

Can Knowledge Be Distributed?: The Dynamics of Knowledge in Interdisciplinary Alliances

Funded by the KDI Program, National Science Foundation
October 1, 1999 – September 30, 2002

Year One Status Report

September 15, 2000

Distributed Knowledge Research Collaborative <http://www.dkrc.org>:
G. Bowker*, J. Brown, B. C. Bruce*, N. Burbules*, M. DeVaughn, M. Guziec, C. Haythornthwaite*, M. Huston, A. Kanfer*, S. Lastra, K. Lunsford, T. McDonough, J. Porac*, K. Vann, J. Wade*

**co-Principal Investigators*

EXECUTIVE SUMMARY

The goal of this project is to investigate distributed knowledge processes among multidisciplinary teams and the role that technology plays in these processes. We are focusing our inquiry on the six scientific Applications Technologies teams who were initially part of the National Computational Science Alliance, funded by NSF's PACI program. This research is motivated by the concern that the nature of knowledge processes in groups and the goals of electronic infrastructures to support distributed knowledge processes may be in direct conflict with one another. The current document provides a status report on the first year of the project. This executive summary will outline our research questions, methods, our team, technologies we use, data collected so far, initial observations and finally a description of what is in the full status report.

Research questions. Initially, our research question was how does embedded knowledge become mobile, with a focus on the communication infrastructure, knowledge characteristics and group context. Over the course of our first year, however, discussion of this question and initial research has given way to more specific research issues being addressed by our team. More detail on how we are addressing each of these issues can be found at <<http://www.dkrc.org/inprogress.shtml>>.

- What are the publication & citation patterns within/among the AT Teams? How do these patterns change as collaborative work changes?
- What patterns of personal & professional relations exist within/among the AT Teams? Do technologies affect these patterns? If so, how?
- What different technologies do the AT Teams use, how frequently, and for what purposes? How do teams position their technology use in terms of collaboration and larger scientific enterprise(s)?
- How do technologies shape attitudes toward where, when, what, and in what manner to publish? How are these attitudes reflected in AT Teams' argumentation? How are these attitudes reflected by grey literature?

- How might we re-define and better understand the processes by which things become "knowledge" and "embedded and/or distributed" knowledge?
- How do social networks of information exchange relate to the sharing of embedded and mobile knowledge?
- How might we variously define collaboration? How has collaboration been defined historically, and how do these definitions affect understandings of collaboration today?
- How do alliances or organizations typically transfer knowledge?
- How might single AT Teams (in this case, the Environmental Hydrology and Chemical Engineering teams) define, create and transfer knowledge? How do the teams negotiate interdisciplinarity?
- What metaphors do the AT Teams use? In what ways and for what purposes? How do metaphors relate to definition, creation, transfer of knowledge?
- How do distributed knowledge team processes interact with communication technology?
- How do new publication formats determine which research agendas are pursued?

Methods. Knowledge processes take place at interpersonal levels and have organizational constraints and influences. Therefore, our study of knowledge processes is multi-level and multi-method. Our methods include:

- Ethnography
- Structured interviews
- Textual analysis
- Social Network Analysis
- Bibliometric Analysis

Research team. In addition to bringing multiple methods to bear on our study of distributed multidisciplinary knowledge processes, our team is itself multidisciplinary. Our investigators come from disciplines as diverse as sociology of scientific knowledge, computer science, philosophy, education, information science, social psychology, business and social science. Moreover, since the grant was awarded, four of the seven investigators have moved from the University of Illinois to other sites. Therefore our team is also distributed. In fact as we are an example of the type of knowledge team we are studying, we have been the subject of research ourselves. See
<<http://www.dkrc.org/projects/dkrcethn.shtml>>.

Our team of investigators had been meeting weekly on the campus of the UIUC for the 18 months before the grant was awarded. After the grant was awarded, and our team became distributed we continued with our weekly meetings, and implemented two face-to-face meetings annually. Our team of investigators has grown to include nine research assistants and the group has started referring to itself as the Distributed Knowledge Research Collaborative (DKRC), to refer to the collaborative and distributed nature of our work and focus of our investigation. It is our hope that the research collaborative will span time, space and funding and will provide a stimulating environment to share and

construct new knowledge and will become an online resource for disseminating knowledge and information about distributed knowledge processes.

Technologies. To that end, we have created a Web site to share ongoing knowledge constructed in our collaborative and also to share useful links we have found. The Web site at <http://www.dkrc.org> contains links to Current Projects; Publications; Grants; Awards & Activities; Conferences & Workshops; Calls for Papers & Proposals; Distributed Knowledge Seminar, Spring 2001; Links & Bibliographies; Research Team; Sponsors.

Also, in the process of studying how scientists are using various technologies and creating new ones we are also using and contributing to new technologies. Some of these technologies include:

- Inquiry web log
- Open Directory: Knowledge Management category
- Distributed Knowledge, a web-supported course
- Transcription tools
- WebEX
- Videoconferencing tools: Livelan/Picturetel/Polycom
- Hierarchical Distributed Dynamic Indexing
- Library and Information Science Library Reserves
- HotOffice

More information on each of these technologies and how we've used them is included in the **Technology Developments** section.

Data collected.

- Ethnography
40 ethnographic interviews have been conducted, primarily in one AT team.
- Structured interviews
The anchors of each of the six AT teams have participated in structured interviews.
- Textual analysis
Preliminary gathering of articles from one of the AT teams.
- Social Network Analysis
Social network survey instrument is being prototyped. We have the first pass at the initial population.
- Bibliometric Analysis
44 of approximately 81 complete CV's or biographical sketches collected to identify the set articles. Preliminary comparative analysis completed on two AT teams.

