Supplemental Materials

for the

Managing Collaboration in Team Science Projects webinars

Recommended General Works

The National Cancer Institute has taken the lead in Team Science for NIH.

- A good starting point is its online resource portal: www.teamsciencetoolkit.cancer.gov
- It also published a useful manual:
  - Collaboration & Team Science: A Field Guide L. Michelle Bennett Howard Gadlin Samantha Levine-Finley https://www.cancer.gov/about-nci/organization/crs/research-initiatives/team-science-field-guide/collaboration-team-science-guide.pdf
  - Chapters cover: Building a Research Team, Fostering Trust, Developing a Shared Vision, Communicating About Science, Sharing Recognition and Credit, Handling Conflict, Strengthening Team Dynamics, Navigating and Leveraging Networks and Systems

SciTS and Team Science Resources

- It's worthwhile to join the International Network for the Science of Team Science. They have an excellent resource page with links to relevant articles: https://www.inscits.org/scits-a-team-science-resources

Science of Team Science Group on Mendeley

- This is an online community that shares research and practical advice on all aspects of team science. There ae links to *many* journal articles and books.
  - https://www.mendeley.com/community/science-of-team-science-(scits)/
  - I recommend you get the Mendeley desktop app, which lets you search and browse articles by topic.

Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond

- This is a general report by the National Academies Press
- PDF Download available free at http://nap.edu/18722

Research Collaboration and Team Science: A State-of-the-Art Review and Agenda

- By Barry Bozeman and Craig Boardman
- Review of Scholarship in the field

The Handbook of Transdisciplinary Research

- https://www.researchgate.net/file.PostFileLoader.html?id=54a5c047d685ccc46f8b45e6&assetKey=AS:273661385216000@1442257366403

TRAINING

Toolbox Dialogue Initiative for Team Science training

- visit at http://tdi.msu.edu/
- The Toolbox Project provides training to interdisciplinary teams to help them develop shared knowledge through facilitated, dialogue-based workshops that help teams identify and examine the range of assumptions they make about their collaborative project.

The Motivation Assessment for Team Readiness, Integration, and Collaboration

http://matricx.net/

COLLABORATORIES

Science of Collaboratories – NSF project from the early 2000s -- http://soc.ics.uci.edu/

Bibliography and database of Collaboratories are helpful but dated

Bos, N., Zimmerman, A., Olson, J., Yew, J., Yerkie, J., Dahl, E. and Olson, G. (2007), From Shared Databases to Communities of Practice: A Taxonomy of Collaboratories. Journal of Computer-Mediated Communication, 12: 652–672. doi:10.1111/j.1083-6101.2007.00343.x

TYPOLOGY:

Shared Instrument

This type of collaboratory increases access to a scientific instrument. Shared Instrument collaboratories often provide remote access to expensive scientific instruments such as telescopes, which are often supplemented with videoconferencing, chat, electronic lab notebooks, or other communications tools.

Community Data Systems

A Community Data System is an information resource that is created, maintained, or improved by a geographically-distributed community. The information resources are semi-public and of wide interest; a small team of people with an online file space of team documents would not be considered a Community Data System. Model organism projects in biology are prototypical Community Data Systems.

Open Community Contribution System

An Open Community Contribution System aggregates efforts of many geographically separate individuals toward a common research problem. It differs from a Community Data System in that contributions come in the form of work rather than data. It differs from a Distributed Research Center in that its participant base is more open, often including members of the public who want to contribute.

Virtual Learning Community

This type of project's main goal is to increase the knowledge of participants but not necessarily to conduct original research. This is usually formal education, i.e., provided by a degree-granting institution, but can also be in-service training or professional development.

Community Infrastructure Project

Community Infrastructure Projects seek to develop infrastructure to further work in a domain. By infrastructure we mean common resources that facilitate science, such as software tools, standardized protocols, new types of scientific instruments, and educational methods. Community Infrastructure Projects are often inter-disciplinary, bringing together domain scientists from multiple specialties, private sector contractors, funding officers, and computer scientists.

