Virtual Team Science: Reflections on Kirkman's Paper

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Team science, like much of the rest of the team-oriented world, has been moving steadily to embrace more interactions where participants are in different geographic locations: so called "virtual teams." It is worthwhile to examine whether what we have learned about teams in one kind of setting, namely, the business world, extends to such distributed teams in science. Kirkman discusses some of the potential differences between these kinds of teams, though there was a sense at the July 1 workshop that much of what we know about one kind of team can be extended to science teams. His interesting paper reviewed a number of factors drawn from the literature that are potentially relevant to the analysis of virtual team science, and he lists a set of practical recommendations that are well worth considering (his Table 2). I will reflect further on the characteristics of science in what follows.

But first, I want to call attention to a potential bias in the kind of literature that Kirkman used for his analysis. To review the literature, he focused on "high quality empirical journals" drawn from a series of fields that study virtual teams. This results in an important bias in the kind of literature considered. Most fields of computer science treat high quality refereed conference proceedings as first-class publications, equivalent in quality and impact to refereed journal article. There are historical reasons for this that need not concern us, but much of the relevant literature from such fields as human-computer interaction (HCI), computer supported cooperative work (CSCW), social computing, and related fields within computer and information science appear in high quality conference proceedings. Second, the field of social studies of science, comprised mainly of sociologists and anthropologists who study the practice of science, tends to publish book-length monographs that report on their long-term studies of science "in the wild." To be sure, both computer and information science, and social studies of science, also have high quality journals, and to his credit, Kirkman cites several articles from these sources. But to miss conference proceedings on the one hand and books on the other is to miss some key elements of two clusters of work on the nature of team science, including virtual team science. In a separate document I will point out some examples of key studies published in both kinds of venues.

As to the characteristics of team science that might contrast with business teams, I'd like to review a series of characteristics that Kirkman did not discuss in his comments about Table 1 in his paper. Perhaps the major distinction is that science is generally conducted under the auspices of very different kinds of organizations. In the business world, virtual teams exist primarily within the confines of a particular organization, or a business alliance that has strategic goals, and usually, and usually the goals are to make money through whatever business they are in. Of course, this overall goal is embedded in the particulars of different kinds of industries. Financial institutions are quite different from manufacturing companies. Service industries themselves span a huge variety of specific domains. But all share the overriding goal of making a profit, and in the context of shareholder-owned companies, these are often within a very narrow time horizon.

The world of science is anchored in very different organizations, either research universities or large federal laboratories. Yes, there are research organizations in many companies, and some – historically, Xerox PARC – are very university-like in their atmosphere. But most corporate research is also carried out under the overall umbrella of making a profit. This distinction is perhaps what lies behind Kirkman's contrast in time horizons in Table 1. But this is correlated with substantial differences in organizational culture and goals, and ideally should be unpacked in greater detail. For instance, scientific research in universities may have very long-term goals, but there is always the short-term horizon on finding funding to support the research.

Another set of distinctions I want to make is that science comes in many varieties. We tend to think of the more-or-less stereotypic science goal of trying to develop deep understanding of some kind of natural phenomenon. One way in which even this varies is that there is a continuum of risk. Some science projects are carried out in a very routine, low-risk setting, where current understanding is pushed along ever further using well-established research paradigms. This contrasts with projects which are much more high risk and uncertain. Most science managers realize that good science needs a mix of both kinds of activities.

Some science is heavily facility oriented. Two clear examples are high energy physics and astronomy. Indeed, in both instances, these sciences have highly respected subfields devoted to facility development and management. Accelerator physics has all the infrastructure of a science: high prestige publications, regular conferences, and a reward structure tied to these activities. Similarly, many astronomers are devoted to the advancement of either terrestrial or space-based observational facilities. In both physics and astronomy, facility development is driven by the burning science questions at the edge of understanding. But facility design and development requires a deep understanding of the technical infrastructure required to enable cutting edge observations. And high end facilities are usually administered as a shared resource for a broad community, raising a host of issues about access, priorities, and ongoing support.

