Enhancing the Effectiveness of Team Science

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Team Science Webinar Series
UMass Center for Clinical and Translational Science
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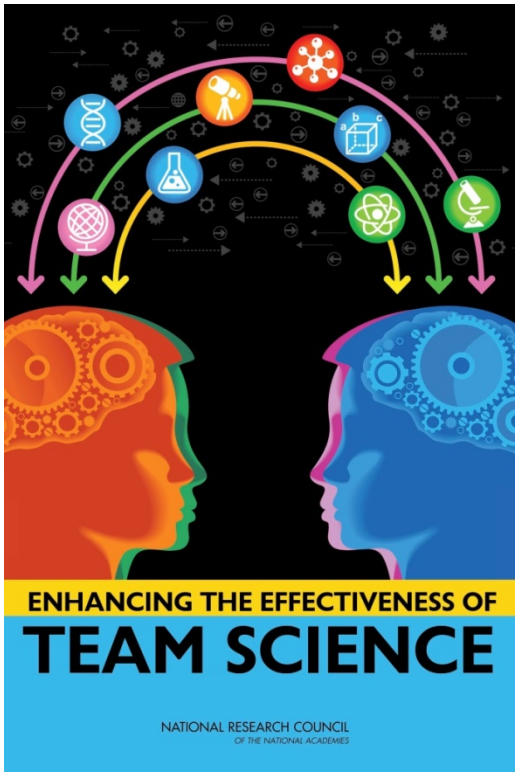

(National Research Council, 2015)

Study sponsored by the National Science Foundation and Elsevier

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Study Background

- **Rationale:** Clear need to provide research-based guidance to improve the processes and outcomes of team science
- **Sponsors:** NSF, Computer and Information Systems and Engineering Directorate, and Elsevier
- **Goal:** Enhance the effectiveness of collaborative research in science teams, research centers, and institutes.
- **Audiences:** NSF and other public and private research funders; the scientific community; the SciTS community; universities; research centers and institutes.

Committee Charge

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… Explore:

- How **individual factors** influence team dynamics, effectiveness and productivity
- Factors at **team/center/institute** level influencing effectiveness
- Different **management approaches and leadership styles** that influence effectiveness
- How **tenure and promotion policies** acknowledge academic researchers who join teams
- **Organizational** factors that influence effectiveness of science teams (e.g., human resource policies, cyber infrastructure)
- **Organizational structures, policies and practices** to promote effective teams

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Committee on the Science of Team Science

- **NANCY J. COOKE (Chair),** Arizona State University
- **ROGER D. BLANDFORD (NAS),** Stanford University
- **JONATHON N. CUMMINGS,** Duke University
- **STEPHEN M. FIORE,** University of Central Florida
- **KARA L. HALL,** National Cancer Institute
- **JAMES S. JACKSON (IOM),** University of Michigan
- **JOHN L. KING,** University of Michigan
- **STEVEN W. J. KOZLOWSKI,** Michigan State University
- **JUDITH S. OLSON,** University of California, Irvine
- **JEREMY A. SABLOFF (NAS),** Santa Fe Institute
- **DANIEL S. STOKOLS,** University of California, Irvine
- **BRIAN UZZI,** Northwestern University
- **HANNAH VALANTINE,** National Institutes of Health

- **MARGARET L. HILTON,** *Study Director*
- **TINA WINTERS,** *Associate Program Officer*

Why Team Science?

- Solving complex modern problems requires a team
- Team Science has been shown to
  - Have large **impact** (Wuchty, et al., 2007; Uzzi, et al., 2013)
  - Demonstrate high levels of **innovation** (Uzzi, 2013)
  - Increase **productivity** (Hall, et al., 2012)
  - Have a **broad reach/uptake** (Stipelman, et al, 2014)