Virtual Community of Practice

This collaboratory is a network of individuals who communicate online about a shared research area. They may share news of professional interest, advice, techniques, or pointers to other resources online. Virtual Communities of Practice are different from Distributed Research Centers in that they do not undertake joint projects. The term ''community of practice'' is taken from Wegner and Lave (1998).

Distributed Research Center

This collaboratory functions like a university research center but at a distance. It is an attempt to aggregate scientific talent, effort, and resources beyond the level of individual researchers. These centers are unified by a topic area of interest and joint projects in that area. Most of the communication is human-to-human.

Types of Collaboratories and their Challenges

	Example	Technology problems	Management Problems
Shared instrument	Keck Telescope	Remote access; data security	Access; technical support
Community data systems	Protein Databank molecular biology, structural biology, computational biology http://www.rcsb.org/pdb/home/home.do	standardization	Eliciting contributions
Open community contribution system	Birdsource Citizen Science project to collect bird observations http://gbbc.birdcount.org/	Cross-platform compatibility, ease of use	Quality control, vandalism, Eliciting contributions
Virtual community of practice	Project Runeberg Nordic Literature http://runeberg.org/admin/	Cross-platform compatibility, ease of use	Eliciting contributions
Virtual learning community	ArchNet Architecture, urbanism, landscape, visual culture https://archnet.org/	Cross-platform compatibility	Goal alignment among collaborators
Distributed research center	Inflammation and the Host Response to Injury Clinical Database, gene sets, informatics tools, etc. http://www.gluegrant.org/	All others, plus ability to virtually "drop-in" to collaborator's workplace	All others, plus shared administrative support, IP policies, career development
Community infrastructure project	FusionGrid Collaborative software tools to access shared devices http://www.fusiongrid.org/	Standardization, provenance	Goal alignment among collaborators, career development

Bos, N., Zimmerman, A., Olson, J., Yew, J., Yerkie, J., Dahl, E. and Olson, G. (2007), From Shared Databases to Communities of Practice: A Taxonomy of Collaboratories. Journal of Computer-Mediated Communication, 12: 652–672. doi:10.1111/j.1083-6101.2007.00343.x. Also see http://soc.ics.uci.edu/

Wicked Problems

Tackling Wicked Problems Through the Transdisciplinary Imagination
John Harris, Valerie A Brown, Jacqueline Russell
Taylor & Francis, Sep 23, 2010 - 336 pages

Special Issue: Working with wicked problems in socio-ecological systems: More awareness, greater acceptance, and better adaptation
Landscape and Urban Planning 154:1-132 (October 2016)

Edward P. Weber and Anne M. Khademian. "Wicked Problems, Knowledge Challenges, and Collaborative Capacity Builders in Network Settings." *Public Administration Review*, Vol. 68, No. 2 (Mar. - Apr., 2008), pp. 334-349

Incommensurability & Divisibility

Blog post on philosophy of science with a good infographic showing ontological and epistemological landscape -- helps understand why people can't trade effectively
https://i2insights.org/2017/05/02/philosophy-for-interdisciplinarity/

"Enhancing research collaborations: Three key management challenges"
Gabriele Bammer 2008 *Research Policy*
doi:10.1016/j.respol.2008.03.004
To wit:

1. Harness Differences:
   integrate diverse relevant contributions;
   prevent incidental differences from interfering.
2. Set Defensible Boundaries:
   Understand the inevitable restrictions (budget, time, political pressure).
   Nurture the creative element
3. Gain Legitimization/Authorization
   Draw lessons from case studies

Forming and Managing Teams

There is an extensive literature on this subject in the social psychology and management/organization journals. The interactive bibliography database on the Science of Team Science webpage can take you to articles focused on the issue with respect to transdisciplinary teams.