Technology Developments

The Distributed Knowledge Research Collaborative is primarily a social science research effort. However, in the course of our work, we have been developing several tools to support our own investigations and contribute to the larger research community. Among these are the following:

- ✓ DKRC web site <<http://dkrc.org/>> -- This web site contains a collection of articles, web sites, conference announcements, and other information useful to researchers in this area. A private online forum is planned for DKRC members to coordinate their research. It is also the central point for access to the other items listed below.
- ✓ Inquiry web log <<http://www.lis.uiuc.edu/~chip/blog.shtml>> --The first of several planned web logs (or "blogs"), this one is an annotated compendium of web sites we have located in our research. It includes links to research articles, portal sites, Internet tools, conference sites, and collaborative media. We are also planning specialized blogs associated with OpenSource references and upcoming Conferences. By collaborating on certain blogs with other interested groups, we will increase our access to relevant web resources and further develop our professional networks.
- ✓ Open Directory: Knowledge Management category <http://dmoz.org/Reference/Knowledge_Management/> -- Project members edit several sections of the Knowledge Management category within the Open Directory search engine/database, including Knowledge Flow, Distributed Knowledge, Communities of Practice, and Computer Mediated Communication. Working with Open Directory facilitates two important processes. First, it is another way for the project to have an impact on the field, given the increasing importance of the web in general and Open Directory in particular as a knowledge resource. Second, through Open Directory submissions by users, we are made aware of new developments well before they might appear in conference proceedings or journals.
- ✓ Distributed Knowledge Seminar, a web-supported course <<http://www.lis.uiuc.edu/~chip/teach/courses/dk/sp01/>> -- This site contains the early version of the materials we are developing for the Distributed Knowledge course (scheduled for Spring 2001). As with our other web-based resources, these materials may be used by others in their courses. They may also be copied, redistributed, and modified under the terms of the Open Publication License (Version 1.0) <<http://opencontent.org/openpub/>>.

Special Technologies Used

The Distributed Knowledge Research Collaborative is a distributed research effort. Both to support our own investigations and to understand better the impact of different tools, we have been actively exploring various new technologies. Among these are the following:

- ✓ Transcription tools -- We are beginning to locate and test various programs that allow us to transcribe digitized video and audio media. An annotated list of such tools is available at <<http://www.ldc.upenn.edu/annotation/>>. Since the Distributed Knowledge group members share interview tapes and other materials privately through CD-ROM discs, these transcription programs are necessary for our work in these new media.
- ✓ Webex is a real-time Web-based data collaboration tool. It allows our distributed team members to share and modify documents in the course of any meeting. Any file or application accessible to any one of the Webex-linked computers is made available

simultaneously through the Webex window to all participants. This greatly facilitates our capacity to actively collaborate together in inquiry-based activities. We can brainstorm together and in the process explore the ideas together as if we were sitting together with all the resources of our combined computer-based resources. There is no need to distribute the relevant documents before hand, we can decide which documents, files, sites and applications we want to include in our inquiries "on the fly".

- ✓ LiveLAN is a visual collaboration tool which allows for full-motion videoconferencing. Though distributed geographically, in our meetings we are allowed to see and hear each other thus assisting in our ability to communicate as a group. The visual component greatly enhances the ability of geographically distributed participants to communicate in a free flowing form of discussion in which the order or structure of the exchange is not pre-determined or heavily moderated.
- ✓ Interactive Papers <<http://ctern1.ed.uiuc.edu/ipp/default.cfm>> --Implementing a web-based technology that has been developed locally at UIUC, the DK group members are beginning to make drafts of papers available to the public or selected readers for feedback and commentary.
- ✓ Library and Information Science Library Reserves <<http://www.library.uiuc.edu/lsx/reserves.htm>> -- This web service, run by GSLIS at UIUC, temporarily makes published articles available "on reserve" so that DK group members may read and discuss them easily.
- ✓ HotOffice web space <<http://www.hotoffice.com/>> -- We have been testing this web service as a means for sharing information privately within our own distributed group. Providing a secure document server, bulletin boards, e-mail services and group calendar, HotOffice organizes materials and makes them accessible across computer platforms.

Outline of the report. In the following sections we first provide summaries of each of the ongoing projects. Then we a list of publications from the DKRC, bibliographies that have been generated by the collaborative and a list of grants and awards. This is followed with the two-page NSF style CV's from all the researchers in DKRC. Finally we include related documents in an appendix.

Project Summaries

Social Networks of Knowledge Exchange

co-PI: Caroline Haythornthwaite; RAs: Michelle Kazmer, Sarai Lastra

Social networks show the way in which resources – in our case resources about knowledge – are shared and distributed among members of a population. Of importance in our context is who is connected to whom in the AT teams, what exchanges they engage in that support the creation of new knowledge. Moreover, we want to explore what technologies – whether it is face-to-face meetings, computer-mediated communication, or use of shared data or analysis tools – provide the infrastructure that supports such exchanges.

The first task in this endeavor is to understand what types of exchanges are important in knowledge processes. Using input from previous research, reading, discussion at weekly DK group meetings, interviews conducted with AT team anchors, and early results from the DK ethnographic studies, a network questionnaire has been developed to explore AT team knowledge processes. Because social network questionnaires can be lengthly for individuals to complete, particularly when exploring overlap in multiple types of exchanges, this initial questionnaire focuses on the types of exchanges. While there are some questions about technology, a full network survey regarding exchange and technology use will take place separately.

The pre-work engaged in with the DK group suggests these broad categories of knowledge processes as important points of exchange among members of the creative, interdisciplinary AT teams:

- ***knowledge acquisition:*** e.g., who learns from or with whom; exploring how knowledge within the discipline is exchanged among team members
- ***knowledge transfer:*** e.g., who learns from or with whom about knowledge from other disciplines; exploring how knowledge not available within the team or within the discipline crosses into the team
- ***knowledge creation:*** e.g., who works with whom on endeavors that break new ground; exploring the locus of knowledge creation
- ***knowledge products:*** e.g., who co-authors or co-designs with whom; exploring who creates, co-constructs, or shares work products with whom

To gather social network data it is important to interview all members of the network and to do that it is first necessary to identify who does or does not belong to the network. Effort over the last year has gone in to defining the population for each AT team. With that task nearing completion, we have the definition of the population for the network questionnaire.