However…

- Not all science requires a team
- Team science is difficult

Defining Key Terms

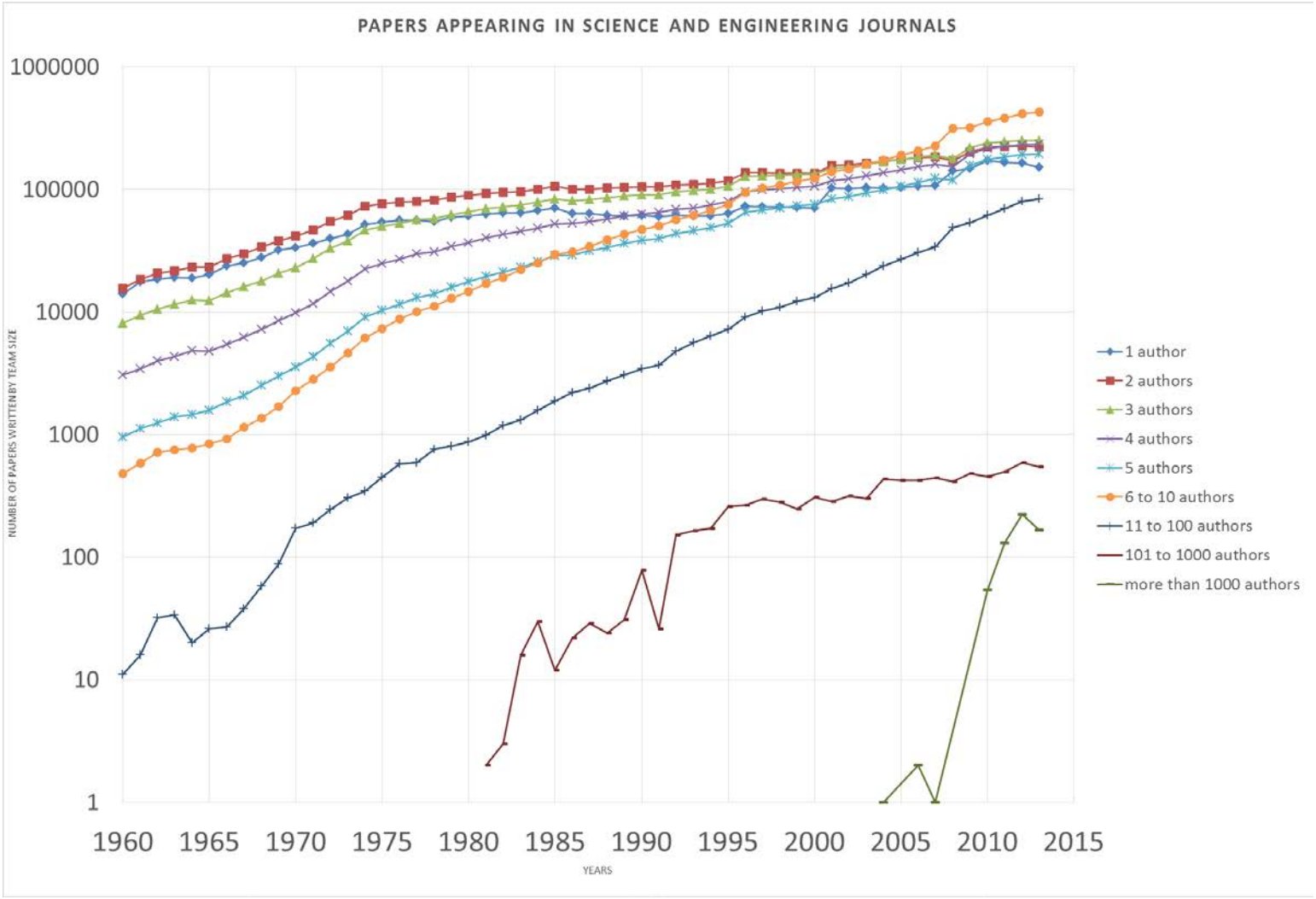
- ***Team science*** – collaborative, interdependent research by more than one individual
- ***Science team*** - Two to 10 individuals who conduct team science
- ***Larger group*** - More than 10 individuals who conduct team science
- ***Team effectiveness*** – A team's capacity to achieve its goals and objectives

Science Teams (2 to 10)