EG:
Managing the wicked problem of transdisciplinary team formation in socio-ecological systems Patricia E. Norris *et.al. Landscape and Urban Planning* 154 (2016) 115–122

The NAS Report *Enhancing the Effectiveness of Team Science* has a chapter that is very helpful –this table lists some of the team processes that need attention, and provides citations to the literature you can use to identify and justify the interventions you propose.

TABLE 3-1 Team Processes Related to Team Effectiveness: Interventions and Support

Process	Interventions	Empirical Support for Interventions
Team Mental Models	• Training • Leadership • Shared experience	• Systematic theory, method development, and research • Meta-analytic support (DeChurch and Mesmer-Magnus, 2010)
Transactive Memory	• Face-to-face interaction • Shared experience	• Theory, measurement, and research findings • Meta-analytic support (DeChurch and Mesmer-Magnus, 2010)
Cognitive Team Interaction	• Training • Team composition	• Theory, measurement, and research findings (Gorman, Cooke, and Amazeen, 2010; Gorman and Cooke, 2011)
Team Climate	• Strategic imperatives; team mission/goals; policies, practices, and procedures • Leadership • Team member interaction	• Body of systematic theory, method development, and research (Carr et al., 2003; Zohar and Hofmann, 2012; Schneider and Barbera, 2013)
Psychological Safety	• Leader coaching, inclusion • Positive interpersonal climate	• Systematic empirical support
Team Cohesion	• Antecedents not well specified • Theory = team composition • Theory = leadership	• Systematic empirical support • Meta-analytic support (Gully et al., 1995; Beal et al., 2003)
Team Efficacy	• Mastery experiences • Vicarious observation • Verbal persuasion • Theory = leader behavior	• Systematic empirical support • Meta-analytic support (Gully et al., 2002)
Team Conflict	• Team composition, faultlines • Conflict management skills	• Empirical support • Meta-analytic support (De Dreu and Weingart, 2003; Thatcher and Patal, 2011; de Witt, Greer, and Jehn, 2012)
Team Process Competencies	• Training • Theory = leadership	• Empirical support • Meta-analytic support (LePine et al., 2008)
Team Regulation	• System design • Theory = leadership	• Body of systematic theory and research • Meta-analytic support (Pritchard et al., 2008)

SOURCE: Adapted from Kozlowski and Ilgen (2006). Reprinted with permission.

Exchanging Knowledge

1. Boundaries & Boundary Objects

We didn't discuss "boundary objects" in the workshop -- but this is an important concept. Boundary objects are the focus for transdisciplinary teams to hash out the language of trade.

Carlile has two articles introducing a framework for crossing boundaries:

Paul R. Carlile. 2004. "Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge across Boundaries" *Organization Science*, 15(5):555-568
Stable URL: http://www.jstor.org/stable/30034757

Paul R. Carlile, (2002) A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. *Organization Science* 13(4):442-455.
http://dx.doi.org/10.1287/orsc.13.4.442.2953

He discusses three properties of knowledge at a boundary:
difference – what needs to be overcome
dependence – what is pooled, sequential, or reciprocal
novelty – the need to abandon old knowledge, or possibility of discarding novelty as irrelevant

A boundary object is a tool, method, or object:

1. a boundary object establishes a shared syntax or language for individuals to represent their knowledge. It must be able to represent what is at stake for the traders.
2. effective boundary object at a semantic boundary provides a concrete means for individuals to specify and learn about their differences and dependencies
3. Effective boundary objects facilitate the pragmatic transformation of knowledge

