Response to "Improving Virtual Science Team Effectiveness: What Can Be Learned from Virtual Organizational Teams Research?"

by

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Introduction

The formal systematic examination of science teams is a relatively new field of inquiry and, therefore, has several challenges with regards to establishing a coherent and comprehensive set of research findings. As Fiore (2008) points out, "Although the ideas coming out of these discussions of team science are informative, they completely ignore the vast storehouse of knowledge developed in the study of groups and teams arising out of psychological, organizational, and communication sciences" (p. 261). While there is a need for a more holistic understanding of science teams, it is also important to recognize that the nature of team-based work – in all areas, not just science teams – has undergone a dramatic shift with the advent of more advanced Information and Communication Technologies (ICT) over the past two decades. So-called "virtual" teams that are potentially more culturally diverse and not geographically co-located often depend on advanced forms of ICT in order to facilitate communication, as well as the coordination and completion of work activities (Kirkman, Gibson, & Kim, 2012, Olson, Zimmeran, & Box, 2008).

While there is a growing research literature within management, organizational behavior, applied psychology, information systems, and communications research communities regarding the salient factors that impact the performance of virtual teams within organizations, Kirkman (2013) correctly highlights the lack of systematic integration of such research findings into the research on virtual science teams.[1] Kirkman's paper (2013) serves the science team research community by initiating a conversation regarding the generalizability of research findings from the broader virtual organizational team literature to the contexts of virtual science teams. Both types of virtual teams (organizational and science) are compared across eight key dimensions: *time horizon*, *leadership*, *membership*, *task type*, *task-interdependence*, *structure*, *accountability*, and *disciplines* (Kirkman, 2013, p. 52). Furthermore, the manuscript also links the major themes regarding virtual organizational teams (Kirkman et al, 2012) with seven critical areas of research for the study of science teams (Falk-Krzesinki et al., 2011).

[1] Kirkman (2013) acknowledges his review of the research is limited and excludes research from several related research fields (i.e. online communities) in order to focus primarily on organizational virtual teams.

Researchers may discuss the validity of comparing virtual organizational teams and virtual science teams along particular dimensions or how particular connections are drawn between research findings. However, the overall contribution of the Kirkman paper is that it provides an initial foundation on which to build a broader research conversation. The discussion below is intended to augment the discussion initiated by Kirkman (2013) and to highlight several issues for greater emphasis within the broader discussion of virtual science teams. The following issues are discussed: defining virtual science teams, the variation within and across scientific disciplines, and the need for studying science teams within broader institutional contexts. The discussion is in part informed by experience gained while working with colleagues at the Florida State University studying virtual science teams that use facilities at the National High Magnetic Field Laboratory (NHMFL) (Burnett et al, 2009).[2]

Defining Virtual Science Teams

How key concepts are defined early in the development of any field of study is important since such definitions will necessarily serve as indicators regarding what is ultimately valued within the field and what is not. Conceptual definitions also necessarily shape how researchers measure such concepts during the research process. With regards to the study of teams, science teams are often characterized as teams which must combine specialized expertise, theoretical approaches and research methods across disciplines in order address complex problems (Borner et al, 2010; Kirkman, 2013). Furthermore as Kirkman (2013) identifies, science teams are often characterized as requiring high levels of interdisciplinarity in order to generate new scientific knowledge that addresses complex science or public issues (e.g. public health problems, medical research, environmental issues) (see also Stokols, Misra, Moser, Hall, and Taylor, 2008; Falk-Krzesinki et al., 2011). Finally, science teams – and teams in general – are often considered virtual when they employ various ICT to facilitate communication and coordination when geographically dispersed.

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While such definitions make sense when considering many of today's high profile scientific endeavors, they also lead to questions. For instance, *will such definitions necessarily influence the types of science teams or the lines of scientific inquiry that will be examined by the science of science teams community or supported by major funding organizations?* It appears clear that definitions will serve to frame the scope of what is considered a reasonable avenue of research within the community seeking to understand virtual science teams. This may be a necessary prerequisite to developing an integrated and coherent body of knowledge regarding the factors that influence virtual science teams, as it would be for any research field or discipline. However, since the systematic study of science teams is relatively new and is attempting to forecast what types of scientific enterprises will yield the greatest benefits to society, creating a workable definition of what constitutes a "virtual science team" is necessarily difficult and caution should be exercised in order to allow for opportunities to study and understand a wide variety of virtual science teams across a broader set of scientific enterprises.