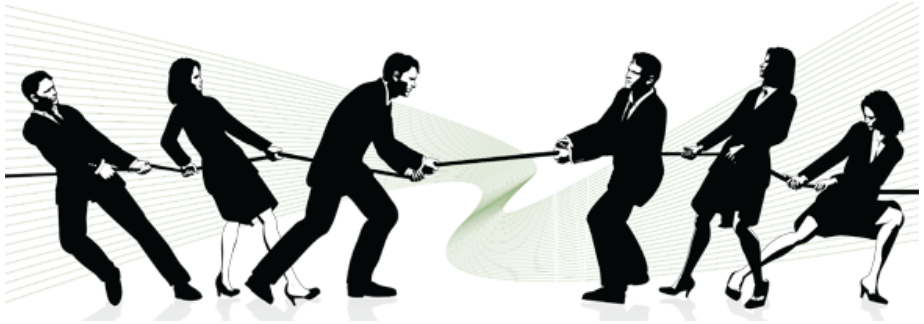
95 percent of all shared publications

Larger Groups (over 10)

5% of publications by 11-100 and <1% by 100+


PAPERS APPEARING IN SCIENCE AND ENGINEERING JOURNALS
NUMBER OF PAPERS WRITTEN BY TEAM SIZE
1000000
100000
10000
1000
100
10
1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
YEARS
1 author
2 authors
3 authors
4 authors
5 authors
6 to 10 authors
11 to 100 authors
101 to 1000 authors
more than 1000 authors

Key Features that Create Challenges for Team Science



- Large membership diversity
- Deep knowledge integration
- Sometimes large size
- Goal misalignment with other teams
- Permeable boundaries
- Geographic dispersion
- High task interdependence

Improving Team Effectiveness

Conclusion: *Strong body of research conducted over decades demonstrates* ***team processes related to team effectiveness****. Interventions that foster positive team processes offer most* ***promising route to enhance team effectiveness****.*

Interventions in 3 Areas:

- **Team Composition**
- **Team Development**
- **Team Leadership**

Team Effectiveness

Composing the Team

- ***Conclusion:*** *Research in non-science contexts has found that team composition influences team effectiveness, and this relationship depends on the complexity of the task, the degree of interdependence among team members, and how long the team is together.* ***Task-relevant diversity is critical*** *and has a positive influence on team effectiveness.*

- ***Conclusion: Task analytic methods*** *developed in non-science contexts and research networking tools developed in science contexts allow practitioners to consider team composition systematically.*

Recommendation 1

Team science leaders and others involved in assembling science teams and larger groups should:

- **Consider using task analytic methods** and tools that help identify the knowledge, skills, and attitudes required effective performance of the project so that task-related diversity among team or group members can best match project needs
- Consider **applying tools such as research networking systems** designed to facilitate assembly of science teams
- Partner with researchers to **evaluate and refine these tools and task analytic methods**

Team Professional Development

Conclusion: *Research in contexts outside of science has demonstrated that several types of* ***team professional development interventions improve*** *team processes and outcomes.*

Team Professional Development

Composition → Team Building → Team Training

Increased Effectiveness →

Team Training Examples

- Cross Training
- Reflexivity training
- Knowledge Development
- Team Coordination Training

