Team Science 101

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2023-24 ISCE Workshop Series

October 27, 2023

My involvement in the Science of Team Science field

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Evaluating an Interdisciplinary Undergraduate Training Program in Health Promotion Research

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SciMedCentral Journal of Translational Medicine & Epidemiology

Research Article

The Transdisciplinary Orientation Scale: Factor Structure and Relation to the Integrative Quality and Scope of Scientific Publications

Shalini Misra[1]*, Daniel Stokols[2] and Lulu Cheng[3]

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Keywords
• Transdisciplinary orientation scale
• Scientific outputs
• Science teams
• Scientific collaboration

GROWING CONVERGENCE RESEARCH (GCR)

Team Science 101 Workshop Learning Objectives

- Distinguish between different types of cross-disciplinary research
- Identify the complexity dimensions of your team
- Identify criteria for effective team science
- Identify team science skills and competencies for successful research outcomes
- Reflect on your own team science skills and competencies

Workshop Organization

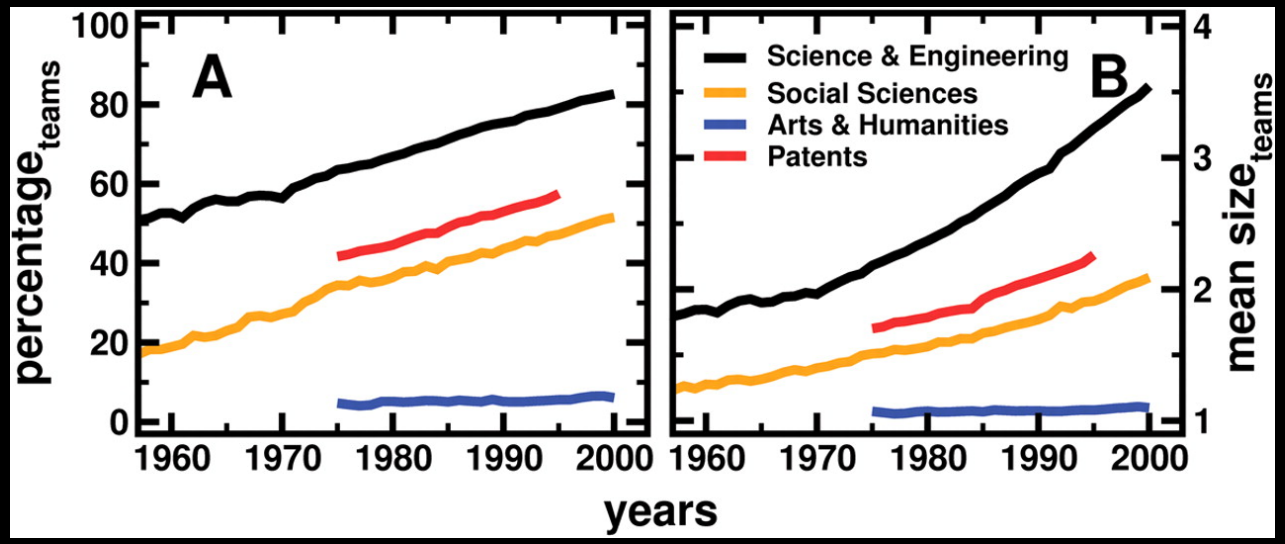
- Part 1: Foundations of the “Science of Team Science” (30 min)
- Part 2: Effective cross-disciplinary team science (20 min)
- Part 3: Skills and competencies for effective team science (30 min)
- Open discussion and questions (10 min)

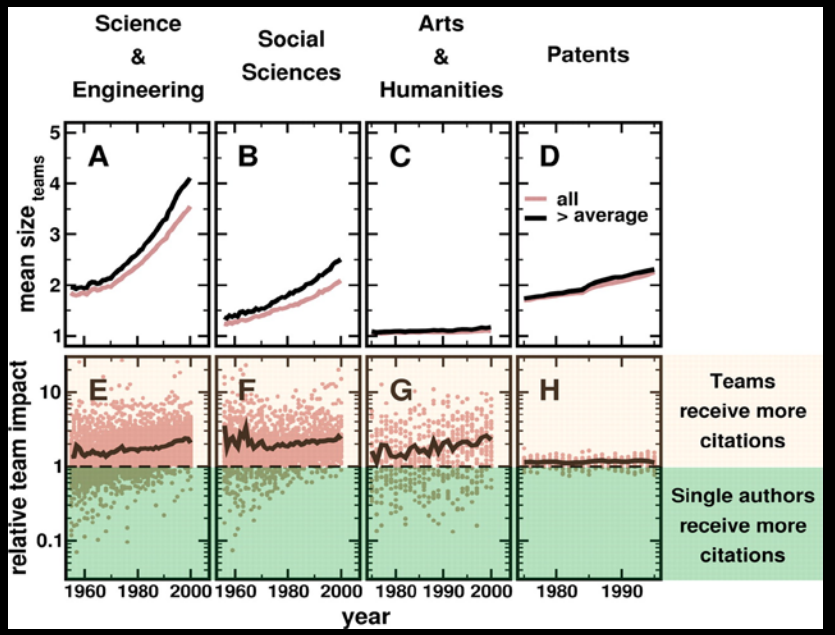
The process of knowledge creation has fundamentally changed

- Teams
  - dominate the production of knowledge – in all fields
  - produce more highly cited research than individuals do
  - produce exceptionally high-impact research

The Increasing Dominance of Teams in Production of Knowledge

Stefan Wuchty,[1]* Benjamin F. Jones,[2]* Brian Uzzi[1,2]*†

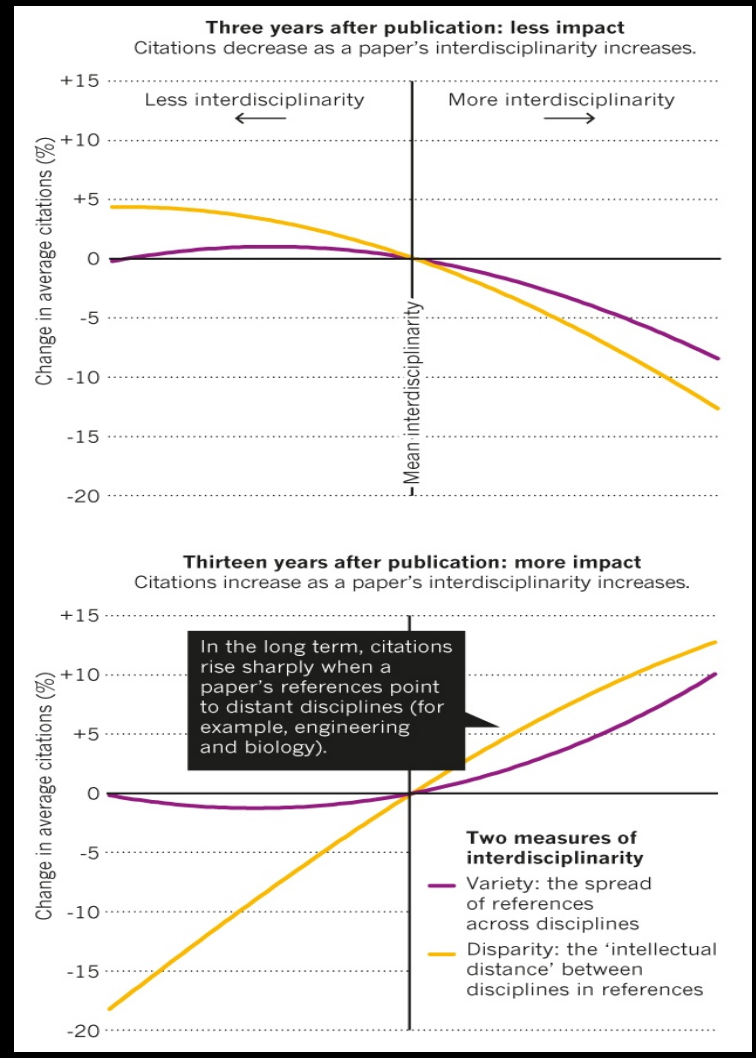




Wuchty, Jones, & Uzzi, 2007

Cross-disciplinary research dominates science

- Cross-disciplinary (CD) publications are
  - increasingly citing work outside of their own disciplines
  - more impactful over time
  - rated as having significant societal impact

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RESEARCH ARTICLE

Interdisciplinarity and Impact: Distinct Effects of Variety, Balance, and Disparity

Jian Wang, Bart Thijs, Wolfgang Glänzel

INTERNATIONAL COMPARATIVE PERFORMANCE OF THE UK RESEARCH BASE 2016

Larivière & Gingras, 2014; Wang et al. 2015; Elsevier, 2015

What is driving these trends?