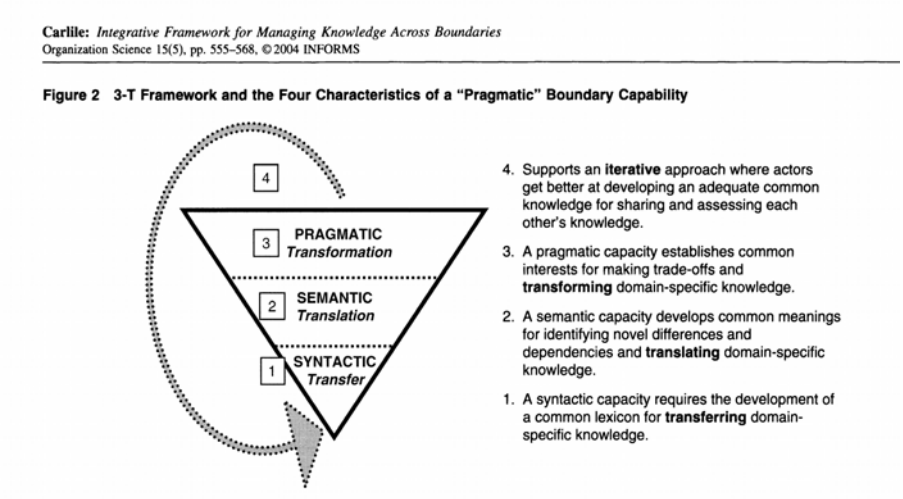


Table 1 Comparative Summary of Approaches to Sharing and Assessing Knowledge Across Boundaries

	Syntactic boundary: A transfer or information-processing approach	Semantic boundary: A translation or interpretive approach	Pragmatic boundary: A transformation or political approach
Circumstances	Differences and dependencies between actors are known. A common lexicon is developed that is sufficient to share and assess knowledge at a boundary.	Novelty generates some differences and dependencies that are unclear—different interpretations exist. Common meanings are developed to create shared meanings and provide an adequate means of sharing and assessing knowledge at a boundary.	Novelty generates different interests between actors that impede their ability to share and assess knowledge. Common interests are developed to transform knowledge and interests and provide an adequate means of sharing and assessing knowledge at a boundary.
Solutions	*Theory*: Information processing (Shannon and Weaver 1949, Lawrence and Lorsch 1967)—**transferring** knowledge	*Theory*: Learning (i.e., communities of practice)—creating shared meanings (Dougherty 1992, Nonaka 1994), **translating** knowledge	*Theory*: "Creative abrasion" (Leonard-Barton 1992)—negotiating practice (Brown and Duguid 2001); **transforming** knowledge (Carlile 2002, Bechky 2003)
	Techniques: Syntactic capacity, taxonomies, storage and retrieval technologies.	*Techniques*: Semantic capacity, cross-functional interactions/teams, boundary spanners/translators	*Techniques*: Pragmatic capacity, prototyping and other kinds of boundary objects that can be jointly transformed
Challenges	Increasing capacity to process "more" information (Galbraith 1973) **A common lexicon is necessary but not always sufficient to share and assess knowledge across a boundary.**	Making tacit knowledge explicit (Polanyi 1966, Nonaka 1994) **To create common meanings to share and assess knowledge often requires creating new agreements.**	Changing knowledge that is "at stake" (Bourdieu and Wacquant 1992, Carlile 2002) **To create common interests to share and assess knowledge requires significant practical and political effort.**

IN CONTRAST, there is evidence that boundaries don't have to be traversed – they can be transcended by protocols or practices.

Ann Majchrzak, Philip H. B. More, Samer Faraj, (2012) Transcending Knowledge Differences in Cross-Functional Teams. *Organization Science* 23(4):951-970. http://dx.doi.org/10.1287/orsc.1110.0677

