Research Team Integration: What It Is and Why It Matters

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Collaboration in Science

- the working together of researchers to achieve the common goal of producing new scientific knowledge (Katz & Martin, 1997)

  - Modes of collaboration were transformed from "little science" to "big science" (de Solla Price, 1963)
  - "Modern" forms of collaboration include complex division of labor (Hagstrom, 1964)
  - Nobel laureates in science had more collaborators at all stages of career than non-laureates (Zuckerman, 1967)
  - "Invisible colleges" created through collaborations among core groups of faculty and students (Crane, 1972)

Shift in Science Towards Research Teams

- <u>Interdisciplinary</u> collaborations have become more prevalent (Metzger & Zare, 1999)

- <u>Multi-university</u> collaborations have become more prevalent (Corley, Boardman, & Bozeman, 2006)

- <u>Research teams</u> increasingly dominate the production of knowledge (Wuchty, Jones, & Uzzi, 2007)
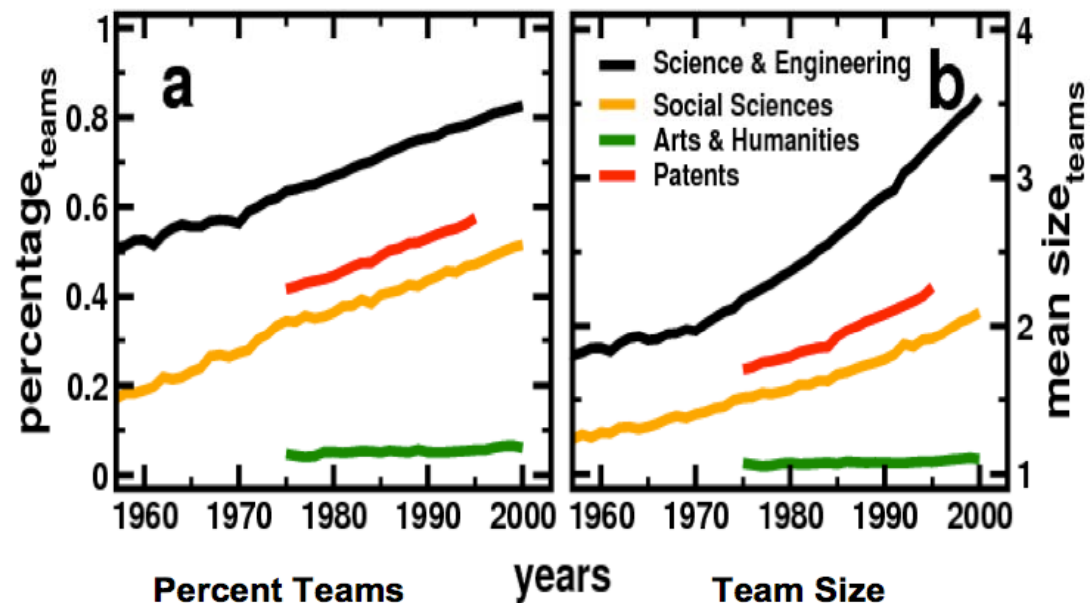
ITR Study of Research Teams

N=491 (out of 549) funded projects in the Information Technology Research (ITR) program at NSF

- Program grew from US $90M in 2000 to US $295M in 2004

- Typical project was funded 3-5 years ($500,000-$1M/year), had five Principal Investigators (PIs), represented two disciplines and two universities

- Interview/observation data gathered from 2-day PI meeting

- Surveys completed by 885 PIs (at least one per project, 68% response rate)

Primary Findings

- More universities in a project, on average, predicted fewer outcomes

    - Fewer knowledge outcomes (publications, patents)**
    - Fewer tools (software, hardware)^t
    - Fewer students trained & with jobs**
    - Less leverage for future research (new grants)^t

  **$p < .01$
  $^t p < .10$

- Coordination (division of responsibilities, knowledge transfer) accounted for the negative relationship between number of universities and outcomes

- Controls: Year started, R&D expenditures, Budget, Number of PIs, Number of Disciplines (*n.s.*)

Lack of Research Team Integration?