Understandably, the degree of reliance on ICT by the team is a common factor in defining virtual teams. However, *how should the science of science team community conceptualize virtuality?* As Kirkman (2013) indicates, studies of virtual organizational teams have already begun to consider virtuality as a multidimensional concept that can also encompass informational value, synchronicity of communication tools and geographic dispersion (Kirkman and Mathieu, 2005; Kirkman, 2013). Similarly, geographic dispersion can also be further broken up into spatial, temporal, and configurational dimensions (O'leary and Cummings, 2007). With regards to virtual science teams, all three virtuality dimensions may impact overall team performance. For example, the virtual science teams that use the NHMFL facilities vary with regards to member characteristics (e.g. skill specializations, seniority, disciplinary orientation, institutional affiliations, and location) and size. Virtual science teams that conduct condensed matter physics experiments at the NHMFL often have one or two team members conduct the experiment and collect the requisite data. In many instances, lab users employ ICT to consult with or coordinate activities with other team members in distant locations. Even when carrying out actual experiments, rarely are all team members geographically co-located. Moreover, specific scientific

activities, ICT use, as well as the level and nature of interaction between team members may change over the course of the team's lifecycle. Consequently, virtuality with respect to science teams may be considered multidimensional, dynamic, and endogenous with other team factors that influence performance.

Variation Within and Across Scientific Disciplines

In addition to exercising caution when defining core concepts related to virtual science teams, great care should be exercised when considering the different disciplinary contexts, norms, and cultures that influence virtual team performance. So two important questions are, *how should we consider and discuss scientific disciplines?* And, *what importance should researchers of virtual science teams place on the mix of disciplinary orientations within a science team in relation to other factors that influence performance?* With regards to the first question, it is important to remember that when scientists – much like laypeople – speak of a specific academic field or discipline, such as "physics", to describe a type of research or someone's educational background, they are essentially using an oversimplified means of describing a body of knowledge, the methods employed to study a set of phenomena, and/or a set of norms or activities that are sanctioned by a research community (see Fiore 2008, p. 254-255 for a detailed discussion). This oversimplification is in many ways necessary to provide broad research categories or delineations between research areas if simply for ease of discussion. However, it is important to realize that focusing on broad disciplinary labels often masks variation pertaining to knowledge, skills, and norms that make up the cultural environment of virtual science teams. As an example, the researchers conducting particle physics research at CERN may have different skills, backgrounds, and operate in a different cultural environment than do researchers conducting condensed matter physics work at the NHMFL. As a result, virtual science teams that conduct high energy physics research may have vastly different knowledge, technical skills, and norms than do virtual science teams made up of condensed matter physicists that participate in materials science research. It is important to recognize that such variations within scientific disciplines are important because it is the specific task, knowledge,

informational, social, and technological characteristics which partly influence the performance, and the *evaluation* of performance, of virtual science teams. While team science researchers often discuss the necessity for interdisciplinarity, they are essentially describing the need to understand how science teams are able to integrate ideas across member communities with varying characteristics. With regards to virtual science teams, understanding specific characteristics rather than simply focusing on high-level disciplinary categories allows team science researchers to better understand how teams may be able to employ the various types of ICT required to effectively share information. Likewise, it may shed light on how to establish trust between team members, reduce internal team conflict, and better manage team-based activities. Ultimately, understanding specific social, technical, or informational factors regarding the knowledge, skills, training, and background of virtual team members may shed more light on the performance of virtual science teams than defaulting to more simplistic and opaque measures such as scientific discipline.

