Understanding Team Effectiveness for Scientific Teams

Stephen M. Fiore, Ph.D.
University of Central Florida
Cognitive Sciences, Department of Philosophy and
Institute for Simulation & Training

Fiore, S. M. (2021). Understanding Team Effectiveness for Scientific Teams. Invited Presentation, NASEM Committee on Increasing Diversity and Inclusion in the Leadership of Competed Space Missions. National Academies, Washington, DC, USA (Virtual), April 27, 2021.

Overview

Part I. Team Science Challenge 1

- Why Team Science?

Part II. Team Science Challenge 2

- Understanding the Science of Team Science

Part II. Team Science Challenge 2

- Understanding Teamwork in "Team Science"

The National Academies of
SCIENCES • ENGINEERING • MEDICINE
Advising the Nation

Part I. Team Science Challenge 1
Why Team Science

Team Science Challenge 1 - *Understand why we have to take team science seriously*

ISSUE - *Dealing with Scholarly Structure*

- Disciplines are distinguished partly for historical reasons and reasons of administrative convenience (such as the organization of teaching and of appointments)… But all this classification and distinction is a comparatively unimportant and superficial affair. **We are not students of some subject matter but students of problems. And problems may cut across the borders of any subject matter or discipline** (Popper, 1963).

ISSUE - *Dealing with Siloed Structures*

- What is critical to realize is that "the way in which [organizations] have divided up the sciences does not reflect the way in which nature has divided up its problems" (Salzinger, 2003, p. 3)

Popper, K. (1963). *Conjectures and Refutations: The Growth of Scientific Knowledge.* London: Routledge.

Salzinger, K. (2003). Moving Graveyards. *Psychological Science Agenda, Summer, 3.* Washington, DC: American Psychological Association.

Part I. Team Science Challenge 1
Why Team Science

ISSUE - Collaborations influencing the **practice of science** and **production of knowledge**. *To achieve success in scientific collaboration we must surmount these challenges.*

Highlights from evaluation of >19M published papers and > 2M patents:

- research is increasingly done by teams
- high impact research is performed by teams (citation index data)
- shift toward "collective research" is evident
- team size is steadily growing over time

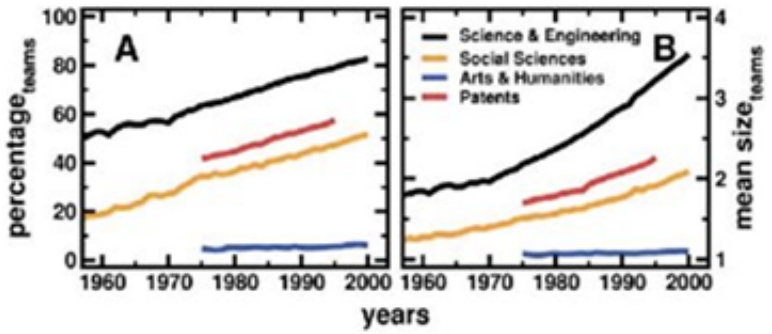


Fig. 1. The growth of teams. These plots present changes over time in the fraction of papers and patents written in teams (**A**) and in mean team size (**B**). Each line represents the arithmetic average taken over all subfields in each year.

Wuchty, S., Jones, B.F., & Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science, 316*, 1036-1039.

Part I. Team Science Challenge 1
Why Team Science

UCF Cognitive Sciences

We are Overcoming Challenges

1. Increased **emphasis on collaborative research** projects that create a team of scholars cutting across disciplines to address complex phenomena
2. **Policy, Academia, and Industry** communities all making more of a concerted effort to understand and improve collaborations
3. Tremendous **growth** in study and understanding of teams

- ***Social Sciences and the study of teamwork***
  - Matured into its own area of inquiry producing a rich base of knowledge
  - Helped us to better understand the complex coordinative processes engaged by teams

SciTS MESSAGE 1: ***Scientific study of teamwork could be true catalyst for change***

Society for Industrial and Organizational Psychology

NCA National Communication Association

INGROUP interdisciplinary network for group research

International Association for Conflict Management IACM

CSCW ACM Conference on Computer-Supported Cooperative Work and Social Computing

Academy of Management

Overview

Part I. Team Science Challenge 1

- Why Team Science?