- Large, ambitious, complex scientific initiatives
- Need to address societal challenges
- Advances in computational and technological capabilities
- Increased public and private investment for cross-disciplinary research
- Team-based problem focused units at universities
- Hiring and P&T policies that recognize cross-disciplinary team science


Source: Getty Image


Source: NASA


Source: CERN

Hall, Vogel, & Croyle, 2019; Hall et al., 2018

There are debates about the scientific and societal value of cross-disciplinary research

- Less “disruptive” research over time – universally across fields
- Narrow cross-disciplinarity over broad cross-disciplinarity
- Need for engagement with distant fields and breadth of knowledge
- Strong resistance to broadly cross-disciplinary and deeply integrative work

Article | Published: 04 January 2023

Papers and patents are becoming less disruptive over time

Michael Park, Erin Leahey & Russell J. Funk

Nature **613**, 138–144 (2023) | Cite this article

Published: 14 September 2023

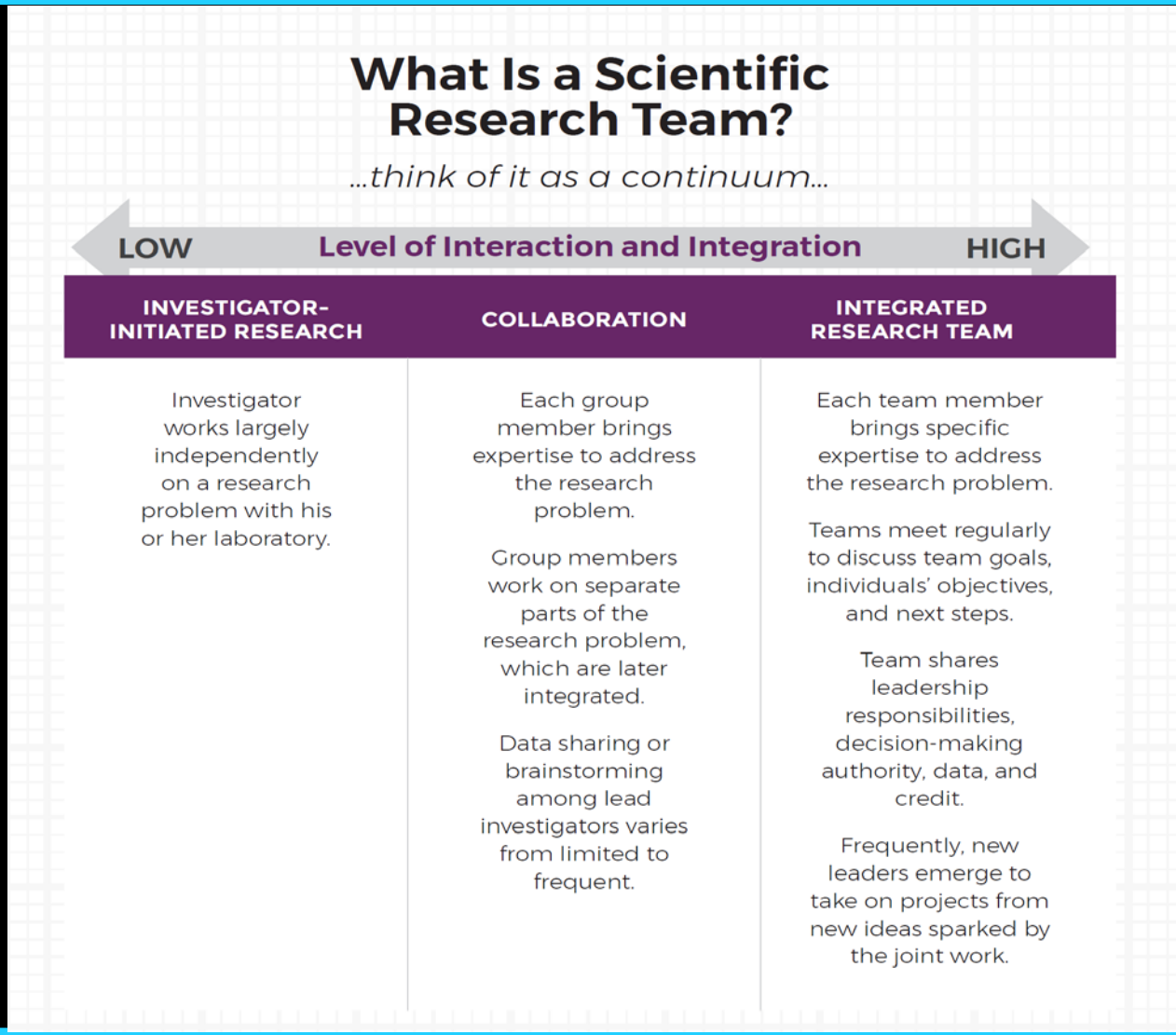
Convergence Research as a ‘System-of-Systems’: A Framework and Research Agenda

Lisa C. Gajary, Shalini Misra, Anand Desai, Dean M. Evasius, Joy Frechtling, David A. Pendlebury, Joshua D. Schnell, Gary Silverstein & John Wells

Park, Leahey, & Funk, 2023; Shi & Evans, 2023; Gajary, Misra, Desai et al., 2023

"Science of Team Science" (SciTS)

- Team Science: Collaborative and often cross-disciplinary approaches to analyzing research questions about particular phenomena
- Science of Team Science: A branch of science studies concerned with understanding and managing circumstances that facilitate or hinder the effectiveness of team science initiatives