A.B.

University A

C.D.

E.F.

G.H.

University B

I.J.

University C
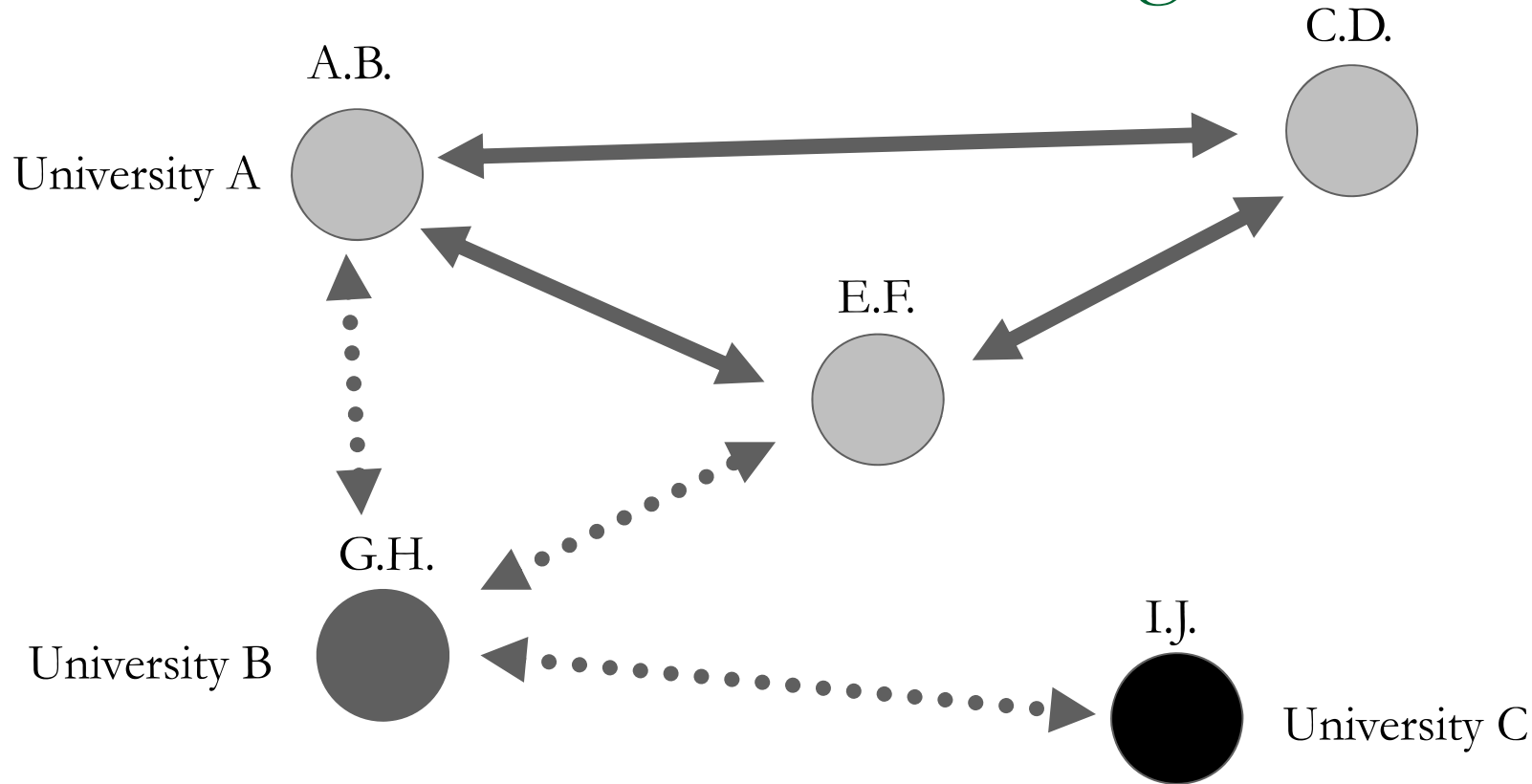
work together and publish together (32% of ITR pairs)

work together but do not publish together (39% of ITR pairs)

do not work together and do not publish together (29% of ITR pairs)

Research Team Integration

- Organization Theory Literature
  - Lawrence and Lorsch (1969)
    - "the process of achieving unity of effort among the various subsystems … of the organization's tasks" (p. 34)
  - Barki and Pinsonneault (2005)
    - "the extent to which distinct and interdependent organizational components constitute a unified whole" (p. 166)
- We define research team integration as the extent to which the team <u>combines its distinct expertise and work into a unified whole</u>.

