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## ABSTRACT

Research collaboration has become increasingly global, as collaboration technologies continue to advance and as research problems become more interdisciplinary and global. Virtual research teams have processes and challenges that are unique from a typical virtual team, and we need a better understanding of how such teams can utilize virtual research environments to their advantage. We examine this question from a review of the relevant literature and an analysis of experiences and reflections from a doctoral seminar that studied and experienced the process of virtual research collaboration.

## Keywords

Virtual research collaboration, virtual research teams, virtual research environments, global research and development.

## INTRODUCTION

The growing globalization of research and development has spawned increasing interest in the nature of global research collaboration. The advent of the Web and sophisticated technology-supported environments provides greater opportunities for researchers to work with experts from around the world in projects that span institutional boundaries, disciplines, geographies, and cultures (Keraminiyage, Amaratunga, and Haigh., 2009; Voss and Procter, 2009; Wusteman, 2008; von Zedtwitz, Gassmann, and Boutellier, 2004). Different terms are used in the literature to denote various forms of virtual collaborative research, including collaboratories (Bos, Zimmerman, Olson, Yew, Yerkle, Dahl, and Olson, 2007), e-science (Farooq, Ganoë, Carroll, and Giles, 2009; Pennington, 2011), e-research (Borda, Careless, Dimitrova, Fraser, Frey, Hubbard, Goldstein, Pung, Showbridge, and Wiseman, 2006; Fraser, 2005) and open research teams (Söldner, Haller, Bullinger, and Möslin, 2009). While such collaborations have great potential benefit, they also have many challenges, including difficulties with sharing and transferring knowledge, achieving shared understanding, formulating the research problem, and coping with different epistemologies (Pennington, 2011; Porac, Wade, Fischer, Brown, Kanfer, and Bowker, 2004; Söldner et al., 2009). In addition, although we have a significant body of knowledge on virtual teams in general, we are still in an early stage of exploring best practices and related use of information and communication technologies (ICTs) for the specific context of virtual research collaboration.

Motivated by the general importance of this topic and the potential for information systems (IS) researchers to take a leading role in developing this area further, the authors conducted a Ph.D. seminar whose purpose was to simultaneously study and experience the process of conducting research in a virtual team of collaborators. Based on our review of relevant literature and our experiences and reflections from the Ph.D. seminar, this paper addresses the following research question: *What*

*factors make collaboration in virtual research teams challenging and what technology capabilities are needed to support virtual research teams?*

The next section summarizes existing knowledge on virtual research teams and technology environments and discusses challenges for this form of work. We then present experiences and reflections from the doctoral seminar and conclude with a summary of next practices for virtual research teams.

## VIRTUAL RESEARCH TEAMS AND TECHNOLOGIES

We define *virtual research teams* (VRTs) as any form of research collaboration that spans one or more boundaries, including geography, culture, time, organizational affiliation, and/or discipline. Because of geographic and often temporal dispersion of researchers, their collaboration is facilitated by information and communication technologies that allow for exchange of ideas, data, reports, equipment, instruments, and other resources. Our focus is on VRTs that collaborate for a specific research purpose, whether it is a single project or longer-term relationship. The literature of virtual teams identifies these boundaries and characteristics as discontinuities, which are “*gaps or lack of coherence in aspects of work, such as work setting, task, and relations to other workers or managers*” (Watson-Manheim, Chudoba and Crowston, 2002, p. 193). Discontinuities have been observed empirically to have different effects in different settings (Watson-Manheim, Chudoba and Crowston, 2012), suggesting that discontinuities are often context and situation specific. VRTs are often comprised of individuals with different disciplinary backgrounds and epistemologies that can lead to discontinuities and problems with knowledge sharing and interaction (Cummings and Kiesler, 2005; Newell and Galliers, 2000; Pennington, 2011; Söldner et al., 2009). Research problems are dynamic and characterized by high levels of complexity, they often require a different approach than the tasks of traditional project teams, and they involve collective conceptualizations and coordinated knowledge creation (Söldner et al., 2009). Logistics, interaction, communication, and content sharing become complicated when team members are at multiple institutions (Lawrence, 2006). Orchestrating interactions that create collective conceptualizations or coordinated knowledge production between individuals with different scientific backgrounds is challenging (Porac et al., 2004; Pennington, 2011). To be willing to share ideas with an unknown audience, trust must exist, but it is challenging to develop trust using technology across geographic and cultural boundaries (Farooq et al., 2009). All these issues contribute to unique and substantive challenges for virtual research teams.