Knowledge Development Example

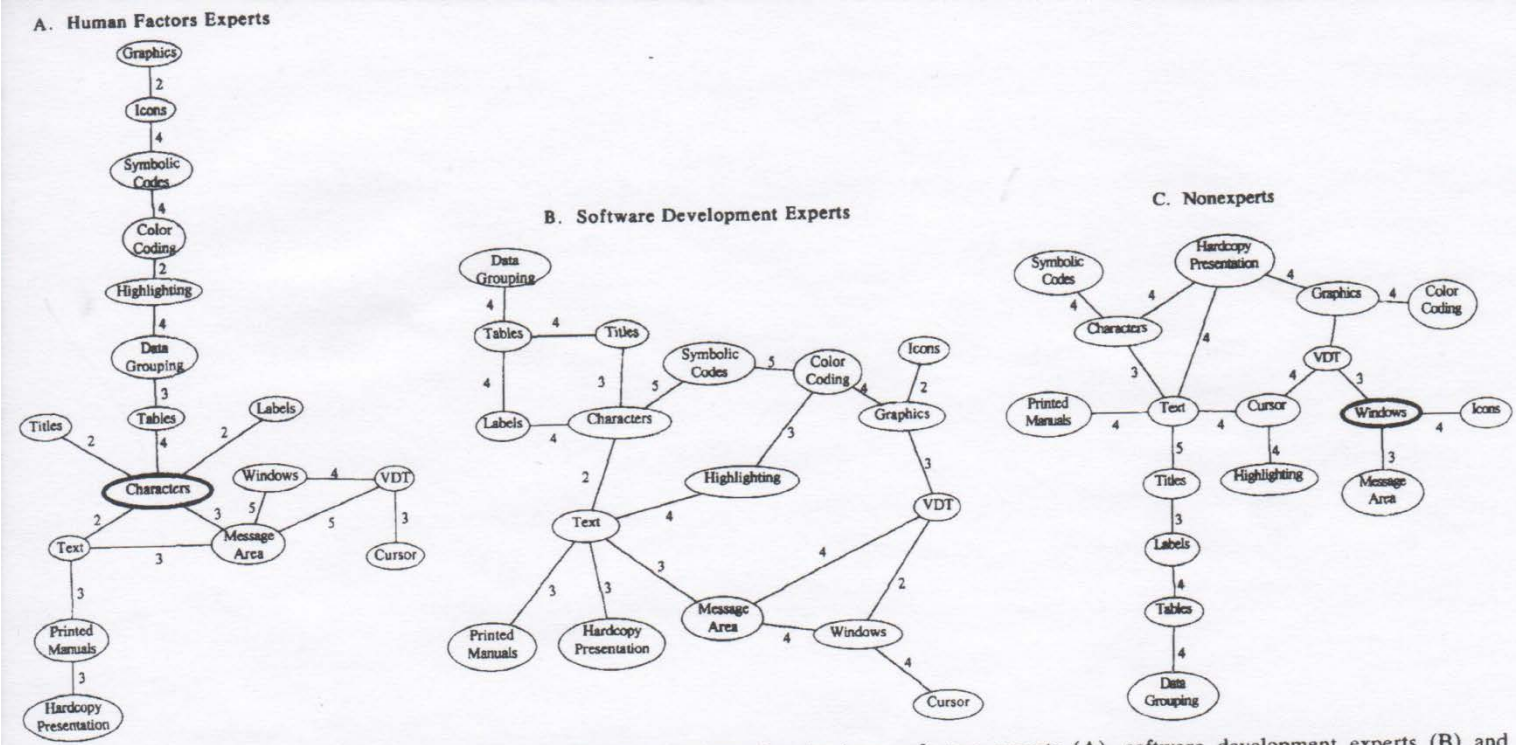


FIGURE 6. Pathfinder networks of concepts related to display of information for human factors experts (A), software development experts (B) and non-experts (C). The number next to a line indicates the strength of the link between two nodes, with lower numbers indicating greater link weights. Central nodes are indicated by bold lines.

Gillan, D. J., Breedin, S. D., & Cooke, N. J. (1992). Network and multidimensional representations of the declarative knowledge of human-computer interface design experts. *International Journal of Man-Machine Studies, 36,* 587-615.

Team Professional Development Recommendation

Team-training researchers, universities, and science team leaders should **partner to translate, extend, and evaluate the promising training strategies**, shown to improve the effectiveness of teams in other contexts, to **create professional development opportunities for science teams**.

Educating Team Scientists

- ***Conclusion:*** *Colleges and universities are developing cross-disciplinary programs designed to prepare students for team science*
- ***Little empirical research*** *is available on the extent to which participants learn the targeted competencies.*
- *Research to date has not shown whether the acquisition of the targeted competencies contributes to team science effectiveness.*