Follow-Up Questions

- Since the goal of the ITR program was to support research integration across disciplines, to what extent did it occur?

- Are there different kinds of research team integration?

- What are some of the challenges to research team integration?

- What are some of the ways to support research team integration?

ITR Follow-Up Interview Study

Interviewed 55 researchers from 23 institutions and 52 research projects

- ❑ interview sample was drawn from ITR research teams at top 100 universities according to their R&D expenditures (70 percent of the sample in top 20%)

- ❑ stratified by geography (15 researchers from the Northeast, 13 from the South, 7 from the Midwest, and 20 from the West)

- ❑ half- to one-hour interviews that took interviewees through their projects (initiation, execution, and dissemination)

Talking about Research Team Integration

- "There was really not much, you know, cross-university research. After it was funded, you were able to do research independently." (Researcher #47)

- "We didn't ever really do as much on the bridging as we wanted." (Researcher #35)

- "Each of us had a sense of the requirements for what the other was going to be building and each of them was able to use what the other was doing as a test case of the fulfillment of the bigger vision." (Researcher #50)

Categorization Scheme / Content Coding

- ## Co-Acting Research Teams
  - individuals or small sub-groups worked and published separately, with no dependence on other sub-groups for their final outcomes. 50% of sample (N=26 teams)

- ## Administratively-Integrated Research Teams
  - integrated their administrative and support capabilities (e.g., common goals, project director, shared program committee) but did not work closely together. 15% of sample (N=8 teams)

- ## Operationally-Integrated Research Teams
  - members coordinated and combined their research work and created unified research achievements. 35% of sample (N=18 teams)

Categorization Scheme / Example Quote

- Co-Acting Research Teams
  - "The initial vision I think was also not that strong. It was a little bit more of a potpourri of sub-projects that were tied together by a theme, but they didn't necessarily have a strong collaboration. … There's many, many publications that came out of it, but they were individual efforts and not, or small group efforts, and not the collaboration." (Researcher #36)

Categorization Scheme / Example Quote

- Administratively-Integrated Research Teams
  - "It's almost like the proposal document served as a charter for our department to say, 'This is who we are. This is how we define ourselves. This is a common direction that we want to be headed.'" (Researcher #31)

Categorization Scheme / Example Quote

- Operationally-Integrated Research Teams
  - "It was highly interdependent. We were writing a new code from scratch essentially. We couldn't really carve up the tasks very easily. Everyone had to work together on this. And so there was a really tight coupling between the computer science people who were sort of right in the middle where, the middle level of the code and then the chemistry people who were sort of giving their interface part, but then writing the guts down below." (Researcher #6)

Challenging Research Team Integration

- Inter-Disciplinarity
  - "it's partly driven by the pressures of publication, because it's related to, for graduate students, 'Can I get a good job after I graduate?' … I mean me and my group and my students, while they are cross-cutting, there is a pressure, especially coming from the students, that they want to be able to publish, write papers and publish within their own well-defined communities." (Researcher #45)
  - "our group splintered along disciplinary lines, where, you know, I was attending those meetings, [co-PI] was attending those meetings, we were agreed on what had to be done, but then [co-PI] and I got busy for a period of time, and … each of us missed three meetings. And the next thing you know, the team essentially began to fracture into two, one that was doing more physics, and the other that was the more social science people. And that, to me, was a big disappointment." (Researcher #52)