The questionnaire is being piloted on the DK group in August 2000 (see the appendix). Data will be gathered by phone or face-to-face interview by research assistants Michelle Kazmer and Sarai Lastra. Interviews will be carried out one team at a time, trying to get all members of the team before moving on to the next team. Interviews will be conducted starting September 2000 and should be complete by the end of Fall 2000. Analysis of results will begin as soon as a full team has been interviewed. Caroline Haythornthwaite will be discussing preliminary results in January 2001 at an NCEAS Workshop on Scientific Collaboration in Santa Barbara.

New Forms of Publication in Networked Collaborations

PI: Nick Burbules; RA: Tim McDonough

This paper has two key elements: one is a study of the changing practices taking place in scientific collaborations, as researchers develop new ways of sharing research results with each other. New information and communication technologies make possible a host of the forms of publication, and new ways of collaborating *in and through* these processes of collaboration — in other words, viewing publications not only as the end point or product of collaboration, but as a medium in which ongoing collaboration takes place.

This way of thinking about publication requires shifting certain traditional assumptions about what a “publication” is: the idea that an essay must exist in one and only one form; that it cannot be revised *after* it is “published”; that authorship must be attributable to discrete individuals; and so on. As people circulate prepublication versions, publish articles as “gray literature,” publish their data for others to reanalyze, and so on, it becomes more clear that traditional ideas about authorship, or when a paper is finished, are being implicitly transformed.

The second element of this essay, then, is to move forward from these shifting understandings to discuss some possible alternative models of publication that can support collaborative inquiry: some of these are already taking form, others are yet to be imagined. But viewing the activities of publication in this more dynamic fashion also reflects changing understandings of knowledge and how it comes to be shared or “distributed” within communities of inquiry (see Epistemology of Distributed Knowledge paper).

Epistemology of Distributed Knowledge

PI: Nick Burbules; RA: Tim McDonough

Discussions of distributed knowledge frequently invoke one or more dualisms to characterize the ways in which knowledge comes to be shared within a community of inquiry. These pairings include: mobile and embedded knowledge; individual and shared knowledge; procedural knowledge (knowing how) and codified knowledge (knowing that); or tacit and explicit knowledge. Questions about distributed knowledge, then, frequently have the form, “How does X knowledge become Y knowledge?” (How does embedded knowledge become mobile, How does individual knowledge become shared knowledge, and so on.)

We will argue that this is an unproductive frame for understanding what distributed knowledge is, and how it works in communities of inquiry. Beginning with a different way of analyzing the problem, we will explore how the processes of hypothesis formation, investigation, testing, justification, and negotiation of knowledge claims all are changed when viewed in a distributed context. Dichotomies like individual versus group knowledge obscure these dynamics.

The conditions that allow something to *become* known — methods of inquiry, standards of argument and evidence, the criteria that set a benchmark of when something is established well enough, and to the satisfaction of enough participants, to be called “knowledge” — all depend on social collaborations. It is not a matter of something becoming knowledge, and then being distributed; insofar as it has come to be held as knowledge, it must *be* distributed.

This essay will offer a framework of an epistemology based on these ideas, and show how it applies in contexts of technologically mediated collaboration.

Metaphors and Third Spaces in Collaborative Relations

PI: Nick Burbules; RA: Tim McDonough

This essay begins with a key question about collaboration, particularly in interdisciplinary groups: How do participants with different vocabularies, theories, and discursive traditions find ways to talk together about shared phenomena?

Here we find useful the notion of a “third space” (Pratt), a zone of common meanings and understandings that must often be created and renegotiated over time. Several elements play a role in the process, including shared practices and “boundary objects” (Star). Here we focus on the use of metaphor, or more generally figurative language, in collaborative groups as one mechanism by which shared meanings get constituted.

Yet traditional understandings of metaphor do not help in unpacking this problem: although it literally means to “carry over,” we do not think it is useful to think of metaphor as simply transferring associated meanings from one concept to another (“Time is an arrow,” for instance). Rather, metaphor involves an active process on the part of both speaker and hearer to reconstruct their concepts in light of the new possibilities suggested by a metaphor: “carrying over” associated meaning from one to the other is only one way of doing this. A “third space” analysis suggests that something new, something *sui generis*, is often developed in these understandings, which both means an *expansion* of meaning and requires an effort of intersubjective negotiation to create a zone of *shared* meaning (even though the parties will also mean something different as well).

Another element of traditional metaphor theory that is not helpful in this analysis is the sharp distinction of figurative and literal language; in fact we will argue that although metaphors can offer particularly vivid examples of this process at work, there is nothing fundamentally different about what is happening in these cases and what happens in a host of other discursive encounters. It may be more useful to use a coinage like “metaphoring” to suggest that we are frequently doing this, especially in collaborative settings.

Forms of Collaboration

PI: Nick Burbules; RA: Tim McDonough

This study tries to avoid the limitations of “prescriptive” models of collaboration: ones that stipulate one or more forms that collaboration should take, with the implicit assumption that collaboration is a good thing if it can only be fostered in the proper ways.

It is a very different starting point to ask why “collaboration” has acquired the cachet that it has (see Bowker and Vann). For this study, we begin with a more agnostic set of assumptions, in order to generate a set of ways of thinking about collaboration that are more susceptible to empirical study as to their effects, benefits, and shortcomings.

First, we begin with an argument about why prescriptive or stipulative conceptions of collaboration can be counterproductive when it comes to framing research questions. We will show some of the diversity of meanings that “collaboration” has come to hold — but always, to paraphrase Raymond Williams, with the “rosy glow” of something to be desired.

Second, we ask why people have thought collaboration is valuable, or more precisely, why people think it has become so especially valuable today. These factors include: the changing nature of problems under investigation; the changing nature of workplaces; the changing nature of technologies; and the pervasive assumption that collaboration is an end in itself, something to be fostered apart from the ways in which it might increase a group’s effectiveness of working toward a particular goal.

Third, and at the core of this study, we want to develop a typology of practices that actually instantiate collaboration: co-authoring, peer review, brainstorming, and so on. When collaboration is understood in terms of specific practices, it is easier to study, for one thing; but more than this, it is possible to examine the actual effects, beneficial and otherwise, of such practices without the “rosy glow” of prescriptiveness making us turn questions of whether to collaborate (in specific ways) into the question of merely how to encourage them, because they are presumed to be a good thing. Finally, framing the issue this way makes it more clear how the rhetoric of “collaboration” itself can play a coercive role in driving particular practices that in fact may inadvertently work against the interests of individuals and groups.