Part II. Team Science Challenge 2

- Understanding the Science of Team Science

Part II. Team Science Challenge 2

- Understanding Teamwork in "Team Science"

The National Academies of
SCIENCES • ENGINEERING • MEDICINE
Advising the Nation

Part II. Team Science Challenge 2
Understanding Science of Team Science

UCF Cognitive Sciences

Team Science Challenge 2 – *Understand what is the Science of Team Science*

- What do we mean by teams
  - Multiple information sources and intensive communication
  - Task-relevant knowledge with meaningful task interdependencies
  - Affective and attitudinal factors influence group dynamics
  - Coordination among members with specialized roles

- Reframing interdisciplinarity as a process of teamwork to be mastered (Fiore, 2008)
  - Allows us to leverage science of teams
  - Changes question to understanding team activities necessary for science
  - Makes the achievement and measurement of interdisciplinarity more tractable

Fiore, S. M. (2008). Interdisciplinarity as teamwork: How the science of teams can inform team science. *Small Group Research, 39(3),* 251-277.

Part II. Team Science Challenge 2
Understanding Science of Team Science

UCF Cognitive Sciences

A New Field - *Science of Team Science*

- Commitment to **develop scholarly examination of teamwork in science**
  - Goal to understand and improve how scholars interact and integrate across disciplinary, professional, and institutional boundaries

"the inherent complexity of contemporary public health, environmental, political, and policy challenges… [leads to] realization that an integration of multiple disciplinary perspectives is required to better understand and ameliorate these problems" (Stokols et al., 2008).

- Must understand how to make full use of the **scientific capacity** of science teams (Salazar et al., 2012)

Salazar, M. R., Lant, T. K., Fiore, S. M., & Salas, E. (2012). Facilitating innovation in diverse science teams through integrative capacity. *Small Group Research, 43(5),* 527-558.

Stokols, D., Misra, S., Moser, R. P., Hall, K. L., & Taylor, B. K. (2008). The ecology of team science - Understanding contextual influences on transdisciplinary collaboration. *American Journal of Preventive Medicine, 35(2),* S96-S115.

Part II. Team Science Challenge 2
Understanding Science of Team Science

UCF Cognitive Sciences

National Academies of Science Consensus Study

- **Rationale:** Clear need to **provide research-based guidance** to improve the processes and outcomes of team science
- **Goal: Enhance effectiveness** of collaborative research in science teams, research center, and institutes.
- **Audiences: Public and private research funders** and **scientific community**.

Enhancing the Effectiveness of Team Science (2015) --
http://www.nap.edu/catalog/19007/enhancing-the-effectiveness-of-team-science

Part II. Team Science Challenge 2
Understanding Science of Team Science

UCF Cognitive Sciences

Report on *Enhancing the Effectiveness of Team Science*

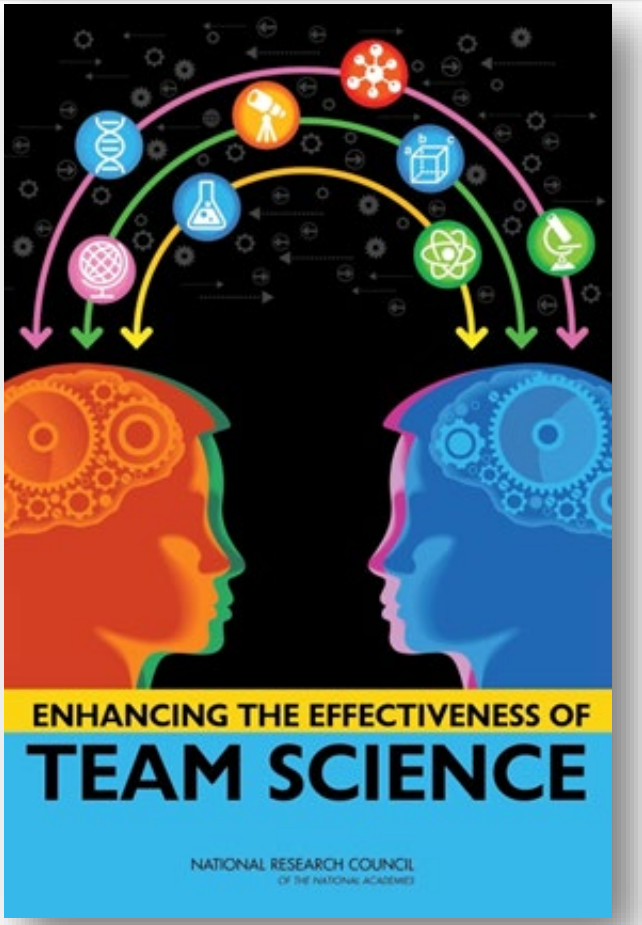
Key Features	Ranges Possible in Team Science	
Size	Small (2)	Mega (1000s)
Task Interdependence	Low	High
Boundaries	Stable	Fluid
Goal Alignment	Aligned	Divergent or Misaligned
Integration	Unidisciplinary	Transdisciplinary
Diversity	Homogeneous	Heterogeneous
Proximity	Co-located	Globally Distributed

