Virtual Scientific Teams: Life-Cycle Formation and Long-Term Scientific Collaboration

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ABSTRACT

Researchers will model the lifecycles of virtual multidisciplinary scientific teams using the facilities of the National High Magnetic Field Laboratory, an interdisciplinary scientific center with distributed facilities in Tallahassee, Florida; Gainesville, Florida; and Los Alamos, New Mexico. The model will be built from data collected through descriptive multiple-case studies, grounded in an analysis of social and organizational factors related to the concepts of the theory of information worlds: social norms, social types, information values, and information behaviors (Burnett & Jaeger, 2008; Jaeger & Burnett, in press). The researchers hypothesize that when the norms and practices of multiple external worlds represented by team members are integrated into the internal norms and practices of the team itself, the outcomes of the project will more likely be successful, and team members will be more likely to work together virtually again.

Categories and Subject Descriptors

K.42.3 [**Computers & Society**]: Social issues – *employment.*

General Terms

Human Factors, Theory.

Keywords

Scientific collaboration, life cycle models, virtual organizations.

1. INTRODUCTION

There are increasing efforts to build an advanced infrastructure for e-science, including high performance computing centers, connected through high speed networks, to facilitate the sharing of both instruments and datasets, and to enable more effective scientific collaborations, learning and professional development (Atkins, Droegemeier, Feldman, Garcia-Molina, Klein, Messerschmitt, Messina, Ostriker, & Wright, 2003).

However, neither infrastructure nor applications guarantee that scientists will use the technology, establish successful collaborations, or share data. Cultural and social factors may either constrain or encourage the adoption and use of technology or data. Similarly, the technology may influence social structures and enable or constrain social interaction, data sharing, and collaboration (Birnholtz & Bietz, 2003; Orlikowski, 1992; Stvilia, Twidale, Smith, & Gasser, 2008).

To improve understanding of the sociotechnical factors affecting lifecycle development, this research asks *what social and organizational factors best support the transition of short-term experiment-focused multidisciplinary virtual scientific collaborations to long-term productive and innovative programs of scientific research?* The goal is to develop and validate a lifecycle model to support distributed scientific teams through the transition from discrete experiment-focused projects to long-term distributed collaborations, thereby advancing innovation and increasing productivity.

2. RESEARCH DESIGN

The project draws its framework from the *theory of information worlds*, which seeks to describe intertwined information exchange and social interaction in a variety of settings. The information worlds of the short-term scientific teams under investigation are *intrinsically transient*, with pre-defined ending points, after which they will cease to exist; thus, they exhibit distinct lifecycles (including specific beginning and ending points). The nature and specifics of the teams' lifecycles have important implications for their interactions, for how they exchange information, and for their success or failure.

One sub-set of research questions seeks to determine how virtual organizations demonstrate that they perform successfully. The specific dimensions along which performance is assessed include willingness to work together again with the same colleagues; willingness to work on virtual teams again; and research output:

1. *Is there evidence that the lifecycle of a virtual team influences the willingness of individual team members*

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to work together again? How does this compare with their willingness to work together again with co-located team members?

2. *Is there evidence that the lifecycle of a virtual team influences the willingness of individual team members to work in virtual teams again? How does this compare with their willingness to work in co-located teams again?*
3. *Do virtual teams generate output as measured by patents, journal articles, and presentations comparable to the output of co-located teams working on similar projects? Is there a difference in the amount of time required to generate such outputs?*

One question investigates the multi- and interdisciplinary research collaborations fostered by the Magnet Lab:

4. *Is there evidence to suggest that the degree of multi- or interdisciplinarity within a team influences its lifecycle or its outcomes?*

The study will also examine relationships between types of teams and team performance:

5. *Do collaborating groups share a definable set of norms and expectations regarding how CMC-based interactions are supposed to function in order to ensure successful collaborations?*
6. *If there are such norms, do they appear to be established ad-hoc by the collaborating groups, or are they established (formally or informally) externally to the groups, and adopted as part of the working strategies of the groups?*
7. *Is there evidence of conflicting norms, or of multiple "information worlds" coming into contact or conflict during collaborations?*
8. *Is there evidence of different types of virtual teams and projects in the research sample, particularly in terms of the different external worlds represented by team members, and are such differences linked to team outcomes or to team members' willingness to work in virtual teams again?*

3. DATA COLLECTION AND ANALYSIS

The research will collect data through descriptive multiple-case studies, and will include content analysis and social network analysis based on observations, interviews, and documentary artifacts of virtual communication generated by scientific teams.

Researchers will collect and analyze a wide variety of documentary artifacts, beginning with a convenience sample of artifacts representative of interactions of teams who completed projects in 2009. Collection and analysis of this sample will provide an opportunity to test assumptions about the nature and purpose of interaction and to develop preliminary classifications along several dimensions. Modes of interaction may be synchronous or asynchronous, and relationships may be one-to-one, one-to-many, or many-to-many. Media may include print, audio, visual, or audiovisual.

