Phase Three

Toward an Intersubjective Reality of the Collaboratory

CHAPTER NINE

Electronic Delphi Among Collaboratory Pioneers

Phase One of this study constructs an objective reality of the collaboratory based on library holdings, and proves as practiced principles Wulf's (1988) and Lederberg and Uncapher's (1989) assumptions that the collaboratory would be built from a relatively equal contribution from the hard and soft sciences as an inherently interdisciplinary environment. An emergent theory of the collaboratory as an harmonious, ungendered, intellectual information environment is put forth.

Phase Two of this study constructs a subjective reality of the collaboratory based on prolonged immersion in the online environment, and finds the collaboratory an instrumentally-determined social environment, with each implementation unique, supported by various combinations of communication and media modes, and generating unique combinations of data stores.

Phase Three of this study seeks an intersubjective reality of the collaboratory by engaging Collaboratory Pioneers in an electronic Delphi to determine the "rules of the road" for the collaboratory and identify skills collaboratory pioneers value in prospective participants.

"Rules of the Road"

In the Executive Summary of the 1993 report, *National Collaboratories: Applying Information Technology for Scientific Research*, the National Research Council identifies the need to determine the "rules of the road" for the collaboratory:

> Although articulating the rationale for collaboration may be easy, achieving effective collaboration is not. In part, the situation reflects the basic training of scientists: scientists have been educated to focus on individual activity and achievement. Moreover, scientists have had to compete with each other to attain recognition and resources. Collaboration tends to be easier on a small scale and when it is local: when a small number of individuals collaborate it is generally possible to proceed on the basis of mutual trust, but **'rules of the road'** are needed for larger-scale collaboration. These and other human considerations shape and constrain the collaborations that do take place: in some instances they also inform the design of incentives to promote collaboration. (NRC 1993, 2) (emphasis added)

What NRC meant by "rules of the road" is a matter of conjecture, but the expected differentiation of rules according to collaboratory size is clear. Nautically speaking, "rules of the road" are

> regulations concerned with safe handling of vessels under way with respect to one another, imposed by governments on ships in its own waters, or upon its own ships on the high seas. (Webster's 1989)

So defined, "rules of the road" for the collaboratory would be inter- or intra-collaboratory protocols. While the functioning collaboratories identified in Phase

Two of this study are, on some levels, interrelated (by common funding source, because some sites hosts several collaboratories, and because the population of Collaboratory Pioneers is very small and necessarily familiar with each others' work), they have not yet evolved to inter-collaboratory sophistication. An example of intercollaboratory work might be an investigation of the properties of plasma between the DEE DII-D Tokamac and the SPARC collaboratories. Nevertheless, as the focus of collaboratory research shifts from technological implementation to sociological and cultural aspects of the work, generic "rules of the road" that apply to all collaboratories, and perhaps between collaboratories, now seem discoverable.

"Rules of the road" may also be organizational and/or cultural. Culture is an overarching part of Nardi and O'Day's (1999) information ecology (comprising people, practices, values, and technology). Anthropology defines organizational culture as

> patterns of shared values and beliefs that over time produce behavioral norms adopted in solving problems. Similarly, culture is a body of solutions to problems that have worked consistently and are taught to new members as the correct way to perceive, think about, and feel in relation to those problems. The sum of these shared philosophies, assumptions, values, expectations, attitudes, and norms bind the organization together. Organizational culture, therefore, may be thought of as the manner in which an organization solves problems to achieve its specific goals and to maintain itself over time. Moreover, it is holistic, historically determined, socially constructed and difficult to change. (Heck 1996)

To mine for the definition and attempt to discover the "rules of the road" for the collaboratory, and simultaneously identify skills collaboratory pioneers value in prospective participants, PhaseThree of this study turns to the Delphi Method.