Abstract: Knowledge differences impede the work of cross-functional teams by making knowledge integration difficult, especially when the teams are faced with novelty. One approach in the literature for overcoming these difficulties, which we refer to as the traverse approach, is for team members to identify, elaborate, and then explicitly confront the differences and dependencies across the knowledge boundaries. This approach emphasizes deep dialogue and requires significant resources and time. In an exploratory in-depth longitudinal study of three quite different cross-functional teams, we found that the teams were able to cogenerate a solution without needing to identify, elaborate, and confront differences and dependencies between the specialty areas. Our analysis of the extensive team data collected over time surfaced practices that minimized members' differences during the problem-solving process. We suggest that these practices helped the team to *transcend* knowledge differences rather than *traverse* them. Characteristic of these practices is that they avoided interpersonal conflict, fostered the rapid cocreation of intermediate scaffolds, encouraged continued creative engagement and flexibility to repeatedly modify solution ideas, and fostered personal responsibility for translating personal knowledge to collective knowledge. The contrast between these two approaches to knowledge integration—traverse versus transcend—suggests the need for more nuanced theorizing about the use of boundary objects, the nature of dialogue, and the role of organizational embeddedness in understanding how knowledge differences are integrated.

See table following for a summary of these practices:

Table 1 Case Descriptions

Pseudonym	Reorienting strategic planning (Team Strategy)	Rethinking space (Team Space)	New approach to quality (Team Quality)
Task of the group	Develop a two-hour experiential module to convince regional general managers to use cultural diversity as a strategic weapon	Develop a strategic plan for how space is used at the company	Identify a new approach to quality that could be used across the diversified company
Novelty of the task for the company	A module planned by "young employees" with no facilitator experience to change senior managers' minds about how to do strategic planning had never been done	Devoting five days of consultants' time to developing a new way of using space not done previously	Creating a white paper describing an approach to quality that could be implemented across the highly diversified company not done previously
Project time and pressure	Over 3 weeks, seven teleconferences of 90 minutes each, with prep work in between, plus 2 days on-site to complete tasks individually, in subgroups, and in full group; 34 hours total	Over 5 days, 30 hours total	Three 2-hour teleconferences before 3 days of f2f meetings, four teleconferences after f2f meetings dispersed over 10 months because members were pressured to perform other duties; 39 hours total
Team member jobs and perspective on problem (from initial interviews)	(1) Brand manager in China: Disconnect between HQ's direction and culture of the region (2) Marketing analyst in France: How historical references (e.g., sweatshop) affect employees' and consumers' view (3) HR trainer in Turkey and Israel: Match between employee needs and management expectation (4) Digital media analyst, Latin America: Social networking helps global employees feel part of a single company (5) Process analyst, United States: Employees ignored as consumers of improvement (6) Diversity analyst, United States: Use this as a model for future workshops (7) Footwear designer, United States: Managers' view of product lines not view of consumers and athletes	(1) Manufacturing engineer: Reinstill early culture into current culture (2) Director of Operations: Concern re how all the pieces (people, buildings, support, management, budget, client tours) fit together w/space plan that can evolve in the future (3) Designer: How can support and space help me do my work? (4) Experience manager: Support services is a discipline in its own right (5) Prototyper: Give me specs to prototype (6) Facilities: People will not move willingly to new spaces (7) Architect and practice exec: How can workspaces encourage communication and "buzz"?	(1) Quality professional for low-volume production: Personal, hands-on (2) Quality professional for high-volume product line: Good formal system in place, but managers will not support (3) Quality software developer: Managers will not use tracking software (4) Plant manager: Too much bureaucracy in company's quality program (5) Product manager: Too many useless quality citations (6) Project manager: Quality citations have unintended consequences that are ignored by quality professionals (7) Director, Quality Audits: Managers are the problem, not the quality program (8) Machine tool quality analyst: Partnering with operators will fix quality system (9) Medical devices quality professional: Our practice is best because it is FDA approved
How were members selected for team	The Diversity VP contacted senior executives for each region and asked for a person who was "under 30," at the company for less than five years, and came from the region	Asked by senior managers as representing a mix of people responsible for different aspects of space (facilities, service, hospitality, prototyping) and design community	Senior managers contacted personnel responsible for quality at each facility and asked them to serve with concurrence of their supervisors; three managers offered to serve as well
How familiar were members with each other?	None worked together previously	#4 and #6 worked for #2; #1 and #5 worked on a project before	Several pairings of individuals who knew each other: #4 and #7, #5 and #6, #2 and #3, #7 and #8

Note. f2f, face-to-face; FDA, U.S. Food and Drug Administration; HQ, headquarters; HR, human resources; VP, vice president.