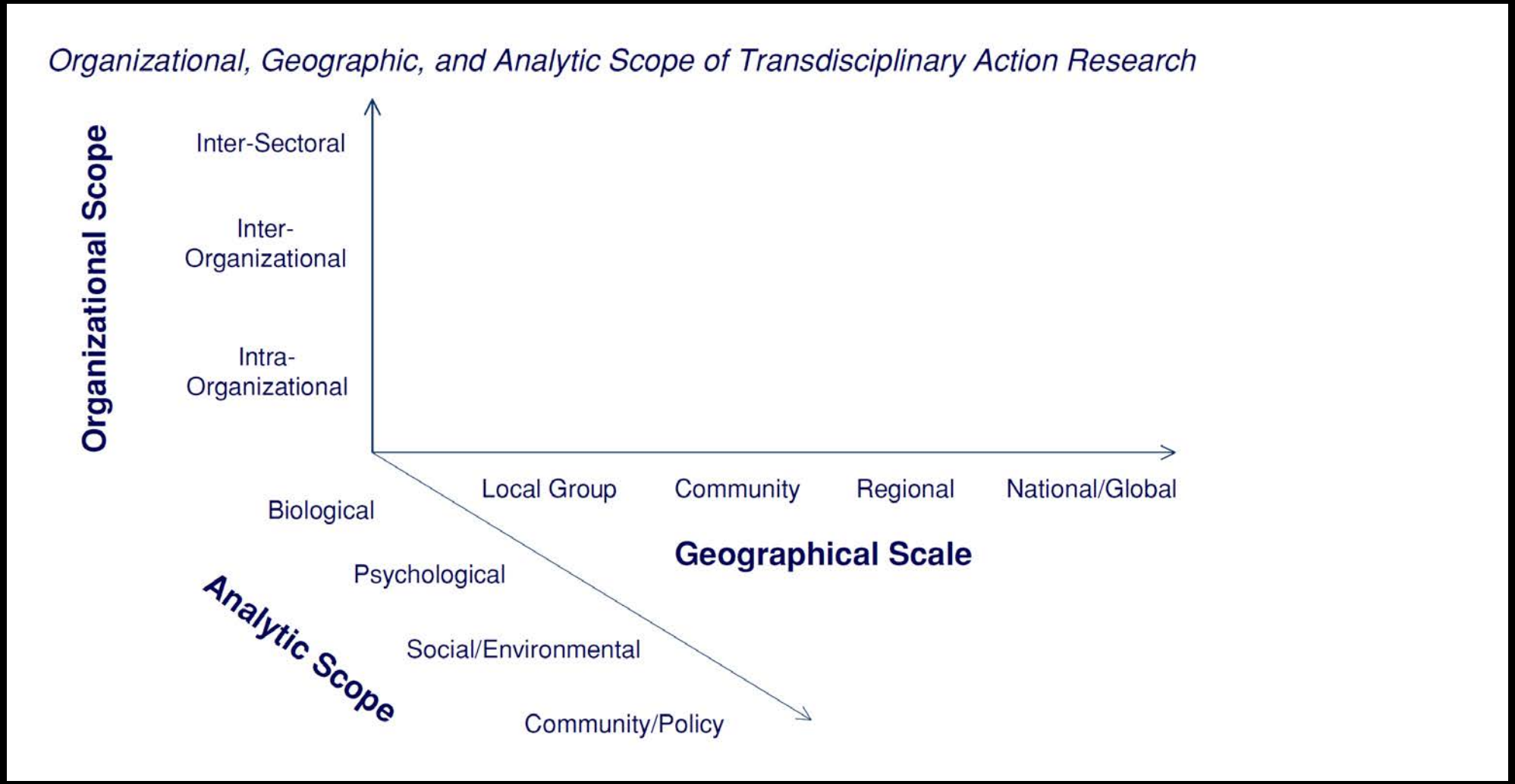


Stokols, Hall, Taylor, & Moser, 2008; Bennett, Gadlin, & Marchand, 2018

Questions addressed in SciTS research

- What *intrapersonal, interpersonal, organizational, and institutional* factors influence the effectiveness of CD team science initiatives?
- How can we *assess success /effectiveness* in CD team science?
- How can *institutional*, *organizational*, and *team* leaders *design and manage* successful CD team science initiatives?
- What *dispositions, attitudes, skills and competencies are needed for effective CD team science*?
- How can we to *train students, early career and seasoned scientists* be effective CD team scientists?

Organizational, geographic, and analytical scope of cross-disciplinary research



Stokols, 2006

Complexity dimensions of team science

Dimension	Range	
Diversity of Team or Group Membership	Homogeneous	Heterogeneous
Disciplinary Integration	Unidisciplinary	Transdisciplinary
Team or Group Size	Small (2)	Mega (1000s)
Goal Alignment Across Teams	Aligned	Divergent or misaligned
Permeable Team and Organizational Boundaries	Stable	Fluid
Proximity of Team or Group Members	Co-located	Globally distributed
Task Interdependence	Low	High

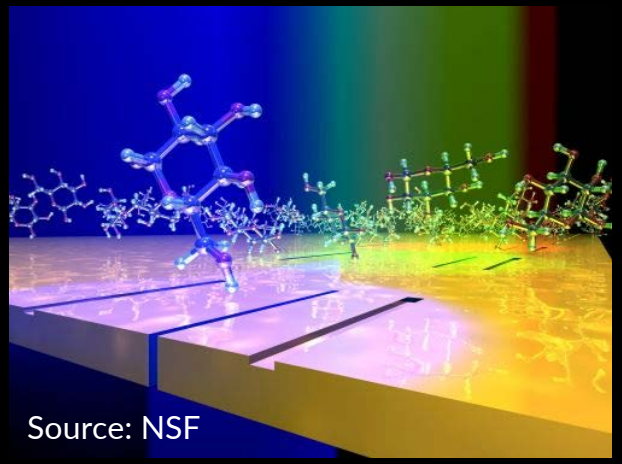
National Research Council, 2015

Taxonomy of cross-disciplinary team science

- *Multidisciplinary*: Researchers work *independently or sequentially*, each from their own disciplinary perspective, to address a particular research problem

- *Interdisciplinary*: Researchers work *jointly but still from disciplinary-specific basis* to address a common problem

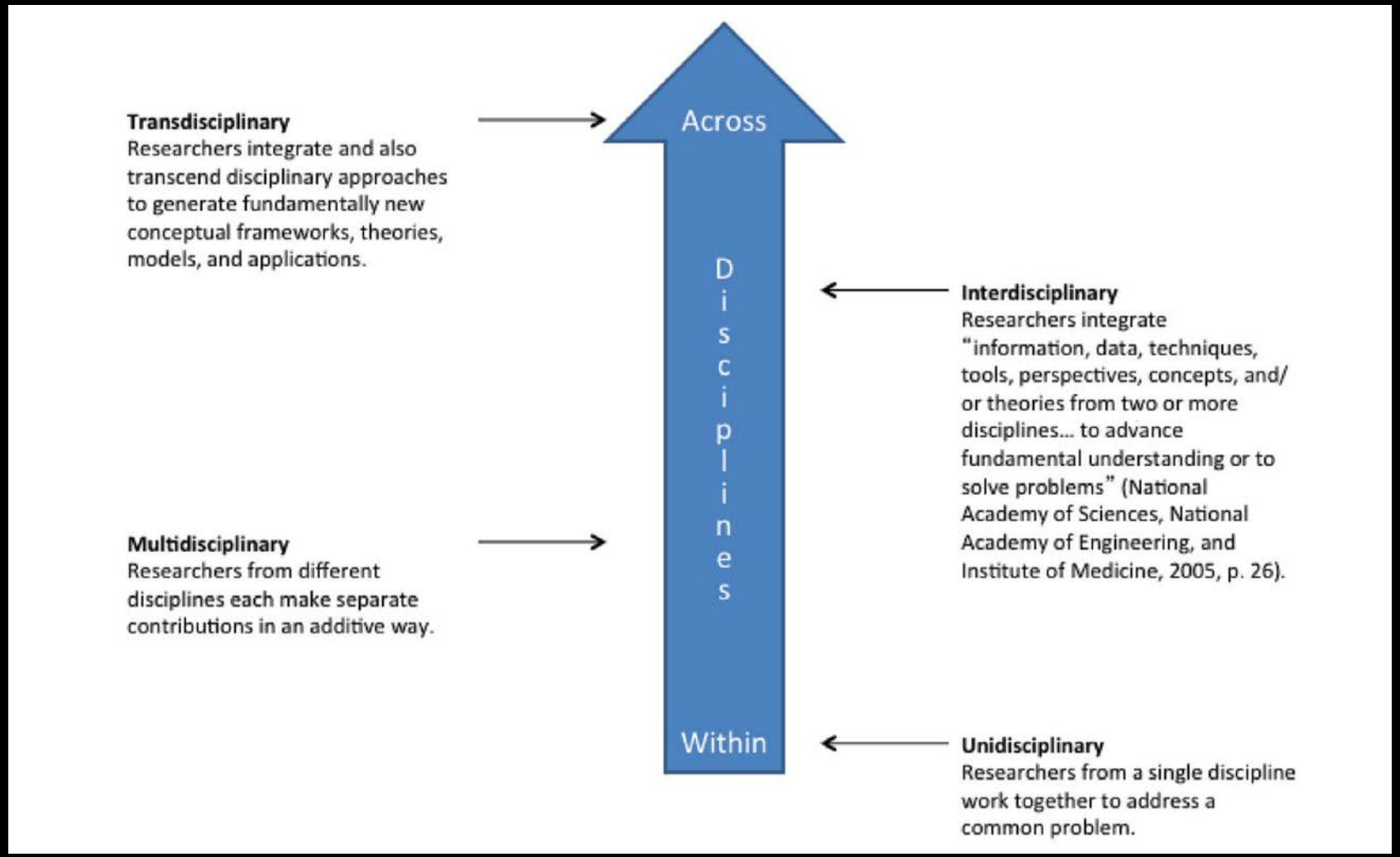
- *Transdisciplinary*: Researchers work *interdependently to develop and apply conceptual frameworks, theories, methods, and measures that both synthesize and extend discipline-specific approaches* to address a common problem