The Delphi Method

Delphi is a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with complex problems (Linstone and Turoff 1975). It consists of a series of interrogations of a group of individuals whose opinions are of interest, with interrogations continuing in '"rounds" where the anonymous responses of participants are submitted to the group whole for comment until consensus, divergence, or stasis of opinion is reached. Delphi is also an interdisciplinary, intersubjective, futures research technique that allows translation of qualitative data for quantitative analysis, and is particularly useful when the field of interest is too new to have adequate historical data for the use of other methods (Lang n.d.).

The Delphi Method was developed by Kaplan, Skogstad, and Cirshick (1949) and refined by Helmer and Dalkey of the RAND Corporation in 1953 to answer the U.S. Air Force's question about the likely outcome of a Soviet nuclear attack on the United States (Linstone and Turoff 1975). Since then, the Delphi has

been used many times, by most disciplines, for a variety of reasons, and under many permutations.

There are no hard and fast rules for Delphi implementation (Turoff and Hiltz, in press). Nevertheless, all Delphi Studies follow a broad procedural outline (Lang n.d.) In brief, the steps for a Delphi are:

1. The problem is identified
2. An expert panel is developed
3. The panel is presented the problem and asked to respond
4. Responses are synthesized into a series of statements
5. The synthesized statements are submitted to the panel
6. The panel responds
7. The process continues until convergence, divergence, or stasis is identified.

Delphi Studies share three distinctive features and common characteristics: anonymity of response, feedback of individual response to the group, and statistical analysis using median and dispersion. Statistical analysis is achieved by synthesizing individual participant responses and presenting them to the group in rounds as statements for individual Likert Scale responses. In most Delphi Studies, participants are kept anonymous and never meet face-to-face. In all Delphi Studies, however, anonymity of responses is maintained to avert

dominance of the group by influential or powerful participants, to avoid specious persuasion, and to avert unwillingness to abandon publicly expressed opinions and other social-psycho affects of face-to-face group decision situations (Welty 1971, Rosenbaum 1991, Turoff and Hiltz, in press).

There are seven basic types of Delphi: the conventional, numeric, policy, and historic Delphi (Strauss and Zeigler 1975), the derivative (when used with other methods), the pedagogical (Rosenbaum 1991), and the conference Delphi. The pedagogical and conference Delphi are executed in face-to-face situations with anonymity of responses (Rosenbaum 1991).

The Delphi Method has been used for futures forecasting, for prioritizing (Cline 1997), for community needs assessment and gathering initial or new information (Carter and Beauleiu 1992). It has been used for soliciting interpretations, predictions, or recommendations (Strauss and Zeigler 1975), for environmental scanning (Lang n.d.), for personnel and budget allocations (Kao 1997), and for participant education (Strauss and Zeigler 1975). The Delphi has been used for both normative (target oriented) and exploratory purposes (Acolyte 1995).

> Delphi operates on the principle that several heads are better than one in making subjective conjectures about the future…and that experts will make conjectures based upon rational judgement rather than merely guessing (Weaver 1971 in Ludwig 1997).

The Delphi's group consensus principle rests on a 1936 study (Loye 1978) by Douglas MacGregor that formulated what came to be known as the "MacGregor Effect, " which refers to his findings that predictions made by a group of people are more likely to be right than predictions made by the same individuals working alone.

The pitfalls of the Delphi Method are well-documented (Linstone 1975, Fisher 1978, Cook 1987), and include concerns that the Delphi does not adhere to traditional tests for statistical significance, sampling errors, and randomness. Delphi has been criticized for its tendency to encourage researcher urges to discount the future, make unwarranted predictions, and oversimplify. Major pitfalls also include the illusion of expertise among the panelists, and sloppy execution (poor panel selection, superficial analysis of responses, and designer's lack of imagination.) It has been faulted for its optimism-pessimism bias, which lures the researcher to project selectively and build on experiential data overlooking entirely new approaches, and for its tendency to researcher overselling or overuse, demonstrated by assuming the Delphi is methodologically appropriate. Further faults include using too many panelists, and methodological mismatch with the goal of the research. The Delphi has been characterized as an elitist rather than democratic process and faulted because participants structure the questionnaire, and finally, because of the possibility of deception.