Challenging Research Team Integration

- Inter-Disciplinarity (Continued)
  - "We tend to avoid tenured track professors on cross-disciplinary teams. We've probably had a few but it's dangerous for them because of the— so the university tenure review process is so hidebound that if they don't have single author papers, and single discipline, then they don't, may not get tenure. So we have to be careful with younger people." (Researcher #8)
  - "Say we might do a piece of research that was very much interdisciplinary and then when you go to publish it you couldn't really publish it in the interdisciplinary way so you'd have to kind of repackage it to fit one or another kind of disciplines. And there was often I would say a fair amount of tension around that." (Researcher #10)

Supporting Research Team Integration

- Communication

  - An awful lot of the work is learning to understand each other's vocabulary. … I didn't know a lot about her field and vice versa. And so ordinarily I would have a series of face-to-face meetings and we would talk about that in detail. In this case … she sent us stuff to read and we sent her things to read. … But it also helped that I had a [other field] junior faculty member … working on the project as well and so he could act as the translator between the two of us." (Researcher #15)

  - Certainly after the funding comes, just communication dedicated to further understanding of and agreement on the significance of the components from the overall picture point of view. Otherwise, experts naturally gravitate towards the aspect that is … of most relevance to their own scopes of activities. So it's really the alignment of goals and objectives." (Researcher #9)

Supporting Research Team Integration

- Leadership
  - "One of the advantages as I was PI. And I have worked in this cross-disciplinary space for a long time. And so basically people knew I wouldn't tolerate any hiding in your discipline. So it was like if you're not part of this cultural change to meld together across these things then we don't need you on the project." (Researcher #8)
  - "Well, so we try to [collaborate] by doing joint publications. … We try to [collaborate] by students who are jointly supervised. … There is of course the carrot and the stick approach. You encourage it by saying how great it is and every time we have a review committee those are the people and the results that are trotted out for everybody see. So obviously people are supposed to get the message." (Researcher #7)

ITR Follow-Up Data Mining

PI publications mined from Google Scholar, Citeseer, and Web of Science

- ❑ Created within-group measures for each research team (to assess productivity before and after ITR project)

- ❑ Predictive scores show relative (not absolute) average productivity (total unique publications) and co-authorship (co-authored publications)

- ❑ Compared co-acting research teams, administratively-integrated research teams, and operationally-integrated research teams (based on coding interviews)