The Complex Multi-Level Environments of Virtual Science Teams

As with many social technical phenomena, understanding the activities of virtual science teams is often a complex endeavor that must consider multiple levels of analysis (Rousseau, 1985). As discussed in the previous section, in order to understand the operation of virtual science teams, one must understand the social, informational, and technical factors that influence individual team members and the teams themselves, along with the broader organizations and institutions (e.g. universities, departments, laboratories) in which they operate. There is a growing recognition that science teams must be studied as part of broader multi-level systems (Borner et al., 2010), but *what types of research orientations are appropriate for examining the multi-level environments of science teams and specifically virtual science teams?* In the case of science teams, the most prevalent work comes from academic researchers in organizational psychology examining team processes employing experimental or simulation studies (see for example Marks, DeChurch, Mathieu, Panzer, Alonso, 2005) or network analysis to examine the place of science teams within broader scholarly networks (Wagner et al., 2011). Such research orientations

contribute greatly to the overall knowledge of team science. However, a fully integrated theoretical and methodological approach has not yet emerged, which allows researchers to understand the highly contextual nature of intra-team communication and information behavior of virtual science teams while also capturing the complex interactions across multiple-levels of analysis (Kirkman, 2013).

One option is to employ aspects of small world theory in order to examine the information environments of virtual science teams. Examining the information worlds of virtual science teams allows for a better awareness of how common beliefs, cultural norms, and accepted behaviors influence how information is valued and how ICT are used to carry out knowledge work (Burnett and Jaeger, 2008). Such a perspective allows for a conceptual understanding of multi-level information worlds (or possibly overlapping worlds) to which virtual teams or individual team members may belong. Furthermore, a focus on how information is valued and used by the team, along with its use of ICT, allows this perspective to provide more insight regarding how dimensions of virtuality impact team performance. Such a perspective, coupled with the use of multiple research methodologies to collect and analysis data, can provide a fuller understanding of how virtual science teams operate within complex environments. The theory of information worlds is currently being used as a theoretical foundation for a study of virtual science teams who use the NHMFL (Burnett et al., forthcoming).

Additionally, multiple research methods were employed by members of the study team, as they examined virtual science teams that used the NHMFL. Network analysis and bibilometric techniques were used to examine administrative data pertaining to team characteristics and knowledge products, in order to identify relationships between the key member characteristics, overall team composition, and performance, as measured by quantity and impact of published research articles respectively (Stvilia et al., 2011; Hinnant et al., 2012). In-depth interviews were conducted with members of select teams in order to gather qualitative data about team-level information worlds, as well as with lab administrators and research staff to better understand the broader information worlds of NHMFL and broader research communities. Similarly, the research team observed scientists conducting experiments at the NHMFL in order to better understand how work activities were carried out in the context of the lab. Examining the

information worlds of virtual science teams in context allowed the research team to better conceptualize the multi-level and overlapping nature of information worlds. Furthermore, the use of multiple research methods assisted in developing a more complete understanding of the specific contextual factors that influence intra-team information values, norms, and behaviors. This approach allowed for a better understanding of the boundary objects that marked the borders between the information worlds of the virtual science teams and the information worlds of other institutions, such as the NHMFL and broader scientific communities. As Kirkman (2013) acknowledges, there have been few studies examining virtual science teams *in the wild*. Employing such multi-method approaches provides researchers the ability to study how virtual science teams form, operate, and develop within complex real world environments. Studies carried out over longer durations may provide heightened opportunities to examine such phenomena across multiple scientific communities and within more dynamic and therefore realistic contexts; to sustain such research, the continued support of major funding organizations is essential.

Conclusion

There is clearly a need to further explore the performance of virtual teams, specifically virtual science teams, as we continue to publically fund such scientific enterprises in hopes that they will yield meaningful benefits to society. Key challenges to this endeavor discussed in this paper are 1) defining virtual science teams, 2) identifying variation within and across scientific disciplines, and 3) exploring the complex multi-level environments of virtual science teams. Ultimately, it may be more important to move beyond broad disciplinary labels and instead focus on the type of specific scientific activity within real-world contexts, in order to more fully understand how many of these factors (or their interactions) meaningfully impact the performance of virtual science teams. This later issue is well discussed in the recommendation section of Kirkman (2013). As discussed previously, a longitudinal research approach has the potential to shed real light how virtual teams form and ultimately perform in developing integrated scientific knowledge.

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