Source: NSF


Source: Foreign Policy

Rosenfield, 1992

The continuum of disciplinary integration

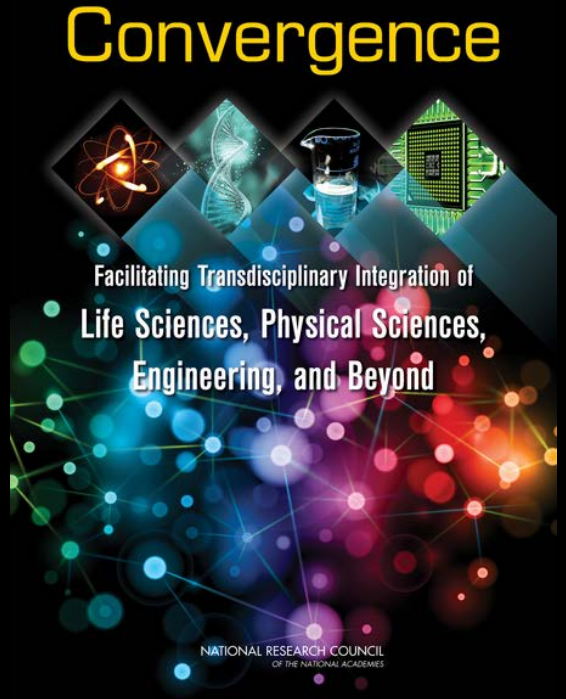


National Research Council, 2015

Convergence research

- "Convergence is an *approach to problem-solving that cuts across disciplinary boundaries. It integrates knowledge, tools, and ways of thinking from life and health sciences; physical, mathematical, and computational sciences; engineering disciplines; and beyond* to form a comprehensive synthetic framework for tackling scientific and societal challenges that exist at the interfaces of multiple fields. By merging these diverse areas of expertise in a network of partnerships, convergence stimulates innovation from basic science discovery to translational application."

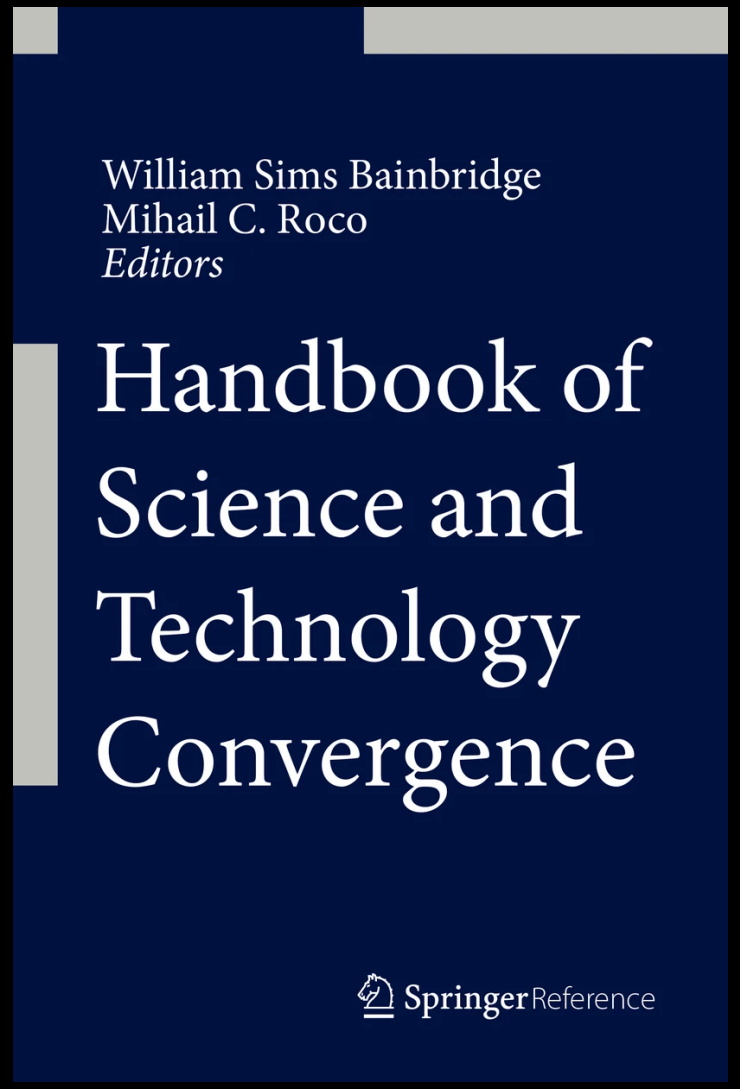
Source: NAS



National Research Council, 2014

NSF definition of convergence research

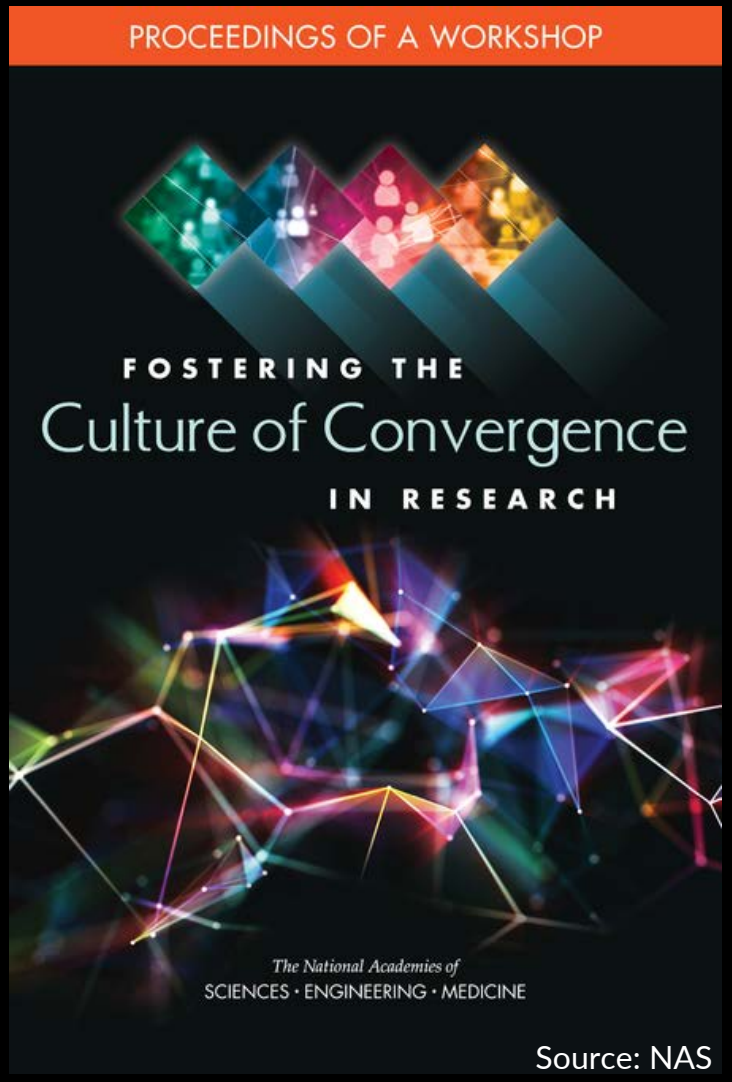
- Addresses vexing research problems focusing on societal needs.
- Integrates knowledge across disciplines (theories, methods, data, research communities).
- Generates new conceptual frameworks, language, constructs, research communities, or even disciplines.