Delphic deception is often illustrated by reference to the Greek myth of Ino, wife of King Athamus of Orchomenus, in which, when the king dispatched a messenger to the Oracle at Delphi, and the King's wife, Ino, bribed the messenger to return with a falsified story, in the second round of consultation at Delphi, the Oracle based her pronouncement on the false version of her first utterances.

Criticism notwithstanding, studies comparing the Delphi's results with other methods (Ulschack 1983) confirm the effectiveness of the method related to generating ideas and use of participants' time (Ludwig 1997). There is renewed interest in the Delphi Method in light of the recent evolution of Computer Mediated Conferencing Systems and the personal computer's ability to immediately scale qualitative responses and calculate and represent quantitative group responses in real time. So used, the Delphi has been put forth as an appropriate platform on which to develop long-term knowledge systems, or "Collaborative Expert Systems" (Turoff and Hiltz, in press) in which statistical scaling techniques convert data from nominal to ordinal or ratio format (making them useful for inferential analysis), and allow dynamic contributions to an evolving, and queriable real-time knowledge system. Several web-based Delphi software programs are being developed and tested (Chen, Chiu and Beiber

1998, Mortensen et al 1997), although there are no reports of implementation or execution.

Turoff and Hiltz (in press) contend that the most important design criteria for the electronic Delphi is participant choice. The effectively designed electronic Delphi would allow participants to choose the sequence in which to examine and contribute to the problem-solving process and to exercise personal judgement about what part of the problem to deal with at any time in the process. Work is only just beginning on the design of the ideal computerized Delphi: one that would allow such sequential, parallel, or asynchronous activity by participants, and there is a need for a model which integrates the individual problem solving process with the group process (Turoff and Hiltz, in press). But, when developed, the electronic Delphi holds great promise as an analytical tool for application to existing and evolving collaboratory archives such as those discussed in this study's Phase Two, as well as for expansive research into the collaboratory's information ecology. This study employs a permutation of the evolving electronic Delphi for the purpose of identifying new information and to probe the emerging collaboratory environment for evolving cultural practices, and, while doing so, to identify skills that might be incorporated in collaboratory training and education programs.

Collaboratory Pioneers

The careful selection of participants and participant group size is critical to the successful Delphi. Delphi participants must be purposively (rather than randomly) selected (Ludwig 1997) based on individual qualifications and characteristics. While Delphi Studies have been successfully conducted with hundreds of participants, the median group size is 15-20 participants (Ludwig 1997). Debecq, Van de Ven and Gustafson (1975) suggest using the minimally sufficient number of respondents. Successful Delphi Studies have been executed with as few as five (Telecat 1998) or six participants (Strauss and Zeigler 1975). Since the Delphi is characterized as more of a "search for public wisdom than it is a search for individual knowledge or deliberative judgment" (Lang n.d.), the careful selection of individual experts who have knowledge of the subject and a participatory temperament is more important than rigid group size requirements.

Participants solicited for this study's Delphi meet the following criteria:

1. Participant must be associated with a functioning collaboratory that meets the CIRAL criteria for inclusion developed in Phase Two.
2. Participant must have a "big picture" position in the collaboratory (i.e. not be simply an occasional collaboratory participant or involved with a single, isolated aspect or portion of the collaboratory such as software development or infrastructure maintenance).

3. Participant must be a practicing scientist who has actively participated in collaboratory experiments and activities for at least one year (i.e. not just be an administrator or manager, or new to the environment).

These criteria reduce considerably the already small number of available Collaboratory scientists. Extensive and broad involvement in, and affiliation with a collaboratory that meets the **CIRAL** criteria was deemed important so that responses would not reflect either a singular experience or a predominately theoretical or administrative perspective. Seven candidates were identified during Phase One and Two of this study and were invited via email to participate in the Delphi. The email invitation included a brief description of the dissertation, with focus on the subject and execution of the Phase Three Delphi. Each invitee was asked to complete the online consent form at http://www.intertwining.org/dissertation/consent/p3consen.htm (Appendix D). A positive consent generated an invitation to nominate others who might also be appropriate participants. Six of the seven invitees agreed to participate. None nominated other participants. The participants were given several months to consider the subject of the Delphi before the Delphi was actually executed, and asked not to discuss the study with anyone during the interim.