Part II. Team Science Challenge 2
Understanding Science of Team Science

UCF Cognitive Sciences

Addressing Team Science Challenge 2

- Evidence base building for guidance on:
  - Assembling teams
  - Group dynamics in teams
  - Supporting leadership development opportunities
  - Virtual collaborations
  - Study and measurement of science teams
  - Promotion & Tenure in science teams
  - Credit for team-based work



Part II. Team Science Challenge 2
Understanding Science of Team Science

- International Network for Science of Team Science (INSciTS)
  - New scholarly society to support understanding and improving scientific collaboration (https://www.inscits.org)
- Annual Science of Team Science (SciTS) Conference
  - A forum to enhance our understanding of how best to engage in team science to meet society's needs

SciTS MESSAGE 2: *Understand that there is a rich and robust scholarly literature on team performance that can improve team science effectiveness*

Overview

Part I. Team Science Challenge 1

- Why Team Science?

Part II. Team Science Challenge 2

- Understanding the Science of Team Science

Part II. Team Science Challenge 2

- Understanding Teamwork in "Team Science"

The National Academies of
SCIENCES • ENGINEERING • MEDICINE
Advising the Nation

Part III. Team Science Challenge 3
Understanding Teamwork "in" Team Science

Team Science Challenge 3 – *Understand that science teams engage in both taskwork and teamwork* (Fiore et al., 2015; Fiore, 2008) – that have associated knowledge, skills, and attitudes…

- **TASKwork** refers to what needs to be accomplished to meet goals and complete objectives - this is the scientific "work" of science teams
  - Attitudes about particulars of a project - Preferences for methodological approaches, trust in certain technologies
  - Behaviors (skills) supporting execution of a project - Developing and running experiments and analyzing and writing findings
  - Cognition (knowledge) necessary for a project - Understanding the relevant theories and constructs
- **TEAMwork** refers to the attitudinal, behavioral, and cognitive factors required to function effectively as part of an interdependent team
  - Attitudinal – Attitudes and/or affect arising from working with teammates (trust)
  - Behavioral – Skills supporting interacting with teammates (communication)
  - Cognitive - Knowledge associated with teammates (roles, responsibilities)

Fiore, S. M. (2008). Interdisciplinarity as Teamwork: How the Science of Teams can inform Team Science. *Small Group Research, 39(3),* 251-277.
Fiore, S.M., Carter, D.R., & Asencio, R. (2015). Conflict, Trust, and Cohesion: Examining Affective and Attitudinal Factors in Science Teams. In E. Salas, W.B. Vessey, & A.X. Estrada (Eds.), *Team Cohesion: Advances in Psychological Theory, Methods and Practice* (pp. 271-301). Emerald Group Publishing Limited.

Part III. Team Science Challenge 3
Understanding Teamwork "in" Team Science

Report Identified Competencies Deficit - From students to professionals (faculty and practicing scientists), do not see development of TEAM competencies for collaboration

Team Competencies

- **TEAM GENERIC** competencies are those **necessary regardless of the context** or the setting
- **TEAM SPECIFIC** competencies are more **directly related to teams** and include knowledge of the abilities held by team members

Task Competencies

- **TASK GENERIC** competencies are those **necessary across task** situations
- **TASK SPECIFIC** competencies **important within particular task**