Source: https://new.nsf.gov/funding/learn/research-types/learn-about-convergence-research#definition

Overlaps between transdisciplinary and convergence research

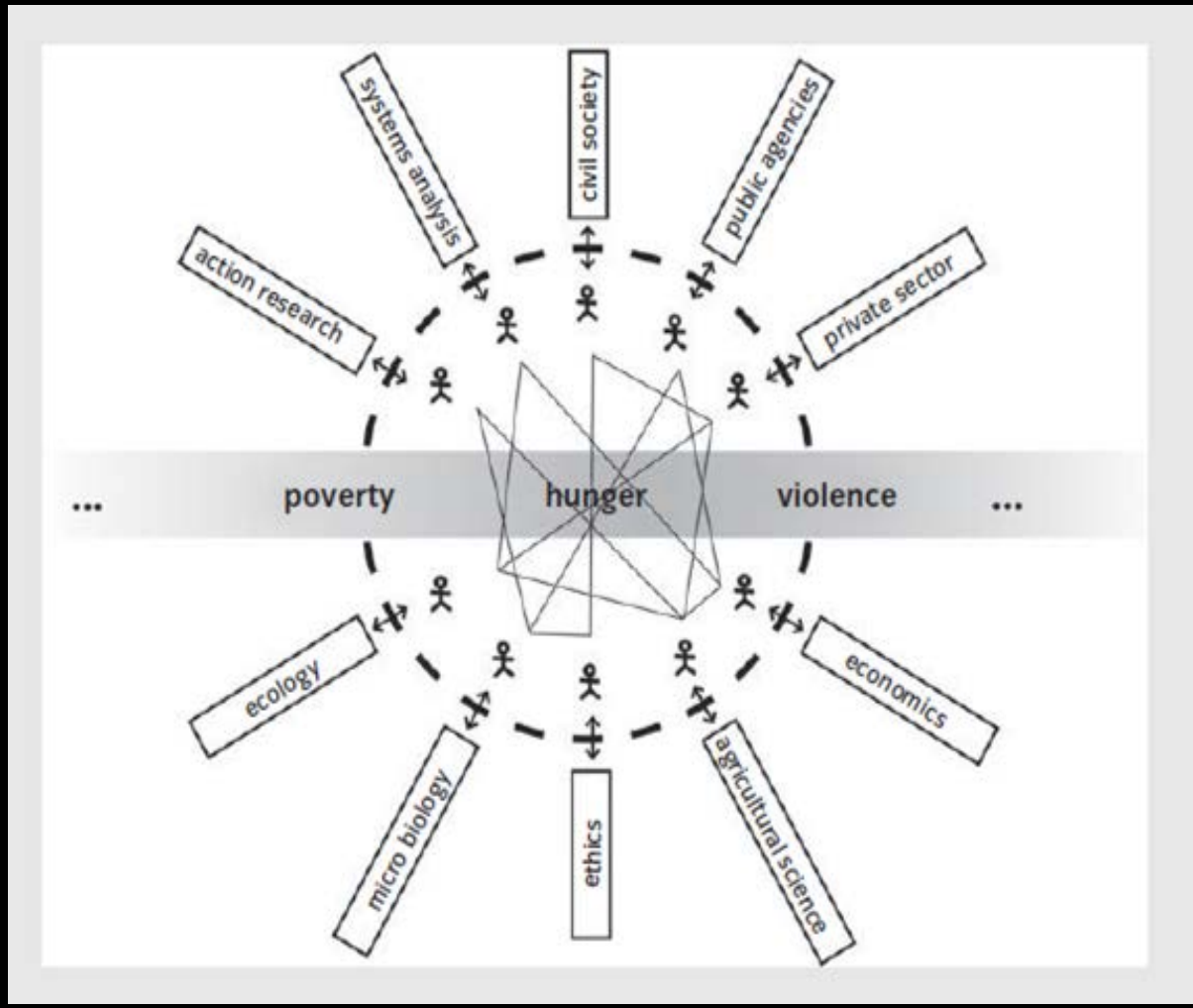
- "...significant overlap exists between the terms convergence, transdisciplinary research, and team science." (NASEM, 2019)
- "Describing how Convergence Research is "more than" other forms of cross-disciplinary (an umbrella term that encompasses multi-, inter-, and transdisciplinary) research remains elusive to both RDI funders and scholars (Gajary, Misra, Desai et al., 2023).
- "Convergence research is similar to transdisciplinary research, which is seen as the pinnacle of integration across disciplines." (NSF, n.d)



Source: NAS

Principles of a transdisciplinary research project

- **Grasp** the complexity of the problem
- **Account for** the diversity of perspectives and worldviews
- **Link** theoretical and contextual knowledge
- **Develop knowledge, practices, policies, and/or products that promote the common good**

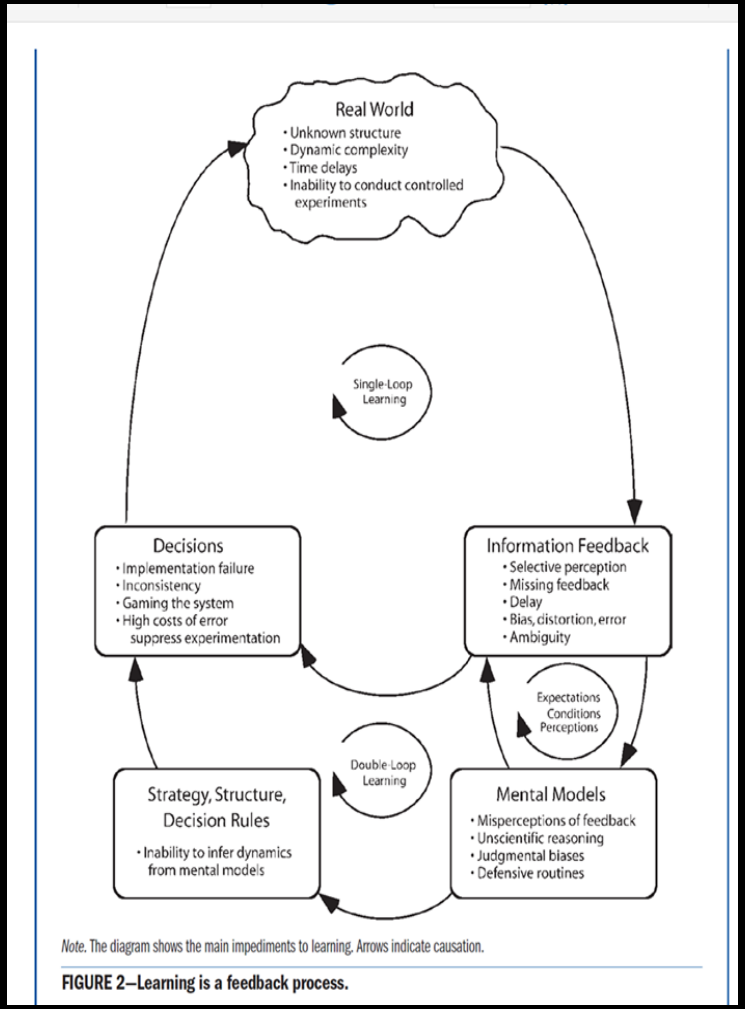


Pohl and Hirsch Hadorn, 2007; Hirsch Hadorn, Pohl, & Bammer, 2010

Integration is central to transdisciplinary / convergence research

Integration is both a process and a product of transdisciplinary problem solving that culminates in a new and more comprehensive understanding.