All of the participants are involved with the functioning collaboratories explored in Phase Two of this study. All are practicing scientists who hold top-

level positions in their respective collaboratories. All have national reputations; several have international reputations. Four of the participants are male; two are female. The researcher did not know any of the participants before the study was executed. Several participants contacted the researcher, as invited, by return email or telephone to ask questions or discuss the technicalities of the Delphi. There was no discussion of the Delphi topic prior to execution of the study, however.

Round One

The six participants were sent the Round One questionnaire (Appendix E) as an email message and asked to respond within two weeks. The questionnaire gave a brief description of the Delphi technique along with the short excerpt from the "rules of the road" paragraph from NRC (1993, 3). Participants were asked to respond to two questions: "What are the 'rules of the road' for the Collaboratory?" and "What skills do you value in prospective participants?" "Rules of the road" was not defined so that researcher bias could be avoided and because it was expected that the emergent definition would be an important finding of the study. Participants were not identified to each other.

Four of the six participants responded to the Round One questionnaire. In many Delphi Studies the unresponsive participants are sent gentle reminders

and urged to complete and return the questionnaire. However, keeping with Turoff and Hiltz's (in press) criteria of protecting and preserving choice in level and sequence of participation in the Delphi process, this study did not follow that practice. It was assumed that unresponsive participants would contribute in later rounds and as they deemed appropriate. One of the participants expressed reluctance to respond to the Round One questionnaire because the questions were sociological rather than physical, and were outside the scope and discipline of expertise, but that person responded briefly nevertheless, expressing the expectation to participate more extensively as the study progressed.

Round One responses ranged from brief sentence fragments to fully developed paragraphs. Each participant's response was read and digested as a body with attention to clues about the respondent's interpretation of "rules of the road." The four responses were distinctly different. Two respondents took a philosophical route, one exploring and interpreting the need for "rules of the road" and the NRC's alleged difference between small and large collaboratories. The other focused on the underlying issue of trust-building in relation to size of collaboratory. Two participants took a more practical approach to the questions, identifying "dos and don'ts" and other functional, behavioral, and cultural matters, one taking a very instrumental approach, the other taking a more sociological approach.

After the general evaluation of individual approaches to the questions, the individual responses to the "rules" and the "skills" questions were chunked into thirty-two freestanding thoughts. Each individual thought was transcribed onto a 5x7" card. The cards were shuffled to achieve random order and transcribed to an interactive web page (the text of which is included as Appendix F). For the "rules" section, respondents were asked to respond to each thought by completing a five point Likert Scale representing their level of agreement with each thought. A comment box was provided after each thought to allow respondents to expand, explain, or develop any of the thoughts. An additional comments box invited participants to add new items to the Round One responses and also allowed participants who did not respond to Round One to add afterthoughts which could be incorporated into subsequent rounds. Eight of the thoughts in the "skills" section was assigned a one-to-ten ranking scale (one being an unnecessary skill and ten being a mandatory skill). The last eight thoughts in the skills section presented the quantitative and qualitative findings of Phase Two of this study. Participants were asked to agree, disagree, make no comment, or indicate that the thought did not apply. A total of forty-one "thoughts" were submitted to the group as Round Two.

Round Two

The Delphi participants were emailed the URL, or online address, of the Round Two instrument and asked to respond within one week. The url is http://www.intertwining.org/dissertation/round2.htm. The email message also included the name, collaboratory affiliation, and email address of all the participants, along with a reminder not to communicate with each other about the study. Responses to the web page form were programmed to feed a concatenated hypertext file and a concatenated, comma delimited text file, and also generated an email message to the researcher with comma-delimited responses enclosed. The qualitative options on the instrument were automatically converted to quantitative data for analysis purposes. Responses were fed into a Microsoft Excel97® spreadsheet designed to allow side-by-side viewing of the Round One thoughts and the Round Two responses and comments of all the participants, as well as the statistical interpretation of the responses.