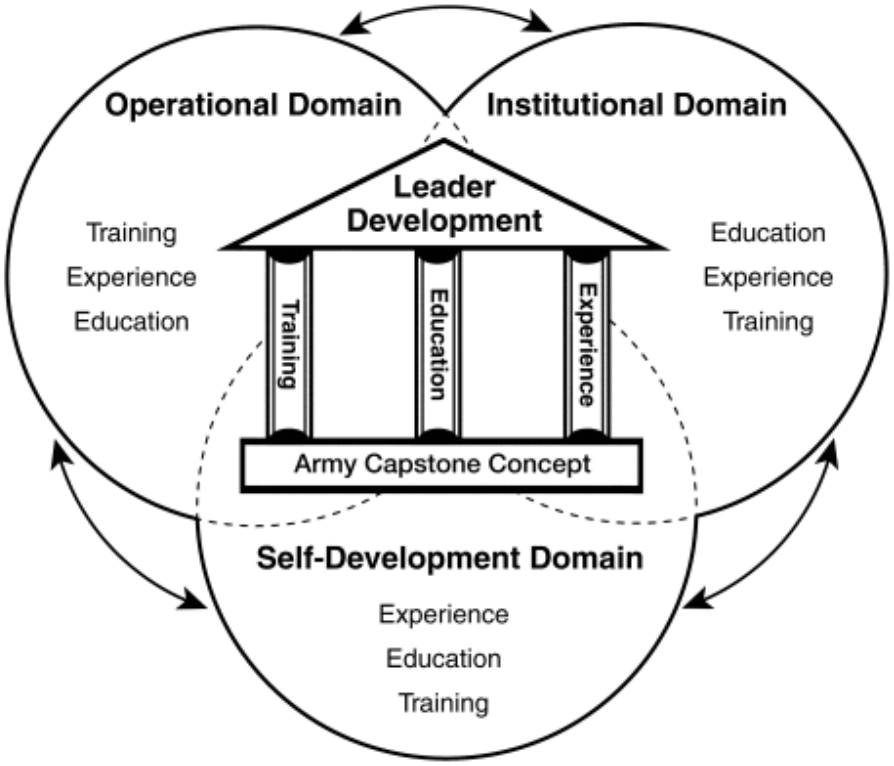
Leadership

Conclusion: *Fifty years of research on team and organizational leadership in contexts other than science provides* ***a robust foundation of evidence*** *to guide professional development for leaders of science teams and larger groups.*

Recommendation 3

Researchers, universities, and team science leaders should partner to **translate and extend the leadership literature** to create and evaluate science leadership development opportunities for team science leaders and funding agency program officers.

Example


Operational Domain
Institutional Domain
Leader Development
Training
Experience
Education
Education
Experience
Training
Training
Education
Experience
Army Capstone Concept
Self-Development Domain
Experience
Education
Training

The Challenges of Virtual Collaboration

- ***Conclusion***: *Research on geographically dispersed science teams and groups has found that* ***communicating and developing trust are more challenging*** *relative to face-to-face teams and groups.*
- *These* ***limitations of virtual collaboration may not be obvious*** *to members and leaders of the team or group.*

Recommendation 4

Leaders of geographically dispersed science teams should:

- Provide activities shown by research to help all participants develop **shared knowledge** (e.g., a common vocabulary and work style).
- Consider **assigning some tasks to semi-independent units** at each location to reduce the burden of constant electronic communication.

Virtual Collaboration and Technology Challenges

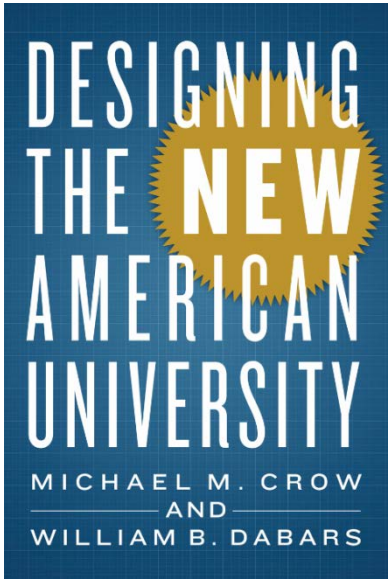
- ***Conclusion:*** *Technology for virtual collaboration often is* ***designed without a true understanding of users' needs and limitations***
- *Even when a suite of appropriate technologies is available,* ***users often do not recognize and use its full capabilities****.*
- *These related problems may impede effective collaboration.*

Recommendation 5

- When selecting collaboration technologies, leaders should **carefully evaluate project needs and participants' technology readiness.**
- Organizations should **promote human-centered collaboration technologies** and provide ongoing training and technology support.