- Critical *evaluation* of disciplinary *insights*
- Critical *evaluation* of your own *positional biases*
- *Double loop learning:* Change in mental models as a result of evidence / knowledge / information / dialogue / reflection
- Creative *combination* of disciplinary *insights*
- A result that is valid for the particular *context*



Note. The diagram shows the main impediments to learning. Arrows indicate causation.

FIGURE 2—Learning is a feedback process.

Sterman, 2006

What does integration look like in practice?

- *Accommodates* (but does not resolve) epistemological differences
- Does not only focus on factual conditions or structures, but also on the *rightness or wrongness (normative) of the intervention / activity*
  - Concerned about ethical issues
- *More comprehensive* than prior understandings of the problem
  - *Accommodates conflicting insights*
- *Generates new meaning* or new understanding
  - Extended theoretical explanation

Case discussion 1: It's not working

- Dr. Anderson had come to the conclusion that several of his team members joined his team primarily because of the research funding he was able to offer. Once these team members had the resources they needed, they stopped attending team meetings and withdrew from interactions with members of the team. Some team members, especially senior researchers in leadership roles, continued participating in the team effort, but failed to share data openly or discuss research results. Team members often did not interact directly and were openly resistant to considering alternative ideas or perspectives offered by other team members. "On paper, we are a research team, but I get the feeling many team members are focusing on their own research," he said. "I guess they do not share my collaborative spirit."

Bennett, Gadlin, & Marchand, 2018

What do we mean by "successful" cross-disciplinary science teams?

- Criteria for Gauging Team Effectiveness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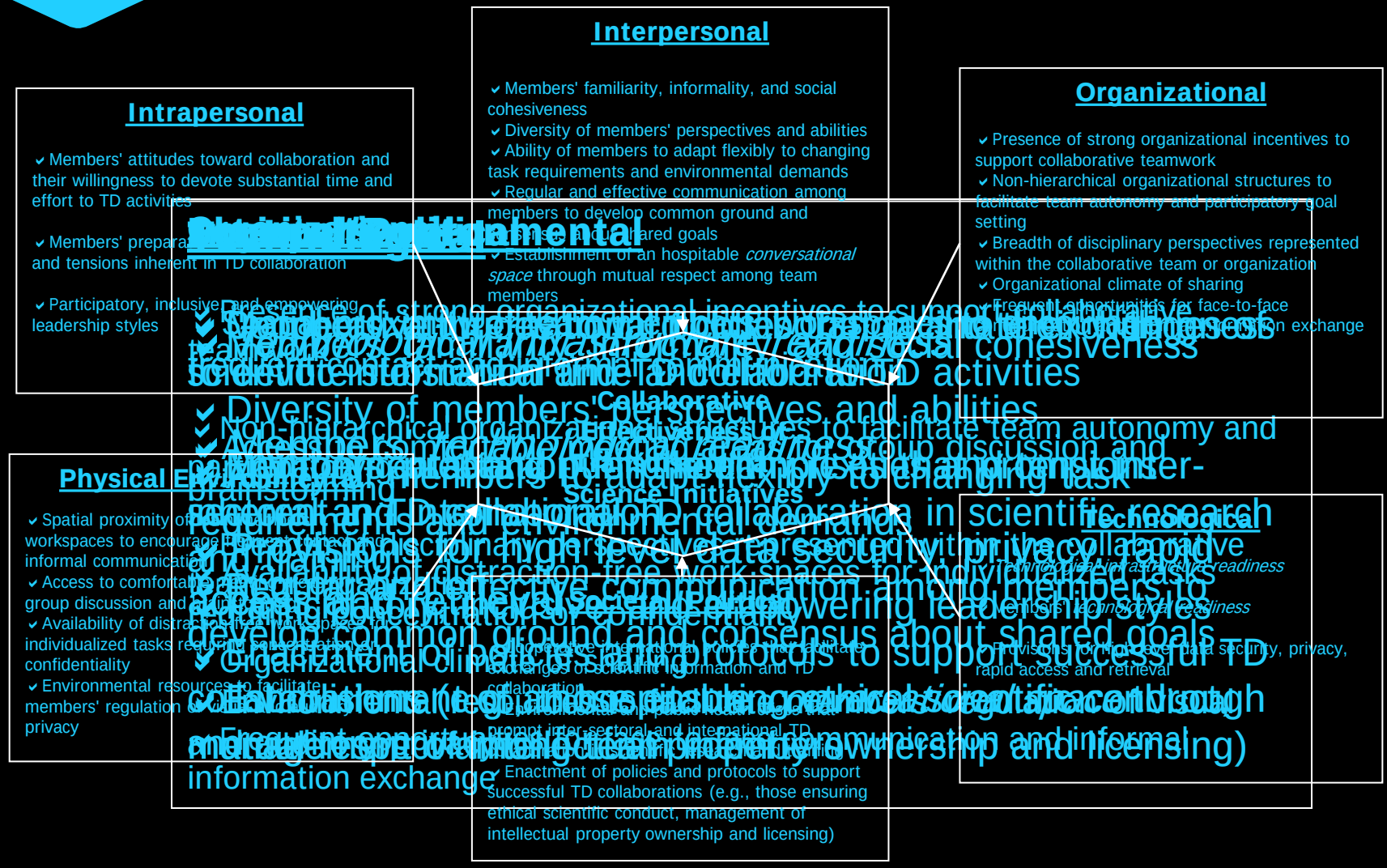
  - Generic Criteria
    - Intended to apply to broad categories of similarly organized initiatives and programs
  - Project-Specific Criteria
    - Assignment of different priorities among the multiple potential outcomes of collaboration depending on diverse, project specific goals

Stokols, Misra, Moser, Hall, & Taylor, 2008

Typology of Contextual Factors Influencing TD Scientific Collaboration at Each Level of Analysis