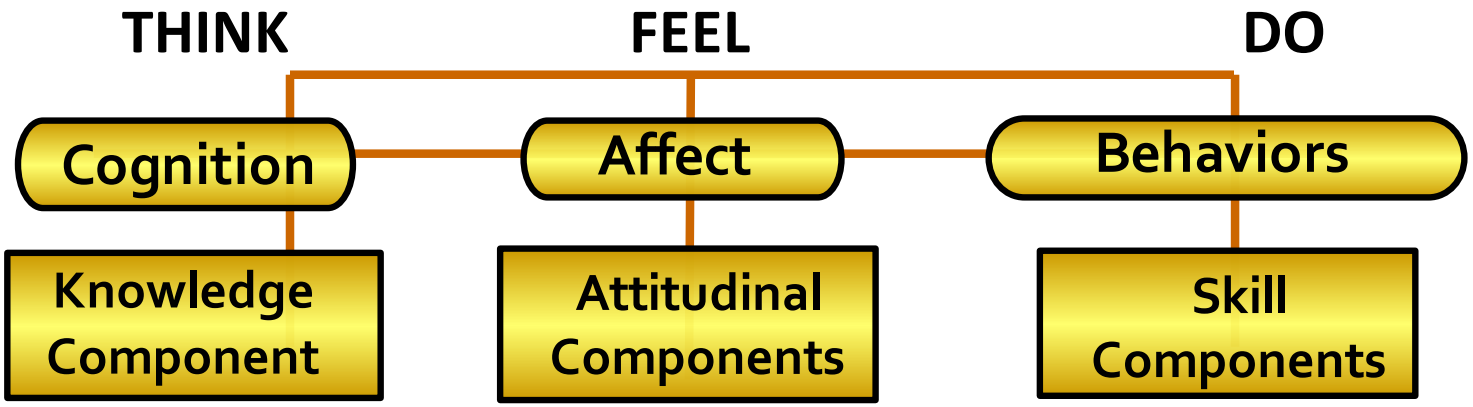
Part III. Team Science Challenge 3
Understanding Teamwork "in" Team Science

		Relation to TASK	
		Specific	**Generic**
Relation to TEAM	**Specific**	***CONTEXT DRIVEN*** • Knowledge – *Team objectives and resources* • Skills – *Particular analyses* • Attitudes - *Collective efficacy*	***TEAM CONTINGENT*** • Knowledge – *Teammate characteristics* • Skills – *Providing teammate guidance* • Attitudes – *Team cohesion*
	Generic	***TASK CONTINGENT*** • Knowledge – *Procedures for task accomplishment* • Skills – *Problem analysis* • Attitudes – *Trust in technology*	***TRANSPORTABLE*** • Knowledge – *Understanding group dynamics* • Skills – *Communication and assertiveness* • Attitudes – *Interdisciplinary appreciation*

Fiore, S. M., *Gabelica, C., *Wiltshire, T., & Stokols, D. (2019). Training to Be a (Team) Scientist. In K. L. Hall, A. L. Vogel, & R. T. Croyle (Eds.), *Strategies for Team Science Success: Handbook of Evidence-Based Principles for Cross-Disciplinary Science and Practical Lessons Learned from Health Researchers* (pp. 421–444). Basel, Switzerland: Springer International Publishing.

Part III. Team Science Challenge 3
Understanding Teamwork "in" Team Science

(Some of the) Components of Successful Teamwork in Science



- Transactive Memory (knowing who knows what)
- Shared Mental Models
- Metacognition

- Psychological Safety (trust in each other)
- Cohesion
- Collective Efficacy

- Communication (super tuning)
- Sharing Leadership
- Performance Monitoring

Fiore, S.M., *Gabelica, C., *Wiltshire, T., & Stokols, D. (2019). Training to Be a (Team) Scientist. In K. Hall, R. Croyle, & A. Vogel (Eds.), *Handbook of Interdisciplinary Team-based Behavioral Research: New Evidence and Perspectives.* Basel, Switzerland: Springer International Publishing.

Part III. Team Science Challenge 3
Understanding Teamwork "in" Team Science

Think about a meeting where no one voiced their opinions…, a meeting without debate… a meeting where attendees were afraid to present alternative viewpoints – **This is A BAD MODEL for science**

- Good science teams **bounce ideas off each other**
- Good science teams **discuss and debate**
- Good science teams **help solve** issues

Attitudes for Team Science Success - *Psychological Safety*

- Belief that one will **not be punished or humiliated** for speaking up with ideas, questions, concerns or mistakes."
  - Teams making more **mistakes** actually **more successful**
  - Create environment in which people feel **comfortable to take risks**
  - Key to fostering innovative workplaces
- Google Study
  - Massive two-year study on team performance
  - Revealed that highest-performing teams have one thing in common: psychological safety
  - ***Allows for moderate risk-taking, speaking your mind, creativity, and sticking your neck out without fear of having it cut off — just the types of behavior that lead to market breakthroughs***

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly, 44(2),* 350-383.
Graham, J. (2016). What Google Learned From Its Quest to Build the Perfect Team. *New York Times.*
https://www.nytimes.com/2016/02/28/magazine/what-google-learned-from-its-quest-to-build-the-perfect-team.html