Direct observations will be conducted of the multidisciplinary teams selected for the multiple-case study. Observations will occur at the Magnet Lab while teams are conducting their experiments, typically over the course of one week.

Members of each scientific team will be interviewed following the completion of their experiments and researchers' analysis of the documentary artifacts and observation reports. Factual incidents will be collected from the documentary artifacts and direct observations. Themes will be identified, the incidents will be sorted into categories, and questions developed.

This study will collect textual and audio data, which will be analyzed using Nvivo software. Although it will be necessary to transcribe audio data, Nvivo allows it to be tagged and stored for ease of retrieval, allowing researchers to recall the data in context. Analysis will employ a codebook including codes for social norms, social types, information value, information behavior, project types, and lifecycle phases. It will also employ in vivo coding, allowing codes to be assigned directly from the audio or textual utterances as they are originally portrayed. In vivo coding ensures that unexpected findings will not be overlooked.

Coding will be compared to ensure intercoder reliability, and where there are inconsistencies, the researchers as a group will make decisions that can be incorporated into subsequent coding. Analysis and interpretation of the data will be the responsibility of the researchers, who have extensive experience in conducting content analysis.

The techniques of social network analysis (SNA) (Wasserman & Faust, 1994) have been widely used to explore group structure, and test hypotheses about dynamics, interaction, information flow, knowledge acquisition, and diffusion. This project will combine the techniques of SNA and content analysis with data and text mining to supplement the qualitative analysis of virtual team behavior with additional information about teams' structural properties and relationships. The Magnet Lab will provide the researchers with access to the electronic communication logs. The researchers will also have access to the Magnet Lab's report and publication repository (http://www.magnet.fsu.edu/usershub/publications/index.html). These data sources, together with interview data and patent information, will be used to construct team social networks and mine for relationships. The study will use Pajek and Stata software for network analysis, visualization, and statistical relationship testing. The social network and statistical analyses tools will be used to identify and test the relationship between structural measures (e.g., network path length, density, centralization, clustering coefficient) and team and project types; model team dynamics; test the relationships between structural characteristics, productivity, and team type (i.e. virtual, co-located) and productivity; and likelihood of scientists joining the team.

4. CONCLUSION

The lifecycle model(s) developed in the research will enable multidisciplinary virtual scientific teams to better exploit computer-mediated communication technologies to extend their lifecycles from discrete projects to the long-term programs of research required to solve complex scientific problems. Every effort, including external evaluation, will be made to ensure that the model may be generalizable to other federally funded national laboratories, as well as to private sector scientific collaborations, thus enhancing national scientific productivity and global competitiveness.

The model(s) are expected to contribute to the advancement of both practical and theoretical knowledge: 1) within the domain of collaborative scientific inquiry, the model(s) will enable virtual multidisciplinary scientific teams to better exploit computer-mediated communication technologies to extend their lifecycles from discrete projects to the long-term programs of research required to solve complex scientific problems; 2) within the domains of social informatics and the science & technology studies, the model(s) will provide a framework for implementing theoretically-informed future research on virtual organizations and sociotechnical systems.

5. REFERENCES

[1] Atkins, D. E., Droegemeier, K. K., Feldman, S. I., Garcia-Molina, H., Klein, M. L., Messerschmitt, D. G., Messina, P., Ostriker, J. P., & Wright, M. H. (2003). Revolutionizing science and engineering through cyberinfrastructure: Report of the National Science Foundation blue-ribbon advisory panel on cyberinfrastructure. Retrieved May 25, 2008, from http://www.nsf.gov/oc/oci/reports/atkins.pdf

[2] Birnholtz, J. , & Bietz, M. (2003). Data at work: supporting sharing in science and engineering. In: *Proceedings of the 2003 International ACM SIGGROUP Conference on Supporting Group Work*, 339-348.

[3] Burnett, G. & Jaeger, P. T. (2008) Small worlds, lifeworlds, and information: The ramifications of the information behaviors of social groups in public policy and the public sphere. *Information Research*, 13(2). Retrieved May 11, 2009, from: http://InformationR.net/ir/13-2/paper346.html

[4] Jaeger, P.T., and Burnett, G. (In press). *Information Worlds: Social Context, Technology, & Information Behavior in the Age of the Internet*. Routledge.

[5] Orlikowski, W. (1992). *Learning from notes: organizational issues in groupware implementation.* In: Proceedings of the Conference on Computer-Supported Cooperative Work. Toronto, Canada, 362-369.

[6] Stvilia, B., Twidale, M., Smith, L. C., & Gasser, L. (2008). Information quality work organization in Wikipedia. *Journal of the American Society for Information Science and Technology, 59*(6), 983–1001.