One of the participants who did not respond to the Round One questionnaire replied to the Round Two email message with concern about the number and inclusiveness of the participant pool, and their representation of the group "Collaboratory Pioneers." This respondent offered to "round up" more participants for the study. The researcher replied to the message, encouraging nominations

of qualified participants and providing details about participant criteria. The participant did not nominate additional participants, however, nor respond to the Round Two instrument.

The Round Two email message sent to the other participant who did not respond to the Round One instrument generated a system email message indicating that the person's disk quota was exceeded and that the message could not be immediately delivered, but indicated that attempts to deliver would continue for five days. The system did not generate a final undeliverable message, but the participant did not respond to the Round Two instrument. The four participants who responded in Round One responded to Round Two. None of the respondents added additional comments or items to the Round One responses.

Round Two responses are insufficient in number for the Delphi's traditional interquartile range analysis in which respondents whose answers fall outside the center-most 50% are asked to justify or explain the deviant answer or response. Alternatively, a means-based analysis was executed in which the average answer for each question was calculated and an agree vs.disagree qualitative cross-thought analysis for themes was undertaken.

Seven of Round Two's forty one thoughts generated unanimous agreement; two of the unanimous thoughts were from the "rules of the road" section of the

study, three were from the "skills" section, and two were from the section "testing" the eight qualitative and quantitative findings from Phases One of this study. Only one thought (from the testing section) generated unanimous disagreement among participants. One thought generated a different response from each of the four participants. Detailed analysis of each section of the Round Two responses follows.

"Rules of the Road" -- Discussion

All but one of the twenty "thoughts" about the "rules of the road" for the collaboratory were agreed to or somewhat agreed to by a majority of the respondents. While several of the thoughts generated individual disagreement, only one thought generated majority disagreement. The five point scale for possible responses was agree, somewhat agree, no comment, somewhat disagree, disagree. Respondents provided comments on seventeen of the twenty thoughts, for a total of thirty-two comments.

The two thoughts about "rules of the road" that generated unanimous agreement (with respondent comments) are:

1. Be direct. If you have an idea, complaint, or any comment, say it. If you need something, you must ask. Don't expect anyone to read your mind.

   This is important -- the lack of body language, feedback, etc. makes it very hard to pick up subtle expressions of frustrations, etc.

2. You must get involved and get someone in the collaboratory interested in working with you on a problem.

   Collaboratories should not be approached as a technology push -- deployment should be fueled by the needs of the scientists.

   If you don't, it will slow down the pace of the research project!

   One can only spend a limited amount of time playing with collaboration toys. Eventually you have to work on a real problem.

The only "rules of the road" thought that received majority disagreement concerned publications production. The original thought was:

> When researchers visit a collaboratory facility it is probably to complete an experiment resulting in publications: if a researcher pops into a virtual room/session and discusses ideas with colleagues, there may be no direct publishable artifacts.

Three respondents somewhat disagreed with this thought, and two offered comments:

> Publications do not always come out of each experiment. My experience is that a group of experiments conducted over several sessions will usually get a publication.
>
> Maybe true but this is "apples and oranges." While on a site visit, a researcher will have hallway conversations that do not result in a publication.

Although there was no strong overall disagreement with any of the remaining statements, communication issues related to a balance between "hallway conversations" (unscheduled, spontaneous meetings) and formal

communications, and planned collaboratory meetings, and between experiment flexibility and rigid experiment planning. Both issues have an undercurrent about trust, and generated the strongest dialog among the remaining "thoughts." While planned, regular collaboratory sessions are considered important for stimulating frequent communication, they are seen as the equivalent of coffee breaks, and do not substitute for planned, scheduled project meetings:

> 'down the hall" (type meetings) imply spontaneity. Frequent communication is very important and scheduled meetings help do that.
>
> It depends on the nature of the collaboratory. You cannot always structure the collaboration. It needs to adapt to the types of work. Some require regular participation, others don't.
>
> One frustration I foresee with planned, regular sessions--as with in-person meetings--(is that) participants may not show up, whether due to conflicts or declining interest. To me, it seems the frustration associated with this would be greater for remote colleagues than for colleagues physically down the hall.
>
> That's what coffee break style meetings, or environmental (always on) video are for.