Stokols, Misra, Moser, Hall, & Taylor, 2008

Convergence research is a system of systems

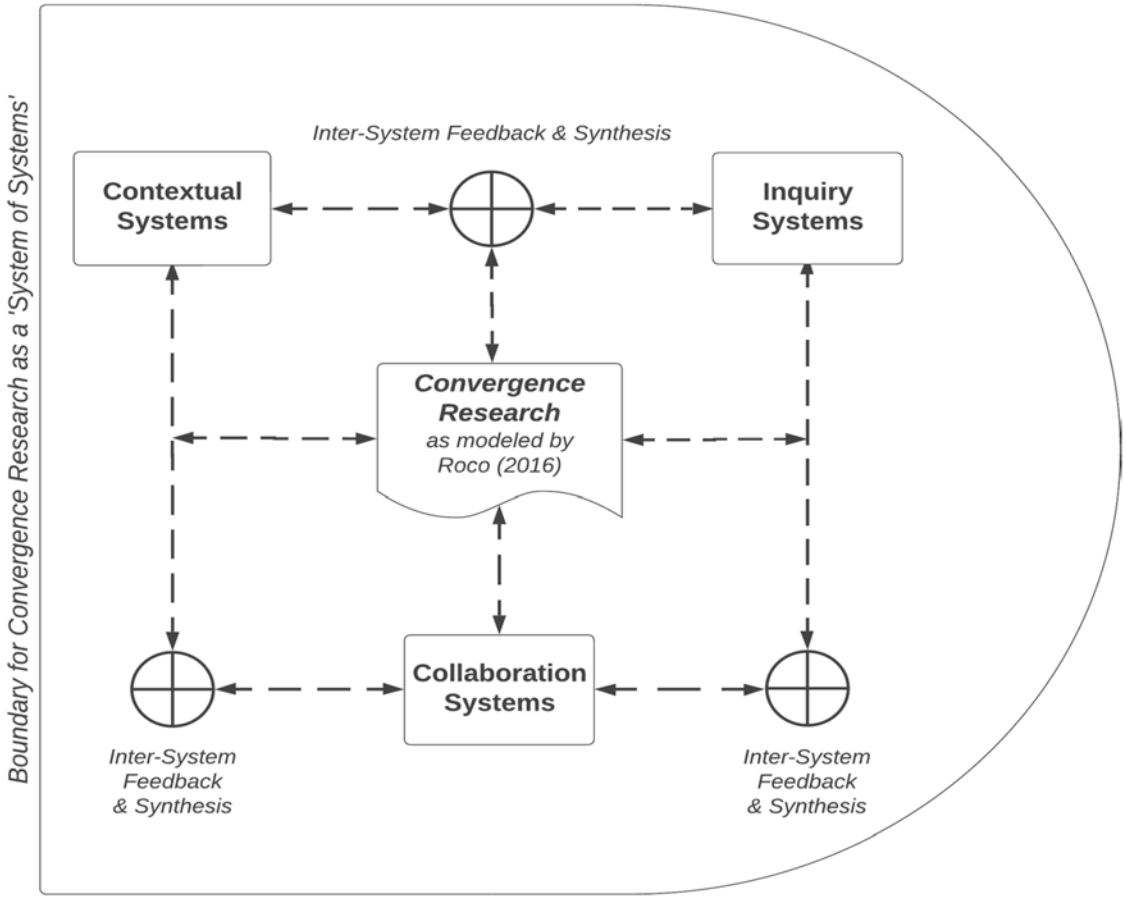
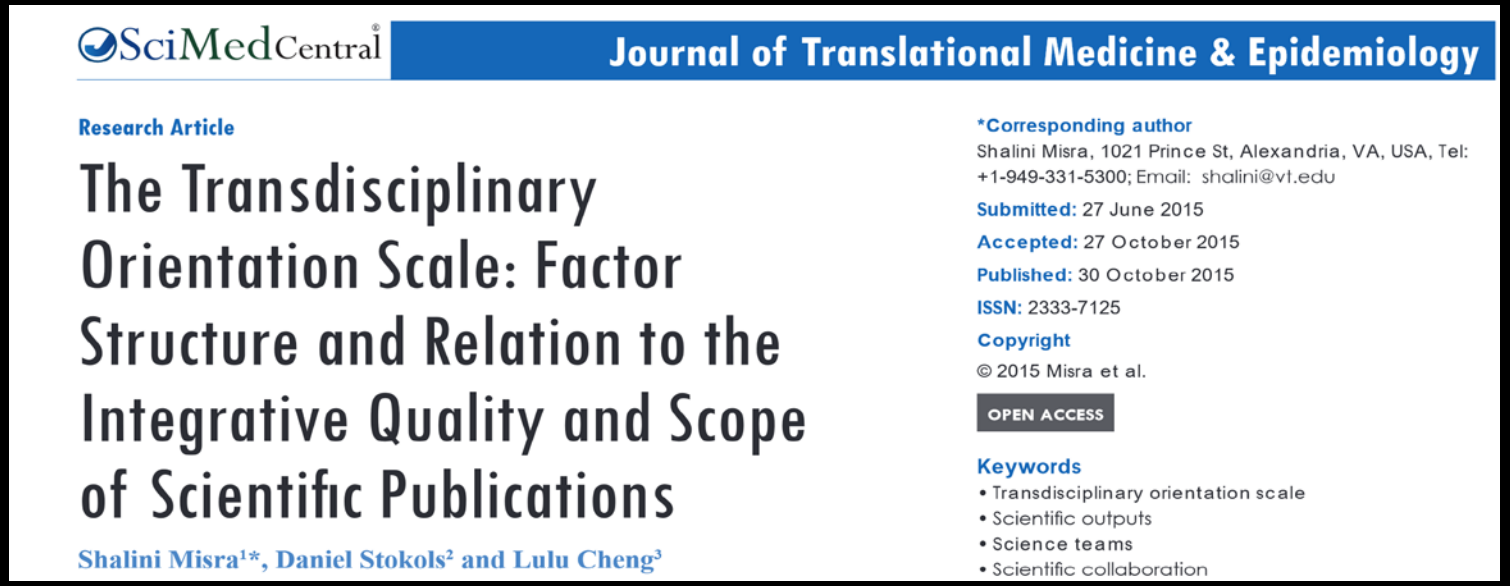


Figure 2 A 'system-of-systems' framework where Convergence Research is conceptualized as a complex adaptive system that dynamically interacts with Contextual, Collaboration, and Inquiry Systems.

Gajary, Misra, Desai et al., 2023

Discussion Question: Am I ready to participate in a cross-disciplinary research team?

Transdisciplinary orientation (TDO)



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Research Article

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Keywords
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• Scientific outputs
• Science teams
• Scientific collaboration

An intrapersonal disposition that emerges over the course of one's scholarly career and predisposes an individual to engage in cross-disciplinary team-based or independent research.

Misra, Stokols, & Cheng, 2015

Core components of transdisciplinary orientation

- **TD Values**
  - Resistance to in-group / out group biases
- **TD Attitudes**
  - Preference of working within a single discipline
  - Resistance to understanding and accepting different worldviews
- **TD Beliefs**
  - Benefits of team science outweigh costs
  - Theoretical, empirical, and translational outcomes of team science

Misra, Stokols, & Cheng, 2015

Core components of transdisciplinary orientation

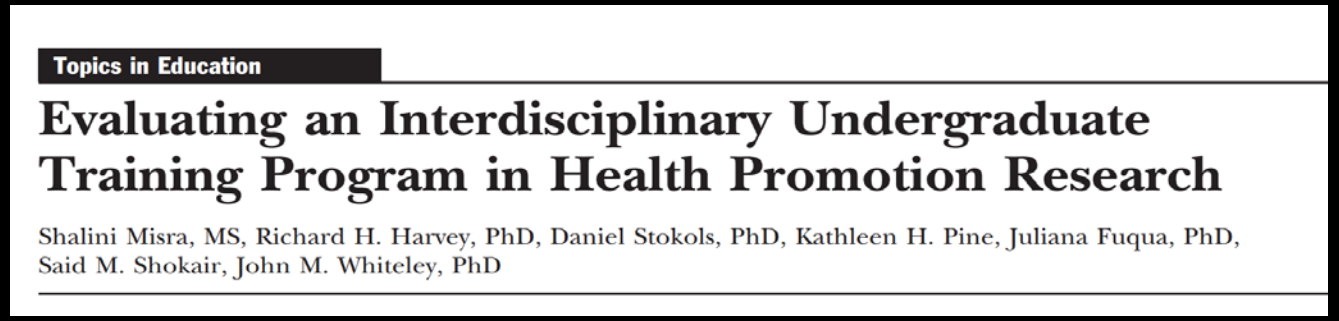
- **TD Conceptual Skills and Knowledge**
  - Conceptualize problems and questions from a holistic perspective
  - Integrate concepts and methods from different disciplines