This essay is closely associated with the essay on an Epistemology of Distributed Knowledge, since the forms of activity constituting collaboration often are just those that concern knowledge development and negotiation; and because these practices of collaboration are shaped in important ways by the technological context they inhabit.

Communication technology use in a distributed group: A case of distance knowledge building

RA: Michelle M. Kazmer

This project, an adjunct to the core grant, consists of an eight-month observation of the researchers themselves and their research assistants. This group was once collocated at UIUC, and worked together to assemble the proposal that led to this KDI grant. By the time the grant project officially started, several members had gone to other universities. They still work together on the grant and other projects.

In order to do their grant work together, the group meets once per week. Because several members are not in Urbana-Champaign, the group began meeting using video conferencing and audio (telephone) conferencing to support their meetings. Therefore this group, while studying distributed knowledge, found themselves building distributed knowledge.

I was not working on the project itself during data collection; this observation was an adjunct project. As an independent researcher I attended all the group meetings. This means I physically attended the meetings at the UIUC site, where four of the original members are still. Other members either called in to a telephone conference line or participated in meetings through videoconference. At the meetings, I collected field notes on paper; there was no audio or video taping, nor were the electronic conferences recorded. I was also added as a recipient on the group's email list, and received and archived all emails sent to that list. During the observation several graduate student members joined the research group, and their integration is incorporated in the ethnographic data.

Preliminary analysis of my field notes and the email archive points to some interesting facets of this groups' distributed knowledge building as it is supported by a variety of communication technologies. For example:

- Presence at the meetings was defined in multiple ways dependent on the location of the participant and how well the technology was working. So, in most meetings here were people physically there; people doing audio and video conferencing through the computer; people doing video using the computer but the telephone for audio; people "there" only on the telephone audio. This led to problems of turn-taking and of attention, and compared with the one face-to-face meeting during the eight months, different levels of participation among members.
- Group processes such as conflict resolution and incorporation of new members, common among many groups, developed in particular ways that related closely to the types of technology being used.

A case study of how this group used technology to support distributed knowledge building is forthcoming, and will explain in more detail how these phenomena occurred.

Archaeology of Collaboration

PI: Geoffrey C. Bowker; RA: Katie Vann

It became clear to us in the early days of our research that there were many different meanings of the term “collaboration” in use among our respondents. This is clearly a key theme in understanding the mobility of knowledge. Moreover, the emerging proliferation and ubiquity of this metaphor in contemporary knowledge production practices compels us to inquire the specificity of its multiple current uses. What is it about this particular historical moment that lends this metaphor its salience? We have undertaken a literature review and a series of interviews on “collaborative” work. The literature review spans multiple literatures - business management literature (visiting UCSD Masters student Paolo Brunello from Italy worked on this); organization theory; and education and distributed cognition being the main sources.

However, we needed to go beyond the literatures in order to locate and understand the development of different practices through which discourses of the collaborative were being constructed and invoked, including the positioning of these discourses in the context of various funding and institutional initiatives. We have therefore interviewed a series of people who have been leading figures in these practices. To date, these include:

Walt Scacchi (Prominent hypertext researcher, based at UC Irvine.)

Thomas Hughes (Historian of technology and of systems science, author of *Networks of Power* and *Rescuing Prometheus*)

John King (Dean of Information Studies at Michigan)

Gary Olson, head of one of the first collaborative projects (the Upper Atmosphere Research project at Michigan) and co-editor of a book in honor of Larry Rosenberg.

Joe McGrath, leading social psychologist who has studied small group collaboration through much of his career

Les Gasser from GSLIS, UIUC (he is one of the founders of the Distributed Artificial Intelligence community, one of whose central problematics is collaboration).

We are arranging interviews with other leaders in the field such as William Wulf, Joshua Lederberg and Keith Uncapher in this country and Kjeld Schmidt and Liam Bannon from the international computer supported cooperative work (CSCW) community.

Together, the interviews and the literature review will enable us to tease out the different sociohistorical anchors of the development of current concepts of collaboration. Early findings indicate that there is a three-layered trajectory comprised of the military/systems engineering movement; the Total Quality Management movement; and the CSCW/Participatory Design movement. Each of these carries specific themes and

imperatives which are coded within a discourse of the collaborative. These themes cross-cut, in delicately held tensions. However, it is clear that these three traditions use many of the same analytical tools. We are also garnering significant insights from what the interviewees do not talk about. For example, none have volunteered to discuss knowledge formation and its relationship to collaborative work; none have talked about problems of crossing disciplinary divides (although most have faced this in their work). These observations give us a way of picturing the discursive space that “collaboration” occupies across business, science and government.

As we complete this sub-project, we will use it to inform our own work on collaboration within the Alliance. Our working hypothesis is that team members from different communities (computer science, information management, environmental hydrology) are tapping into different disciplinary discourses as they conceptualize and operate their own collaborations - and that such differences can explain the specific forms that their collaborative work is taking.

Ethnography of Application Technologies Teams

PI: Geoffrey C. Bowker; RA: Katie Vann

As members of the cross-disciplinary KDI research team, we are conducting ethnographic field studies of two of the NCSA Application Technologies Teams, Environmental Hydrology (EH), and Chemical Engineering (CE). Our KDI Research Team as a whole has been very concerned to understand issues associated with the mobility and embeddedness of “knowledge”. These issues are important because there are powerful presuppositions about the nature of knowledge that underlie efforts to create infrastructures for distributed knowledge creation, and understanding the permutations of meaning and knowledge – both at the level of the intra- and inter-local – will have important implications for how we are to understand the nature of the “distributed”.