Another special focus in a number of science areas is developing large-scale databases that allow the next generation of research questions to be asked. Creating such databases requires deep understanding of the characteristics of the kinds of questions that need to be addressed. There are also large issues of agreement on database formats, metadata, and access rights. Two examples of such scientific projects are the Biomedical Informatics Research Network (B IRN; see Olson, Ellisman, James, Grethe & Puetz, 2008, for details) and the emerging field of metagenomics. BIRN itself is complex, having multiple threads to it centered on related but somewhat different scientific goals. One of these is called Function BIRN, or fBIRN. The goal is to create a huge database of functional magnetic resonance images (fMRI) of the brains of patients with schizophrenia. The science driver is that there are a number of different kinds of schizophrenia, and no individual medical center will see enough patients to build up a sufficiently large sample of the different kinds. By combining brain images across multiple centers (about a dozen) such a rich database can be created. But there were numerous challenges in doing this, such as calibrating the instrumentation across many different sites to the images could be united in a single database. Hence, many interesting scientific challenges in creating the database in the first place.

Another recent example is the new field of metagenomics. This is the study of the genetic characteristics of populations in complex environments over time. One example would be the ocean. Many different individuals collect time- and location-stamped samples of ocean water, whose genetic characteristics are determined and entered into a database. This can be used to better understand what is happening in, for example, specific ocean subcultures, such as coral reefs. Many other aquatic environments have been studied as well, such as lakes, streams, and even underground water. Soils and other biologically active earth elements have also been studied. Finally, there are studies of internal environments, such as the gut of humans or of other fauna. Again, collecting and archiving such data requires a number of specialized scientific processes.

The final set of distinctions I want to mention has to do with some other characteristics of science that go beyond what Kirkman considered in his Table 1. I will develop these as brief bullet points.

- ***Financing science***. While there are certainly some scientific projects that have long-term funding, the most typical science is carried out in 3-5 year funding cycles. This means that researchers are constantly aware of the need to justify further funding through results and publications, and seemingly endlessly writing grant proposals to support their ongoing work.
- ***Collaboration traditions***. Some sciences have developed very strong traditions of collaboration. For example, at least since the Manhattan Project, high energy physicists have understood that to make progress they need to work together. Today we have complex projects like CMS and Atlas at CERN that each involve thousands of scientists. These projects have complex organizational structures that make them work effectively. In contrast, a field I studied with colleagues is earthquake engineering (see Spencer et al., 2008). The National Science Foundation introduced a funding program to underwrite a new generation of state-of-the-art facilities. But there were insufficient funds for every research center to acquire such facilities, so NSF mandated that they would have to share the facilities across institutions. There were many problems with this, as the field had previously had a very strong tradition of individual centers being self-sufficient, having their own facilities.

- ***Incentives for collaboration, data sharing***. Science is a delicate balance of cooperation and competition. While there are growing pressures to share data, with such mandates increasingly associated with research funding, the competition for good jobs, awards, and prestige means there is a natural tendency to hoard results, at least for a period of time. And these matters intersect markedly with career stages. Graduate students, postdocs, and young faculty are the most reluctant to share, while established researchers with good positions are often more open. These create a tense culture regarding cooperation vs. competition that in our experience can make collaboration problematic.
- ***Importance of management plans***. Leadership of virtual teams is important, as Kirkman and many others at the July 1 workshop pointed out. But increasingly, such funders as NSF and NIH require management plans to be part of grant proposals, which means that a whole host of management issues need to be addressed by more than just the leadership even as projects are being planned.

I do not have the time or space to develop a more extensive analysis of the characteristics of science that influence how virtual teams work. This has been the focus of our research for several decades (Olson & Olson, 2000; Olson, Zimmerman & Bos, 2008; Olson & Olson, in press). We have also been developing an online assessment tool based on this research that allows geographically distributed projects, either past, present or future, to analyze their prospects for collaboration success. We have already analyzed a dozen projects represented by nearly 200 respondents. The Collaboration Success Wizard is available for interested projects (hana.ics.uci.edu/wizard/).

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