can be a hindrance to collaboration and suggest alternative strategies drawn from my qualitative fieldwork in studying science.

Keywords: scientific teams; organization/management; team assembly; academic reputation

Research Networks and the Gender Gap – Texas VII

Session Moderator: Julie Klein

Research Networks and the Gender Gap: a Scientometrics Study

Charisse Madlock-Brown (*University of Iowa*) and David Eichmann (*University of Iowa*)

Though the late 20th century marked increasing participation of western women in scientific research centers as students, faculty and staff, disparities persist between the sexes in the 21st. Theories to explain these differences abound. The ability to analyze large-scale publication databases is allowing the scientometric community to more precisely characterize the issue by addressing measures of productivity, impact, and collaboration. Pinpointing the most significant and earliest signs of differences can help policy makers and departmental administrators improve career trajectories by addressing problems where they start. By field, by discipline, and by form of collaboration, women show a greater capacity to collaborate than men(in the national context) (1). Intensity of collaboration is positively correlated with productivity, indicating that greater collaboration may help women to reduce the gender gap (2). However women maybe more likely to collaborate and collaboration may lead to greater productivity. Moreover, simply promoting collaboration may not be enough if collaborative women do not behave in the same way as men.

Social science research indicates that in a variety of settings, women are more likely to limit group size and have only one person on equal rank in their group, while men regularly interact with groups of vary rank based composition (3). We analyze the network characteristics of three medical research institutions to explore the potential for improvement of one's network connectivity characteristics mitigating the performance gap between the sexes. We use data from the VIVO ontology-based profiling data from three universities. We classify the departments in each university into three categories: basic, clinical, or other. The University of Iowa network has 873 authors. The Indiana University network has 823 authors. The Northwestern University network has 727 authors. We use the HITS algorithm to identity well connected first authors(authorities), and well connected second authors(hubs). This algorithm uses an iterative process to identify well-connected first authors who are connected to well-connected second authors who are in turn connected to many well-connected first authors. We correlate these scores with productivity (number of total publications for each author), and h-index (the number of papers h for which and author has h citations). Our results indicate that certain network characteristics are more highly correlated with success for woman than men. We believe these results can be taken advantage of to improve success rates for women in the future. Our presentation will include a detailed discussion of the HITS results, their correlation with performance measures, and other network characteristics.

Keywords: Gender Gap; Network Analysis; Collaboration