Part III. Team Science Challenge 3
Understanding Teamwork "in" Team Science

Behaviors for Team Science Success - Communication Competencies (Fiore et al., 2019)	
Active Listening	· Carefully attending to what is said · Asking other party to explain exactly what is meant · Requesting that ambiguous ideas or statements are repeated
	Competency targets "listening to learn and understand" and "listening to contribute and integrate to problem solving"
Super Tuning	· Tailoring message for the receiver · Drawing on understanding of audience level and form of knowledge · Construct and convey message in appropriate ways
	Competency targets the ability to "express yourself clearly to others outside one's discipline" (e.g., avoiding jargon) and "effectively conveying intended meaning of other disciplinary perspectives"
Assertive Communication	· Directly expressing one's ideas and opinions · Addressing conflict purposely and openly · Addressing differences without intimidation
	Competency targets the ability to "propose ideas", to "defend one's disciplinary values/methods" and to "be directive and appropriately assert your needs and views"

Fiore, S.M., Gabelica, C., Wiltshire, T., & Stokols, D. (2019). Training to Be a (Team) Scientist. In K. Hall, R. Croyle, & A. Vogel (Eds.), *Handbook of Interdisciplinary Team-based Behavioral Research: New Evidence and Perspectives*. Basel, Switzerland: Springer International Publishing.

Part III. Team Science Challenge 3
Understanding Teamwork "in" Team Science

UCF Cognitive Sciences

Cognition for Team Science Success – Transactive Memory Systems

- Memory structures related to teamwork in which members do not store all the knowledge relevant to their work (Lewis, 2003)
  - Team members store knowledge consisting of who knows what
  - *Team-related knowledge related to one's understanding of a teammate's capabilities and expertise*

- Utilizes expertise specialization and coordination
  - Groups specialize in different aspects of task
  - Groups delegate responsibility to coordinate their work efficiently based on knowledge of who knows what

SciTS MESSAGE 3: ***Focusing on attitudinal, behavioral, and cognitive components of group dynamics can improve team science.***

Lewis, K. (2003). Measuring transactive memory systems in the field: scale development and validation. *Journal of Applied Psychology, 88(4),* 587-604.

Summary

Part I. Team Science Challenge 1 - Why Team Science?

- Team Science MESSAGE 1: *Scientific study of teamwork could be true catalyst for change*

Part II. Team Science Challenge 2 - Understanding the Science of Team Science

- Team Science MESSAGE 2: *Understand that there is a rich and robust scholarly literature on team performance that can improve team science effectiveness*

Part III. Team Science Challenge 3- Understanding Teamwork in "Team Science"

- Team Science MESSAGE 3: *Focusing on attitudinal, behavioral, and cognitive components of group dynamics can improve team science.*

The National Academies of

SCIENCES • ENGINEERING • MEDICINE

Advising the Nation

Thank You!

Questions or Comments?

Stephen M. Fiore, Ph.D.
University of Central Florida
Cognitive Sciences, Department of Philosophy and
Institute for Simulation & Training
sfiore@ist.ucf.edu

Some Findings on Gender and Team Science

- More than 20% of the studies highlighted findings related to gender in science teams.
  - The overarching finding on impact was that gender diversity in science teams can lead to better outcomes.
  - Studies found that publications by mixed-gender teams receive more citations (Campbell, Mehtani, Dozier, & Rinehart, 2013), and grant proposals that include at least one female collaborator are more likely to be funded (Lungeanu et al. 2014).

- Influence of female leadership on citation impact remains equivocal (Barjak & Robinson, 2008; Jeong & Choi, 2015)
  - Gender composition of teams not associated with productivity (Lungeanu et al., 2015; Stvilia et al., 2011).
  - Women engage in more collaborations than men (Abramo et al., 2013; Bozeman & Gaughan, 2011; Zeng et al., 2016), particularly outside their own disciplines (Abramo et al., 2013; Lungeanu et al., 2014; van Rijnsoever & Hessels, 2011).

- Yet patterns of collaboration vary by gender.
  - Women less likely to collaborate with international/industry partners (Abramo et al., 2013; Gaughan & Corley, 2010).

- Empirical literature on gender in science is circumscribed by the fact that many areas of research, and many scientific teams, include few, if any, women (e.g., Kegen, 2013; Stvilia et al., 2011).
  - Presents challenges for interpreting the impact of gender on collaboration patterns and outcomes (Benenson, Markovits, & Wrangham, 2014; Zeng et al., 2016).
  - Recognition and utilization of scientific expertise not simply contingent on gender of scientists but also influenced by gender of those assessing expertise, as well as female faculty representation in the discipline(s) in which the teams are operating (Joshi, 2014).