We are utilizing various ethnographic data gathering methods, such as formal and informal interviewing, laboratory/workplace observations, and technical systems inquiry, in an effort to understand the character of the scientific work that is going on in each of these AT contributors’ local sites. We believe that this part of the story to be told about the nature of distributed science/knowledge/intelligence is as important as that part that elucidates the character of the interpenetration of the multiple voices that create distributed formations. It is one necessary point of entry into creating a properly historical account of the meaning of knowledge and distributed intelligence.

In year one of our study we have focused on Environmental Hydrology. We have conducted field studies at six laboratories, and have been fortunate enough to have developed over 40 interviews with principal members of the EH Application Technologies Team and those with whom they work locally (typically University-associated laboratories.) We are also studying developments within the EH AT team over time, by participating in their teleconferencing and email activities.

Over the coming year we will continue to study the Environmental Hydrology AT Team as we simultaneously fold in comparative field studies of the activities of the Chemical Engineering AT Team. We chose to focus on these two specific interdisciplinary formations due to the contrasts between their respective disciplinary configurations and histories, and the imperatives upon which their respective sub-disciplinary cross-fertilizations seem to turn.

Publishing Research Online: A Study on How a Multidisciplinary Team Adjusts

RA: Karen J. Lunsford

Electronic preprint services, online journals, growing databases, individual websites—all of these new electronic venues are changing publication practices. With these new publication opportunities come several problems that the AT researchers must address: questions of peer review, citation and retraction procedures; questions of which publication formats may count toward job placements, grant applications and tenure; and questions of which team members will be considered as authors for a specific work. Initially proposed before I officially joined the DK group, this project examines how AT team members are changing their publication strategies to accommodate new publication venues and are developing arguments within their research communities to justify the value, integrity and validity of these new publication forums.

This project is one of only four graduate student initiatives awarded funding this year by the University of Illinois's Center for Advanced Study. As a Bardeen Scholar, I will present findings regularly to the Center's associates and faculty, and in Spr. 2001, I will attend a special seminar on Research Values and Technology. In addition, my proposal for a presentation on this project has been accepted for my discipline's national convention, the Conference on College Composition and Communication, Denver, March 14-17, 2001.

Work accomplished to date includes

- a working bibliography of scientific publishing practices;
- preliminary transcriptions and analyses of videotaped interviews with the six AT team anchors (the interviews were conducted by various DK group members last year); and
- preliminary rhetorical analyses of articles published by AT team members in which they argue for the acceptance of new publication forums.

Work to be accomplished this semester includes

- further analyses of the available interviews and articles;
- rhetorical analyses of the teams' electronic publications (websites, databases); and
- discourse-based interviews with selected AT team members (to be conducted by myself).

I anticipate that this research will support my planned dissertation on Stephen Toulmin's (1958) model of argumentation. Initial findings suggest that his concept of "warrants" (fundamental assumptions characterizing a specific field or discipline) may allow me to trace how the AT team members are attempting to persuade their colleagues to accept their new textual formats. Their proposed publication practices necessitate a sea change in their respective disciplines' warrants regarding which texts will be allowed to count as disciplinary—and multidisciplinary—knowledge.

This project will build upon the bibliometric and social network analyses that are underway to determine who regularly collaborates and publishes with whom and in what forums. It will also complement Nick Burbules's philosophical essay on "New Forms of Publication in Networked Collaborations" by focusing on AT team members' actual experiences with the changes he outlines.

Mobilizing Knowledge in Interorganizational Alliances Book Chapter

Co-PIs: Joseph F. Porac, James B. Wade, Alaina Kanfer

RAs: Joyce Brown, Michael DeVaughn,

Our chapter reviews the literature on knowledge transfer within alliances. This chapter will be published in an edited book by Oxford University Press entitled, *The Strategic Management of Intellectual Capital and Organizational Knowledge: A Collection of Readings*. The chapter summarizes the literature on knowledge transfer (in general) and knowledge transfer processes within the context of alliances. In addition, other relevant research on alliances and knowledge is synthesized and combined to develop a set of new propositions regarding knowledge transfer within alliances. The abstract for this chapter is shown below.

Mobilizing Knowledge Through Interorganizational Alliances

By

Joseph Porac
Emory University

James Wade
University of Wisconsin

Joyce Brown
Emory University

Michael DeVaughn
University of Wisconsin

What are strategic alliances and how is knowledge transferred within alliances? A strategic alliance is defined as a cooperative agreement between firms who share resources to meet the goals of the individual firms and alliance (Inkpen, 1998). Mowery, Oxley and Silverman (1996) have identified several types of strategic alliances: licensing agreements, technology sharing and joint development agreements, and joint ventures. There are many reasons alliances are formed. For example, firms join alliances to acquire critical resources, new technology, and to satisfy objectives that may not be apparent to others in the alliance (Gulati & Gargiulo, 1999). The main purpose of these types of alliances is to acquire knowledge to gain a competitive advantage in the industry. Knowledge sharing as defined by Appleyard (1996) is "the transfer of useful know-how or information across company lines." However, transferring knowledge in a strategic alliance is difficult because the desired knowledge may not be accessible to the partners. That is, the most useful knowledge may be deeply embedded within the firms' human

resources and, therefore, is difficult to access. This type of knowledge is commonly referred to as tacit knowledge. Tacit knowledge is hard to communicate or share with others because it is not visible, but a way of knowing how things work. (Nonaka, 1994). According to Reed and DeFillippi (1990, cited in Simonin, 1999) "tacitness is defined as the implicit and noncodifiable accumulation of skills that result from learning by doing". In contrast, explicit knowledge is codifiable and easier to transfer. In alliances, firms seek to acquire tacit knowledge because it is more valuable than explicit knowledge. As a result, partner firms face a conflict between sharing and protecting knowledge with alliance partners (Inkpen, 1998). This chapter reviews the literature on how knowledge is shared both within and between alliance members. Illustrative examples of alliances are discussed, and propositions advanced to explain knowledge transfer.