Results of ITR Follow-Up Data Mining
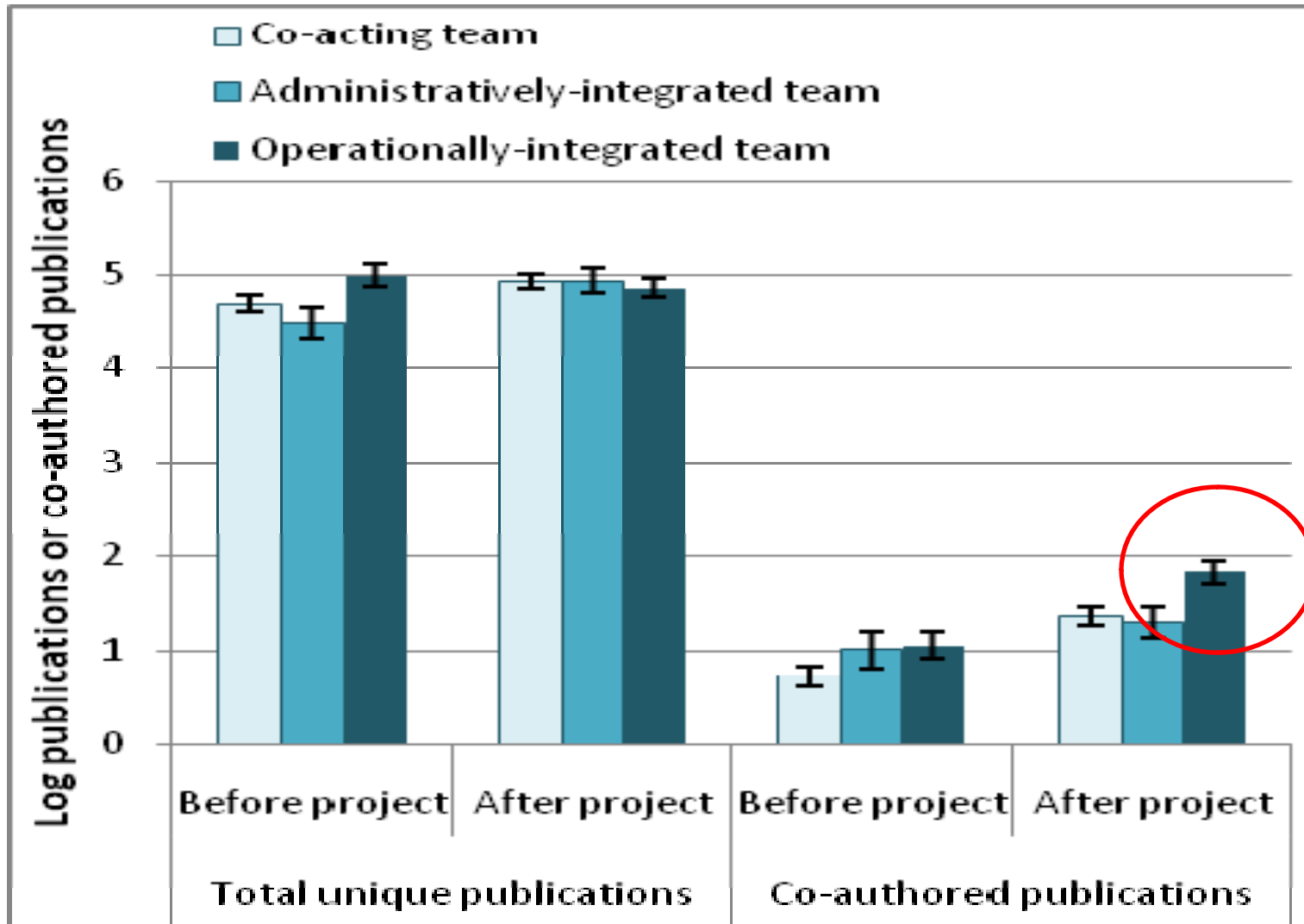
Summary

- Science policy emphasizes the desirability of research teams that can integrate diverse perspectives and expertise into new knowledge, methods, and products – however, integration seems relatively rare

- Retrospective interviews highlighted variation in the extent to which research team integration occurred: co-acting (50%), administratively-integrated (15%), and operationally-integrated (35%)

- Researchers' experienced integration in different ways, though the dominant barrier reported was the challenge of inter-disciplinarity

- Effective communication and leadership on a research team seemed to mitigate inter-disciplinarity for some

Policy Implications

- Should NSF ___?

  -Encourage more collaboration within universities (exploiting in-house expertise)?

  -Make the PIs' track record with collaborators an explicit standard, especially for multi-disciplinary and multi-university collaborations?

  -Give multi-university projects small grants to explore collaborations and overcome barriers?

  -Give enough individual investigator awards that PIs do not collaborate just to get funding?

  -Train scientists to lead great collaborations and then do not abandon them when the "program is over?"

Technological Implications

- Should tools ___?

-Assist in revealing points of contention (rather than simply helping to streamline tasks)?

-Provide real-time updates on analyses and results (since members usually wait until scheduled meetings to report out findings)?

-Help facilitate evenly distributed communication across remote participants (to mitigate tendency towards local communication)?

-Support the organization of work and division of responsibilities to enable integration when the time is right (instead of primarily amount of direct communication)?

More information about prior research…

Cummings, J. N., & Kiesler, S. (2005). Collaborative research across disciplinary and organizational boundaries. *Social Studies of Science*, 35(5), 703-722.

Cummings, J. N., & Kiesler, S. (2007). Coordination costs and project outcomes in multi-university collaborations. *Research Policy*, 36(10), 1620-1634.

Cummings, J. N., & Kiesler, S. (2008). Who collaborates successfully? Prior experience reduces collaboration barriers in distributed interdisciplinary research. *Proc. of CSCW '08* (p. 437-446). NY: ACM Press.