2. Dialogue Mapping

Dialogue Mapping is another technique for crossing syntactic and semantic boundaries
Conklin, Jeff; "Dialogue Mapping: Building Shared Understanding of Wicked Problems," Wiley; 1st edition, 18 November 2005, ISBN 978-0-470-01768-5

OVERSIGHT: MANAGEMENT STRUCTURES & SYSTEMS

Examples of Org Charts to show boundary spanning functions

1: Matrix management structure –people report up to a functional manager and across functions to a project manager:

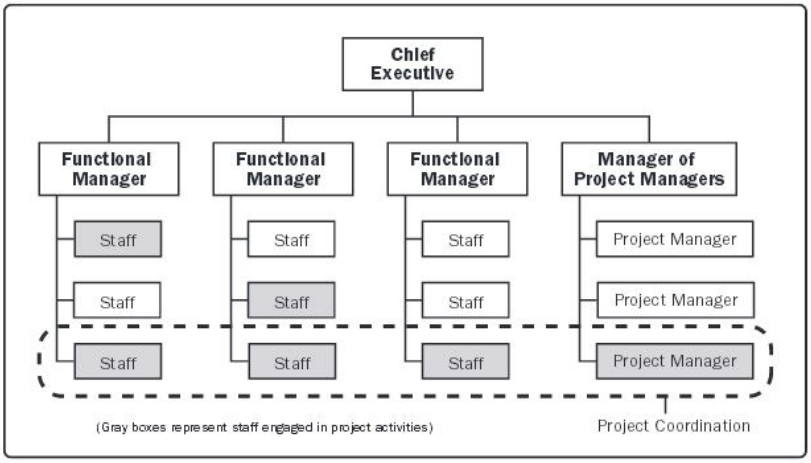
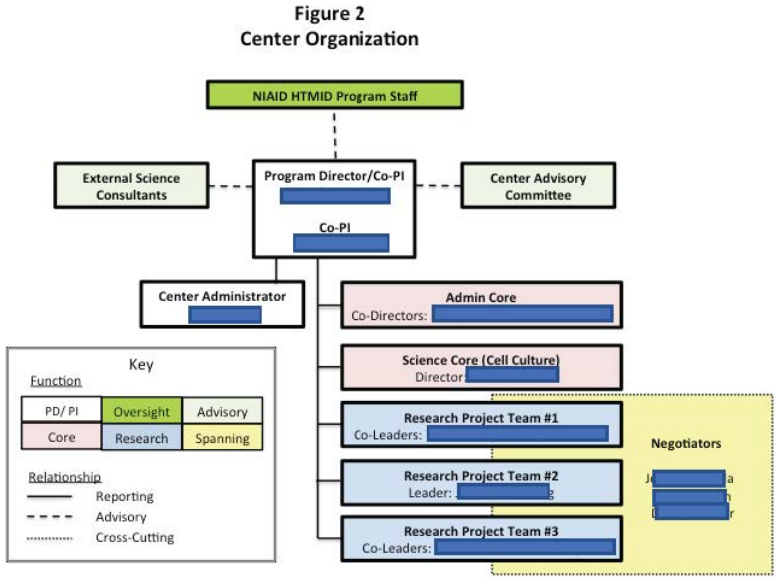


Figure 2-4. Strong Matrix Organization

2. A dedicated boundary-spanning function can also be specified



INFRASTRUCTURE

- Wikipedia page with list of software products for managing collaborations: https://en.wikipedia.org/wiki/List_of_collaborative_software

EVALUATION

- "Special Issue on assessment of interdisciplinary research" *Research Evaluation*, April 2006, Vol. 15 Issue 1