Bibliometric Analysis

Co-PI's: James Wade, Joseph Porac, and Alaina Kanfer. RAs: Joyce Brown, Michael DeVaughn

In this study, the six Application Technology (AT) teams are examined to investigate knowledge sharing within and across teams. The AT teams consist of multidisciplinary members who share the common goal of building computational tools for the next century. To accomplish this objective, these teams work both independently and collectively on the project. Individual teams propose theories and test hypotheses through experimentation. The outcomes are then reported to the scientific community through both formal and informal modes of communication. That is, their findings are shared through written, oral, and electronic modes of communication (e.g., articles, conferences, e-mail, teleconference, etc.). Once these findings are published in journals, they influence the production of new knowledge as these theories and conclusions are replicated and developed by other AT team scientists. In the bibliometric portion of the project, we treat the formal and informal publications as artifacts of collaboration and knowledge construction. Curriculum vitas, journal publications, and Web sites will be analyzed for patterns of collaboration and knowledge sharing among AT team members and between them and their non-AT colleagues. We are interested in collaborations outside of the AT team to place the knowledge processes of the AT teams within their larger related disciplines.

Much of our efforts on the bibliometric project to date have been directed towards defining our population and obtaining complete publication records. All AT team scientists currently involved in the project and those who have previously worked on the projects were identified by viewing the NCSA web site, NCSA intranet, NSF funding of AT team projects, and by asking team members to list their associates. After identifying the population of scientists, requests were made for copies of their current and complete curriculum vitae. From their curriculum vitae, typologies of publications and citations were created in an effort to record the frequency of collaboration. The key measures include 1) total number of publications by team, 2) average number of authors per publication, 3) number of citations (i.e., times cited by others) per author and 4) total number of citations by team.

Using the CVs we have begun to investigate co-authoring patterns and have collected preliminary data on the number of publications in which the authors have collaborated with fellow AT team scientists and on the extent to which AT team scientists publish in the same journals and cite one another's research. These preliminary analyses suggest that there are significant differences between teams and scientific disciplines in terms of multiple bibliometric measures such as co-authored publications and co-citations (i.e. citing each other's research). There are also significant differences in the rate of publication by teams. Some teams publish at a much higher rate than others. Based on a preliminary analysis, we compared the publication and citation data of the Chemical Engineering and the Cosmology AT teams. We found that the Cosmology team was more productive (in terms of total number of publications) and their work more influential (in terms of total number of citations) than that of the Chemical Engineering

team. Finally, the Cosmology team exhibited a high rate of co-citation (i.e. citing one another's research) and published in many of the same journals in the field. In future analyses, we will study the evolution of collaboration patterns among AT team members of the same team over the tenure of the alliance. Such analyses will enable us to assess the extent to which the Alliance has fostered additional research collaboration among team members. Another analysis will focus on the citations of the research papers of AT team members. Through this analysis, we hope to locate the macro-level research networks in which the AT team members are embedded. We also plan to analyze collaboration patterns using email logs and website analyses. Finally, results from the bibliometric analyses will be compared with research findings from two other methods of inquiry -- a qualitative ethnographic study of an AT team and a social network analysis of one or more AT teams -- conducted by other KDI team members. We believe that this triangulated multi-method approach will work synergistically in that findings from each approach will inform one another, leading to invaluable new insights.

Bibliometric Analyses

Efforts have been under way for the past several months to collect CVs and publication data from all AT team members. This information will be used to study the publication record and collaboration patterns of AT team members before and during their involvement with the NCSA Alliance. For example, one analysis will investigate pre-alliance collaboration (as measured by joint research publications) among AT team members of the same team. In addition, collaboration patterns will be examined during the tenure of the Alliance to assess whether the Alliance has fostered additional research collaboration among team members. Another analysis will focus on the citations of the research papers of AT team members. Through this analysis, we hope to locate the research networks in which the AT team members are involved.

Results from the bibliometric analyses will be compared with research findings from two other methods of inquiry -- a qualitative ethnographic study of an AT team and a social network analysis of one or more AT teams -- conducted by other KDI team members. We believe that this triangulated multi-method approach will work synergistically in that findings from each approach will inform one another, leading to invaluable new insights.

Notes on Citation Information

- Publications—Cosmology 8x more cited than Chemical Engineering. Still need to obtain CVs to accurately capture all publications. Some are difficult to get especially common names (e.g. Anderson on Environmental Hydrology).
- Co-author matrix—practically no collaboration among Chemical Engineering, while high collaboration among Cosmology
- Cosmology-- Astrophysical Journal is journal of choice (majority of team member publications). A lot of common outlets, citing of other team members and reciprocal

cites.

- Chemical Engineering is the polar opposite of Cosmology—few common outlets, little citing of team members and no reciprocal citing. No predominant journal (like Cosmology group)

Limitations

Completeness of the publications

Other Things to Examine

Collaboration pre/post alliance

Can collaboration patterns predict who will join/leave the team? A true team vs. a collection of “stars”? Degree of fragmentation/specialization of the particular fields?

Bibliometric Analysis

In this portion of the project, we will be examining publication and citation data from AT team scientists. Key measures include: 1) total number of publications by team, 2) average number of authors per publication, 3) number of citations (i.e. times cited by others) per author and 4) total number of citations by team.

In addition, we will investigate the extent of co-authoring among AT team members. We will track the number of publications in which the authors have collaborated with fellow AT team scientists. Finally, we plan to assess the extent to which the AT team scientists publish in the same journals and cite one another’s research.

Based on a preliminary analysis, we compared the publication and citation data of the Chemical Engineering and the Cosmology AT teams. We found that the Cosmology team was more productive (in terms of total number of publications) and their work more influential (in terms of total number of citations) than that of the Chemical Engineering team. In addition, the Cosmology team produced more joint publications than the Chemical Engineering team. Finally, the Cosmology team exhibited a high rate of co-citation (i.e. citing one another’s research) and published in many of the same journals in the field.

Technology Use by Scientists in Distributed Knowledge Teams

PI: Chip Bruce RA: Karen Lunsford

Proponents of the Alliance argue that new communication and information technologies have the potential to transform how scientists do their work and to make possible the production of new kinds of science. This claim raises several questions: How do scientists currently use these tools? How are their uses changing with the advent of new capabilities and the formation of the Alliance? And, how do these new uses affect their scientific practices?