A *virtual research environment* (VRE) can be defined as “a set of online tools and other network resources and technologies interoperating with each other to support or enhance the processes of a wide range of research practitioners within and across disciplinary and institutional boundaries” (van Till and Redfearn, 2010). Based on our review of the literature, Table 1 identifies technology support needs that are particularly important for virtual research teams.

VRT Support Needs	VRE Capabilities	References
Facilitate shared understanding in defining and agreeing on research problem	Communication (e.g., email, discussion forum, Web conferencing, video wall)	Pennington, 2011 Porac et al., 2004 Söldner et al., 2009
Share and transfer knowledge among diverse team members	Information retrieval and sharing; Data collection and analysis (e.g., document repository, digital library, search engine)	Bullinger et al., 2010 Söldner et al., 2009 Sonnenwald, Lassi, Olson, Ponti, and Axelsson, 2009
Coordinate research project to minimize discontinuities across research or organizational domains	Coordination (e.g., shared calendaring, awareness tool, email alerts, social network) Project and program management (e.g., shared calendar, multi-user project management system)	De Roue, 2008 van Till and Redfearn, 2010 von Zedwitz et al., 2004
Present knowledge at appropriate level of granularity	Artifact design and development (e.g., shared document writing, shared drawing, simulation)	Sonnenwald et al., 2009
Build trust among research team members and strengthen social bonds across geographic and temporal boundaries	Relationship building (e.g., social network, virtual world)	Söldner et al., 2009

**Table 1. Technology Capabilities for Needs of Virtual Research Teams**

## REFLECTIONS FROM EXPERIENCE

During Fall 2011, six IS doctoral students (three from a Norwegian and three from a U.S. university) and three professors (one from a Norwegian and two from a U.S. university) met for a semester-long virtual seminar titled “Collaborative Research Processes Across Boundaries.” All participants wrote weekly journal entries with their insights and reflections relating the material covered that week, guest lectures, and on-going work for the final paper. This section provides reflections on experience from these journals and the course as a whole.

The format provided participants with a rich opportunity for experiencing and reflecting on the challenges and opportunities for working on a virtual collaborative research project. Bi-weekly synchronous sessions in Adobe Connect served as the main forum for interaction. The conferencing tool demonstrated the potential of online meetings for supporting global research teams and, apart from normal startup problems with audio and video in the first sessions, the meeting times were used effectively.

Preparing a detailed agenda and conducting systematic note-taking from the sessions were important factors for success. Yet the format also had limitations and, even though the group was fairly homogeneous with respect to disciplinary and educational background, participants had a difficult time developing a shared perspective on the very concept of virtual research collaboration. The instructors’ role as facilitators in the process was important, but the balancing act for instructors was a difficult one, as they served as members of the team while simultaneously having relatively greater expertise to share.

The first two sessions focused on developing a common ground and shared understanding of the objective of the seminar and the joint paper to be developed. The 90-minute time frame of the sessions proved somewhat limiting for reaching closure. In some cases, even if consensus seemed to have been established, further work on the deliverables revealed misaligned views on what had actually been agreed. This experience implies a need for more frequent synchronous meetings, which was noted in student feedback. Since the course schedule and resources did not allow for this, a project repository and discussion board was used for team interaction and coordination between online meetings. This shared resource did not turn out to be very effective, however, as participation in online discussions was often sporadic. Some participants were not able to access the repository through company firewalls so that the notification function in the product did not serve to keep track of new postings for everyone. Reflections also noted that face-to-face meetings with local sub-groups might have helped to align and sustain shared understanding. Students across the locations were meeting each other for the first time and noted the difficulty of getting to know one another in an entirely virtual environment.