- **TD Behaviors**
  - Communicate openly with team members
  - Conflict resolution skills
  - Lack of team experience

Misra, Stokols, & Cheng, 2015

Assessing transdisciplinarity in scholarly products

- Written Products Protocol
  - Extent of cross-disciplinary integration
  - Levels of analysis implied or mentioned
  - Contributions to theory, methodology, and practice
  - Number of disciplines represented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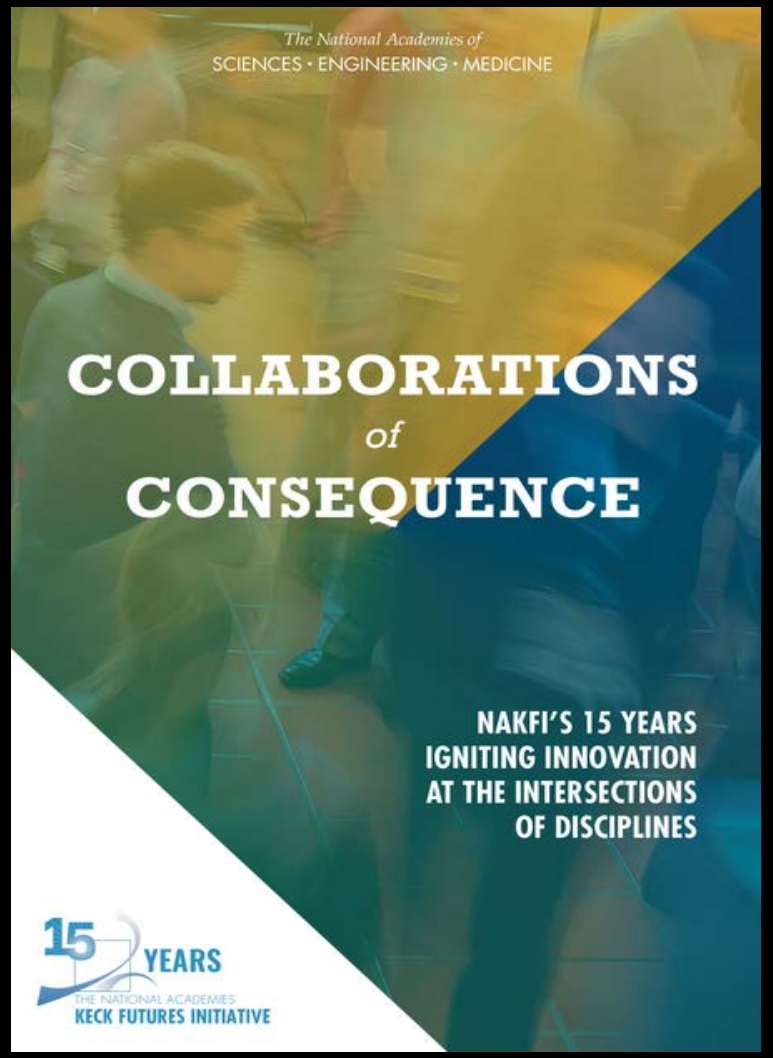

Hall et al,, 2008; Misra et al., 2009; Misra, Stokols, & Cheng, 2015; NAS, 2018

Linkages of TDO to scholarly products

- Researchers reporting *higher levels of TDO* produced *scientific papers* that were rated to be significantly *more interdisciplinary* by independent raters.

- Participants who reported *more experience in participating in cross-disciplinary team science* ventures also reported significantly *higher level of TDO*.

- *Higher self-reported level of TDO* was significantly and positively correlated with independent ratings of the *potential societal impact* of the research reported in the scholar's article.

Misra, Stokols, & Cheng, 2015

Case discussion 2: It's not working

- Drs. Spark and Rey had just completed a manuscript and submitted it for publication. Paper writing had gone pretty smoothly with each of them writing their respective sections based on the work they performed and merging the content. They were quite enthusiastic about the results they combined from similar sample sets and decided they should continue working together. They set up a meeting and asked Drs. Tan and Gagnon to join them. As they started developing ideas and performing initial experiments over the following months, the group members seemed more focused on their individual efforts as opposed to that of the group. In addition, Dr. Tan was not performing the promised experiments, instead making excuses about other priorities. As commitment continued to wane, other group members also found it difficult to find time to complete their assignments. Soon, Dr. Tan stopped attending meetings all together. Dr. Gagnon followed suit. Data generated were either left unpublished or found their way into their individual publications.

Bennett, Gadlin, & Marchand, 2018

Case discussion 3: It's not working

Dr. Salazar and Dr. Buchanan, two scientists from different institutions, were involved in a long- term collaboration. The two PIs did not develop a partnership agreement in advance and there were no explicitly agreed-upon guidelines for determining authorship. Dr. Salazar published a paper in a high-visibility journal using data that had been generated by postdocs in her laboratory as well as by postdocs in Dr. Buchanan's laboratory. Although Dr. Salazar acknowledged Dr. Buchanan's lab's contribution in the paper, none of the researchers from that laboratory were included as authors. Dr. Buchanan disagreed with the way the data from her laboratory were presented in the published paper and asked her to retract it. When Dr. Salazar failed to address the concerns raised, Dr. Buchanan contacted senior-level scientists in Dr. Salazar's organization to air her complaints. These leaders initiated a formal investigation into the charges. By this time, the two investigators no longer trusted one another and their collaboration came to a halt.

Bennett, Gadlin, & Marchand, 2018

Setting Expectations

- Setting Expectations
  - Roles, responsibilities, and contributions to team's goals
  - Expectations for working together
  - Discussing team goals openly
  - Be prepared for disagreements and conflicts in the early stages of team formation
  - Agree on processes for sharing data, establishing and sharing credit, managing authorship
- Tools for setting expectations
  - Collaboration plan
  - Collaboration agreement
  - Welcome letter
  - Institutional agreements

Trust and Psychological Safety

- Calculus–based trust – built on calculations of the relative rewards for trusting or losses for not trusting
- Identity–based trust – built on an assumption of perceived compatibility of values, common goals, emotional/intellectual connection
- Competence–based trust – built on the confidence in people's skills and abilities, allowing them to make decisions and train others
- Swift Trust – built on giving all team members the benefit of the doubt that their intentions are good with clear goals and limited time

Psychological Safety

- **Psychological safety** is a **shared perception** among team members indicative of an interpersonal climate that **supports risk taking and learning** (Edmondson, 1999).

Discussion Question: How can you foster trust and psychological safety in your team?

Key Takeaways

- Devote considerable time to *team composition*
- Set team expectations (e.g., collaboration plan)
- Engage processes to foster trust and psychological safety
- Consider your own *transdisciplinary orientation* and *collaborative readiness*
- Consider training or specific *interventions aimed to promote team effectiveness*
- Consider including *convergence research / SciTS expertise* in your team
  - Team structure to facilitate cross-pollination of ideas
  - Clarify integration challenges
  - Design interventions aimed at promoting team cohesion, team climate, shared team mental models, sense making
  - Communication norms and strategies

References available at

Don’t miss ISCE Team Science Workshops 2 and 3

- Workshop 2: Leading Cross-disciplinary Research Teams (Friday, January 12, 2023 from 10:00 to 11:30 am via Zoom
- Workshop 3: Managing Difference and Conflict in Cross-disciplinary Research Teams (Friday, April 12, 2023 from 10:00 - 11:30 a.m. via Zoom)