We are investigating these questions through the use of interviews coupled with analysis of web sites and publications. Our general approach is qualitative, with the goal of determining participants' perspectives on their use of new tools/media and the impact these have on the way they do their work. Although our aim is to be open to what participants do and say, we also make use of existing conceptual frameworks as methodological lenses for viewing their work.

Turkle (1984) has suggested that the computer acts as a Rorschach ink blot test in the way it evokes diverse responses from people. She argues that these responses tell more about the users than about the new technology. This poses a challenge for our research into the use of new technologies in scientific investigation. We need to analyze three complex, diverse, and evolving arenas. First, we need to consider how new communication and information technologies are developing and to examine their various features. Second, we need a way to characterize the diverse and rapidly evolving integration of these new technologies into scientific work. Third, we need a way to conceptualize the diverse goals of scientists so that we may productively consider how the new media are being used to address those goals.

How then can we simultaneously make sense of three such dynamic enterprises? One approach derives from Dewey's (1956) writings on inquiry. He characterized four main activities: to inquire; to communicate; to construct things; and to express one's ideas. Dewey's four categories, developed long before the electronic age, turn out to be quite useful for analyzing applications of educational technology (see Bruce & Levin, 1997, for its application to learning technologies for science and mathematics). If we apply this four-part taxonomy to the use of new media in scientific investigation, we see a broad array of applications:

Media for inquiry--new ways to inquire about phenomena, including new modes of theory articulation/verification, data collection and analysis. Media for communication--new social realms that reconfigure the relationships among scientists both within teams and between team members and the larger scientific communities. Media for expression--the intermixing of images, sounds, video, tables, charts, graphs, and text, leading in some cases to new concepts of publication. Media for construction--new ways to build tools for further scientific inquiry and communication.

As we applied this taxonomy in the analysis of interviews and publications of scientific application teams, we have seen numerous examples of each of the categories. Our continuing work in this area seeks to understand the patterns of use within and across teams with reference to that taxonomy.

We are also beginning to see other employments of technology that go beyond the taxonomy. Our participants are constantly reconfiguring technologies depending on what they are associating with "technology" at a particular moment. Even if they are talking about a "single" type of technology (e.g., e-mail), it isn't really a "single" thing, something that has a simple dictionary definition in the minds of the researchers. Instead, it is wrapped up in a circle of associations: it helps in generating publication; it enables the group to keep in touch; it provides a paper trail to document the research being done, and so on.

Associations such as these, Latour (1996) has claimed in his study of ARAMIS, help determine whether and how new technologies may be implemented. He argues that, despite (and because of) the presence of various associations with ARAMIS--which might have fundamentally affected and redefined the design of this new transportation system--the underlying design principles of ARAMIS never changed to accommodate new needs, or to privilege some associations over others. As a result, ARAMIS failed as a new technology. Given the importance of these associations, we are currently examining how a careful analysis of the teams' reconfigurations of technologies may mediate and extend the four-part taxonomy we are employing to categorize the teams' technology use.

Bruce, B. C., & Levin, J. A. (in press). Roles for new technologies in language arts: Inquiry, communication, construction, and expression. In J. Flood and D. Lapp (Eds.), Handbook of research on teaching the language arts. New York: Macmillan. <<http://www.lis.uiuc.edu/~chip/pubs/HRTLA.shtml>>.

Bruce, B. C., & Levin, J. A. (1997). Educational technology: Media for inquiry, communication, construction, and expression. Journal of Educational Computing Research, 17(1), 79-102. Reprinted in C.-H. Ku, Y. Chen, & Y. Chuang (Eds.), The Proceedings of the Third International Conference on Multimedia Language Education (pp. 1-16). Kaohsiung, Taiwan: National Kaohsiung First University of Science and Technology.

Dewey, J. (1956). The child and the curriculum & The school and society. Chicago: University of Chicago Press. (Original works published 1902 and 1915)

Latour, B. (1996). ARAMIS, or the love of technology (C. Porter, Trans.). Cambridge, MA: Harvard University Press.

Turkle, S. (1984). The second self: Computers and the human spirit. New York: Simon and Schuster.

Member Publications

Kanfer, A., Bruce, B. C., Haythornthwaite, C., Burbules, N., Wade, J., Bowker, G. C., Porac, J. (Forthcoming). Modeling distributed knowledge processes in next generation multidisciplinary alliances. *Information Systems Frontiers: A Journal of Research and Innovation*, Special Issue on Knowledge Management.

Kanfer, A., Bruce, B. C., Haythornthwaite, C., Burbules, N., Wade, J., Bowker, G. C., Porac, J. (2000). Modeling distributed knowledge processes in next generation multidisciplinary alliances. In *Conference Proceedings of Next Generation Enterprises: Virtual Organizations and Mobile / Pervasive Technologies*, April 27-29, 2000. Buffalo, NY: Academic-Industry Working Conference on Research Challenges 2000 (AIWoRC'00).

Porac, J., Wade, J., Brown, J., DeVaughn, M., Kanfer, A. (Forthcoming). Mobilizing knowledge through interorganizational alliances. Invited chapter in *Knowledge in Organizations*, Oxford University Press.

Bowker, G. & Vann K. (2001, forthcoming). The knowledge economy and policy issues. Invited chapter in *Encyclopedia of life support systems (EOLSS)*. Paris: UNESCO.

Bowker, G. with Susan Leigh Star Sorting Things Out: Classification and its Consequences (Cambridge MA: MIT Press, 1999. Paperback Edition 2000).

Bowker, G. with William H. Kaghan, Crossing Boundaries And Building Bridges: Irreductionist "Frameworks" For The Study Of Sociotechnical Systems, to appear in a special issue of The Journal of Engineering and Technology Management entitled Beyond Sociotechnical Systems, forthcoming, 2000.

Bowker, G. with Leigh Star, The Sociology of Infrastructure in Leah Lievrouw and Sonia Livingstone (eds), Handbook of the New Media, London: Sage, forthcoming 2001. (In prep.)

Bowker, G. Work and Information Practices in the Sciences of Biodiversity in Proceedings of the Very Large Database Conference, Cairo, Egypt, September 2000.