Sub-teams of two members worked on different parts of the joint paper and reported more success than the team as a whole in developing a mode of interaction and communication rhythm that was adapted to their work situation. Despite access to the conferencing tool, email and Skype were reported to be the preferred tools for collaboration. The sub-teams also reported developing a team bonding that they did not feel carried over to the whole team. We experienced some challenges in routines for effective hand-over of a new version of the paper from one sub-team to the next, as a sub-team would sometimes post a new version of the document to the repository without supplementary explanation on the changes made. Even with change-tracking changes functionality, a document with nine co-authors quickly becomes difficult to manage.

The reflections reinforce the importance of explicit structure in virtual research teams, clear and consistent roles, strong facilitation and leadership, continuous communication about norms and process, and quick adaptation in technologies for ensuring complete access for all research team members.

## OBSERVATIONS FROM PRACTICE

The seminar included interviews with three senior executives from global firms in software solutions and services, eco-friendly metal manufacturing, and the pharmaceuticals sectors, located in India, Norway, and the USA, two of which were large and mature companies. The goal was to understand practices being used in global R&D organizations. Key findings are summarized below.

- *Face-to-face contact is still very important, particularly to establish new relationships between collaborating teams whether in person or via video meetings.* All three executives emphasized the importance of in-person meetings to develop a personal relationship among researchers. Mature R&D companies tend to transplant employees to other locations to foster cross-cultural understanding.
- *Communication at many levels is necessary and must use various modes and technologies.* One executive described the use of communication across boundaries and within the organization at work and at dinners (informal settings). He emphasized the need for each team to share what it is doing, why, and how. For example, each team at a distributed site would describe themselves by saying: “This group works in this way. When they say this, this is what they mean.”

- *Intentional hiring* of skilled personnel with experience with virtual teams is a success factor.
- *Managing value differences* across cross-cultural teams is very important. One executive cited the challenge of team members “driving each other crazy” because of their differences, especially of “fundamental value differences” in what you value and how you work. The solution adopted by this firm was to have a “values conversation,” e.g., “This guy is not a scumbag like you think; you just have different work styles.”
- *High-end ICT is neither a panacea nor a requirement for ongoing remote collaboration.* Even though virtual meeting tools have advanced dramatically, the three executives reported that R&D teams still tend to use video, email and telephone meetings for normal communication. However, there were interesting nuances among the three firms.
  - One executive opined technology is not perfect and so one should really address the question “What is the technology going to afford to you?” in designing virtual processes.
  - The top executive from the Indian pharmaceutical contract firm asserted that to overcome language challenges between collaborating researchers in Europe/USA and India, they preferred using email instead of a synchronous medium. This goes contrary to established belief that communicating through text in most cases has low media richness and low social presence and can lead to high level of misinterpretation. It was interesting to hear from this executive that they chose to use email to overcome language barriers and were successful in doing so.
  - The same firm also felt that technology for collaboration was not a necessity. Over-reliance on technology was viewed as a challenge in R&D contract work.

## CONCLUSION AND NEXT PRACTICES

These reflections and experiences illustrate the continuing importance of interpersonal relationships, team building, shared values, and common work practices. We highlighted the unique characteristics of virtual research teams that contribute to discontinuities in these teams, namely different disciplinary backgrounds and epistemologies, dynamic and highly complex nature of research problems, need for collective conceptualizations and coordinated knowledge creation, and overall logistics of individuals working in very different university or industry research settings. Although we did not explicitly examine cultural differences, we experienced challenges related to the global aspects of our team, such as working across different time zones and languages. We also noted the continuing importance of face-to-face interaction, primarily for establishing personal relationships. Although our observations from practice noted that these interactions are seen as supplementing virtual communications, we can still note that technology capabilities need to support relationship building and informal interaction as particularly important for relationship building.

Future developments or “next practices” should be driven by team needs while enabled through technology developments. Generational changes may raise expectations about technology capabilities, seamless integration, and ubiquitous access, with Generation Y’s proclivity to multi-task and deal with distractions as a regular part of work. A future researcher may work in an environment where she communicates via text messages, social network updates, virtual world personas, and gaming personas. Growing sophistication of tools can change the way we do things, e.g., awareness tools or use of virtual worlds for shared presence or three-dimensional artifact building. But no single solution will meet all needs, and how researchers adapt future tools will shape next practices in virtual research teams.

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