Research Universities

Conclusion: *Universities have launched new efforts to promote interdisciplinary team science (e.g., creating research centers and institutes), but the* ***impact of these initiatives on the amount and quality of team science has not been systematically evaluated.***



Reward Structures of Research Universities

- ***Conclusion:*** *University promotion and tenure review policies typically* ***do not provide comprehensive, clearly articulated criteria for evaluating individual contributions to team-based research.***
- ***The extent to which researchers are rewarded for team-based research varies*** *widely across and within universities.*
- *Where team-based research is not rewarded,* ***young faculty may be discouraged*** *from joining those projects.*

Recommendation 6

Universities and disciplinary associations should proactively **develop and evaluate broad principles and more specific criteria for allocating credit for team-based work** to assist promotion and tenure committees in reviewing candidates.

Funding Agencies

Conclusion: *Public and private funders are in the position to* ***foster a culture*** *within the scientific community that supports those who want to undertake team science, not only* ***through funding, but also through white papers, training workshops****, and other approaches.*

Recommendation 7

Funders should work with the scientific community to:

- Encourage the development and implementation of **new collaborative models** (e.g., research networks, consortia)
- Develop **incentives for team science** (e.g., new P&T policies)
- Provide **resources** (e.g., information repositories, training modules).

Funding Agencies

- ***Conclusion: Funding agencies are inconsistent*** *in balancing their focus on scientific merit with consideration of how teams and larger groups are going to execute the work (collaborative merit).*
- *The Funding Opportunity Announcements they use to solicit team science proposals often include* ***vague language about the type of collaboration and the level of knowledge integration*** *they seek in proposed research.*

Recommendation 8

- Funders should require proposals for team-based research to **present collaboration plans** and provide guidance to scientists for the inclusion of these plans in their proposals, as well as guidance and criteria for reviewers' evaluation of these plans
- They should also require authors of proposals for interdisciplinary or transdisciplinary research projects to **specify how they will integrate disciplinary perspectives and methods** throughout the life of the research project.

Advancing the Research

- ***Conclusion: Targeted research is needed to evaluate and refine*** *the tools, interventions, and policies recommended in this report, along with more* ***basic research*** *on team science to guide continued improvement in the effectiveness of team science.*
- *Few if any funding programs support research on the effectiveness of science teams and larger groups.*

Research Challenges

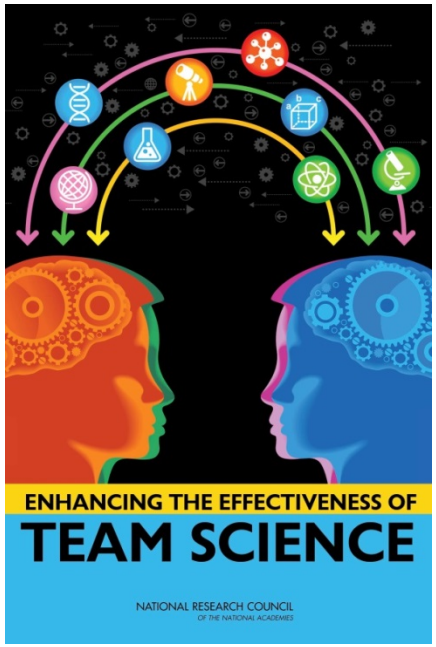
- Multiple goals of team science projects
- Multi-level perspective
- Dynamic individual, team, and organizational processes
- Relationship of processes to goals and outcomes

Recommendation 9

- Public and private funders should **support research on team science effectiveness** through funding.
- **Support ongoing evaluation and refinement of the interventions and policies** recommended above
- **Support research on the role of scientific organizations** (e.g., research centers, networks, consortia) in supporting science teams and larger groups.
- Collaborate with universities and the scientific community to **facilitate researchers' access to key team science personnel and data sets**.

Conclusions

- **There is a rich and robust science of teams that can be extended to improve team science effectiveness**
- The science points to interventions through:
  - Assembling teams
  - Providing professional development and education opportunities and
  - Leadership development opportunities
- Other interventions can improve:
  - Virtual collaboration
  - Promotion and tenure credit for team-based work
  - Support from funding agencies for team science



Report Available

http://www.nap.edu/catalog/19007/enhancing-the-effectiveness-of-team-science