Hall, K. L., Vogel, A. L., Huang, G. C., Serrano, K. J., Rice, E. L., Tsakraklides, S. P., & Fiore, S. M. (2018). The science of team science: A review of the empirical evidence and research gaps on collaboration in science. *American Psychologist, 73(4),* 532-548.

Diversity and Integrative Capacity in Science Teams

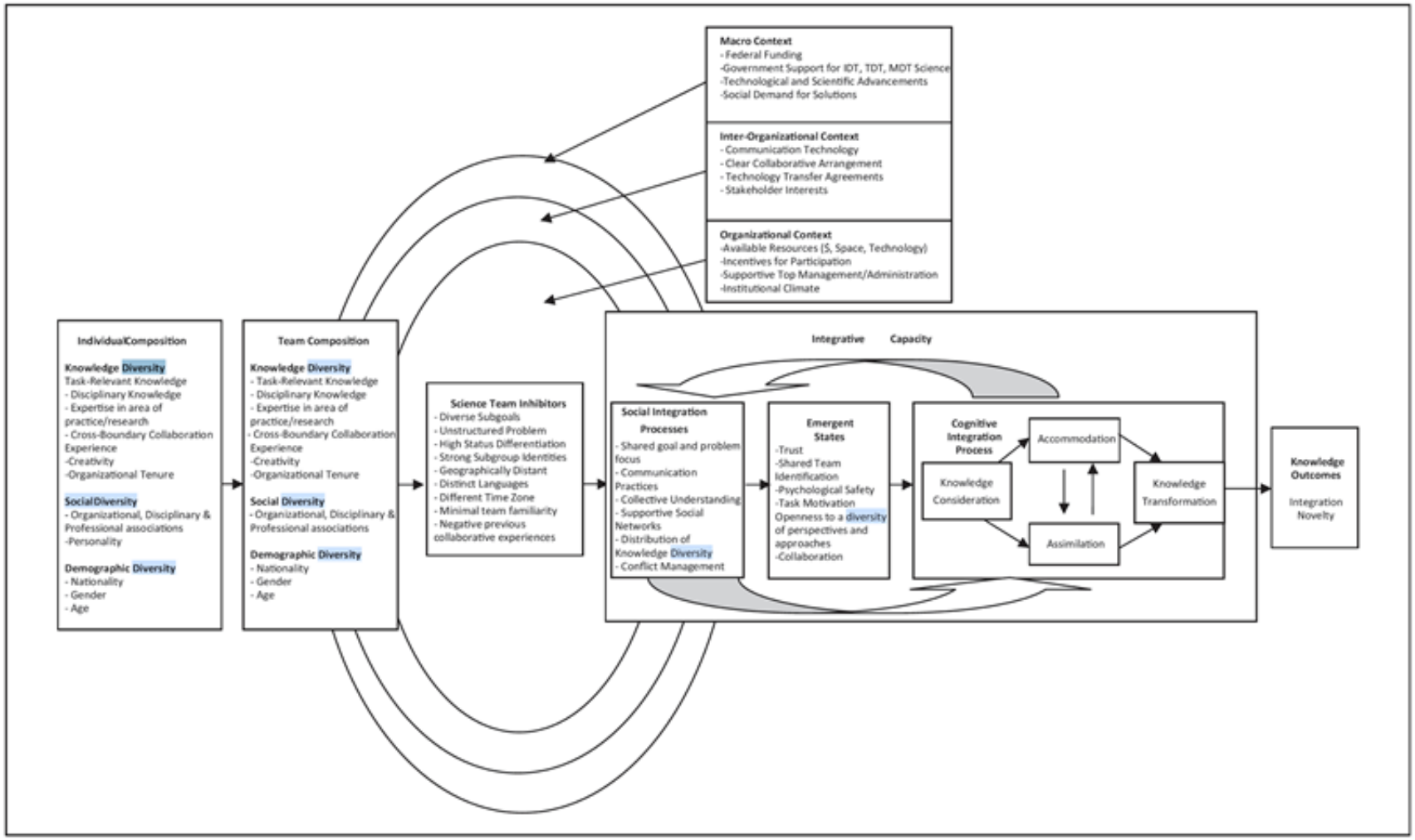


Figure 2. An ecological perspective on integrative capacity

Salazar, M. R., Lant, T. K., Fiore, S. M., & Salas, E. (2012). Facilitating innovation in diverse science teams through integrative capacity. *Small Group Research, 43(5)*, 527-558.