Bowker, G. Biodiversity Datadiversity, Social Studies of Science, forthcoming 2001.

Bowker, G. Mapping Biodiversity, International Journal of GIS, forthcoming 2000.

Bowker, G. with Katie Vann - Vann first author, 'An Archeology of Collaboration'.

Bruce, B. C., & Easley, J. A., Jr. (2000). Emerging communities of practice: Collaboration and communication in action research. *Educational Action Research*, 8(2), 243-259.

Bruce, S. P., & Bruce, B. C. (2000). Constructing images of science: People, technologies, and practices. *Computers and Human Behavior*, 16(3), 241-256.

Nicholas C. Burbules, "Digital texts and the future of scholarly writing and publication." *Journal of Curriculum Studies*, Vol. 30 No. 1 (1997): 105-124.

Nicholas C. Burbules, "Aporia: Webs, passages, getting lost, and learning to go on." *Philosophy of Education* 1997, Susan Laird, ed. (Urbana, Ill.: Philosophy of Education Society, 1998), 33-43.

Garud, R. & Porac, J.F., (Eds.), *Advances in Managerial Cognition & Organizational Informational Processing*. (Vol. 2), Greenwich, CT: JAI Press. Forthcoming, Summer 1998.

Haythornthwaite, C. & Wellman, B. (1998). Work, friendship and media use for information exchange in a networked organization. *Journal of the American Society for Information Science*, 46(12), 1101-1114.

Haythornthwaite, C., Wellman, B., & Mantei, M. (1995). Work relationships and media use: A social network analysis. *Group Decision and Negotiation*, 4, 193-211.

Kanfer, A. (forthcoming) "It's A Thin World: The Association Between Email Use and Patterns of Communication and Interpersonal Relationships" *Information Society*.

Kanfer, A., Sweet, J., & Schlosser A (1997) "Humanizing the Net: Social Navigation With a "Know-Who" Email Agent" *Proceedings of the Human Factors & The Web Conference*.

Bruce, B. C., & Levin, J. A. (in press). Roles for new technologies in language arts: Inquiry, communication, construction, and expression. In J. Flood and D. Lapp, *Handbook of research on teaching the language arts*. New York: Macmillan.

Haythornthwaite, C., Kazmer, M.M., Robins, J. & Shoemaker, S. (forthcoming). Community development among distance learners: Temporal and technological dimensions. *Journal of Computer-Mediated Communication*.

Haythornthwaite, C. (forthcoming). Exploring multiplexity: Social network structures in a computer-supported distance learning class. *The Information Society*.

Haythornthwaite, C. (forthcoming). Building social networks via computer networks: Creating and sustaining distributed learning communities. In Ann Renninger & Wes Shumar (Eds.), *Building Virtual Communities: Learning and Change in Cyberspace*. Cambridge University Press.

Lievrouw, L., Bucy, E., Finn, A.T., Frindte, W., Gershon, R. Haythornthwaite, C., Kohler, T. Metz, J.M. & Sundar, S.S. (in press). Current new media research: An overview of communication and technology. *Communication Yearbook 24*.

Haythornthwaite, C. (2000). Online personal networks: Size, composition and media use among distance learners. *New Media and Society*, 2(2), 195-226.

Haythornthwaite, C., Wellman, B. & Garton, L. (2000). Arbeit und Gemeinschaft bei computervermittelter Kommunikation. In Udo Thiedeke (Ed.), *Virtuelle Gruppen: Charakteristika und Problemdimensionen* (pp. 356-392). Weisbaden, Germany: Westdeutscher Verlag. [Translation of Haythornthwaite, C., Wellman, B., & Garton, L. (1998). Work and community via computer-mediated communication. In J. Gackenbach (Ed.) *Psychology and the Internet* (pp.199-226). San Diego, CA: Academic Press.]

Haythornthwaite, C. (1999). Work and community in networked organizations. In L. d'Haenens (Ed.). *Cyberidentities: Canadian and European Presence in Cyberspace* (pp. 135-145). Ottawa, Ont.: University of Ottawa Press.

Haythornthwaite, C. & Wellman, B. (1998). Work, friendship and media use for information exchange in a networked organization. *Journal of the American Society for Information Science*, 46(12), 1101-1114.
Garton, L., Haythornthwaite, C. & Wellman, B. (June, 1997). Studying online social networks. *Journal of Computer-Mediated Communication*, 3(1).

Haythornthwaite, C. (1996). Social network analysis: An approach and set of techniques for the study of information exchange. *Library and Information Science Research*, 18, 323-342.

Wellman, B., Salaff, J., Dimitrova, D., Garton, L., Gulia, M., & Haythornthwaite, C. (1996). Computer networks as social networks: Collaborative work, telework, and virtual community. *Annual Review of Sociology*, 22, 213-238.

Kazmer, M.M.& Haythornthwaite, C. (Sept., 2000). Managing multiple social worlds: Distance students on and offline. Paper to be presented at the Association of Internet Researchers conference, Lawrence, Kansas.

Haythornthwaite, C. (April, 2000). Network Changes Over Time among Computer-Supported Collaborative Learners. Paper presented at the Sunbelt International Social Network Conference, Vancouver, BC.

Haythornthwaite, C. & Wellman, B. (April, 2000). Is a Computer Network a Distinctive Social Network: The Structure of Communication among Researchers On and Off Line. Paper presented at the Sunbelt International Social Network Conference, Vancouver, BC.

Haythornthwaite, C., Kazmer, M.K., Robins, J. & Shoemaker, S. (January, 2000). Making Connections: From Isolation to Community Membership Among Computer-Supported Distance Learners. Paper presented at the ALISE '00, San Antonio, TX.

Haythornthwaite, C. (1999). Networks of information sharing among computer-supported distance learners. In Proceedings of the Computer Support for Collaborative Learning (CSCL) 1999 Conference (pp.218-222). Palo Alto, California: Stanford University.

Bruce, B. C., & Easley, J. A., Jr. (2000). Emerging communities of practice: Collaboration and communication in action research. *Educational Action Research*, 8(2), 243-259.