Two of the participants somewhat agree that establishing at the onset who will do which part of the experiment and follow up analysis is important. The other two somewhat disagree, one commenting that such planning is no different than on a normal (non-collaboratory) project, and the other warning that maintaining flexibility and willingness to change is necessary since some experiments cannot be planned accurately.

It was generally agreed, and to one participant very important that collaborators commit to making frequent deposits of data, notes, etc. to a shared electronic notebook or database so all collaborators can stay up to date and so the progress of the research can be as efficient as stopping by a colleague's office down the hall to take a look at data. Another participant commented that this takes work. The respondent who somewhat disagreed with this thought explained that while it is helpful, collaboratory technology should be able to automate these processes:

> instruments sending data directly to notebooks or things like the Crosspad - you write on paper and an electronic copy is made that can automatically go to an electronic notebook.

It was agreed that electronic interaction shifts work between collaborators: that when a researcher goes to a facility to do an experiment they are available to help with instrument maintenance and configuration, to get supplies from the storeroom, etc., while remote researcher is not. One respondent commented:

> This is critical. I have heard many people express a lack of interest in collaboratories due to issues like this.

The differing communication needs as related to the trust-building process within large and small collaboratories were generally recognized. One respondent disagreed that size is an important consideration:

> I don't see why (establishing trust in) large scale (collaboratories) should take any longer. If everyone is communicating electronically everyone is

> still on the same scale - i.e. everyone is "equal" electronically, there may be more people/groups to interact with, but I believe the trust level would develop at the same rate as a small collaboratory.

Another did not see size as a trust-building issue unique to collaboratories:

> Isn't this just as for local small and large groups? My statement was that the unique aspect of collaboratories versus local interactions was not the size of the group, but the informal, cross-organizational aspect.

It was generally agreed that trust takes time to build and the time constant is much longer when contact is less frequent due to time and/or distance; however, this was seen as "very personality dependent -- 'trust at first sight' does exist in the world!"

The participants agreed that the balance of trade in informal interaction may favor one person/culture/organization over another with one participant pointing out that this is always true.

All participants but one (who diagreed but had no comment) agreed with the statement

> Our inability to measure value of informal; interactions is one reason we organize--we get common culture, i.e. people learn to provide similar amounts of informal help to each other; all the benefits of these interactions accrue to the organization; both these lesson the need to measure them.

It was generally agreed that many if not most research projects can be enhanced by using a collaboratory, but that collaborators must embrace that collaboratory work will take extra time to get up to speed and is subject to

glitches in technology and the Internet or collaboration will be slowed down such that it will not compete as an effective alternative to traditional methods.

> Collaboratories can provide real benefits now. However, a user who thinks they will solve all their current collaboration problems without encountering some new (smaller) troubles is due for a reality check. Collaboratory developers/promoters need to make sure they don't oversell current capabilities or we'll have some backlash.

It was generally agreed that "rules of the road" are an attempt to find a balance between differing cultures, but such rules are still ad hoc:

> Often, Collaboratories require that you formalize processes (perhaps by writing the procedure into collaboration software) that are currently informal or that differ between organizations.

All but one respondent (who disagreed), agreed with the statement

> Because collaboratories are still new enough to be subsidized (we fund development of tools and creation of virtual facilities, accept papers on these topics, etc.) buys time to get the rules right. As collaboratories become standard practice, the subsidies decrease, and the need to equalize the benefits will increase.

"Rules of the Road" -- Analysis

Delphi participants represent all sizes and types of Collaboratory identified by early EMSL psychosocial studies as discussed in Phase Two of this study. Size of the collaboratory, and level of involvement in collaboratory activity might explain the subtle but remarkable differences in preference for balance between

formal and informal communication, and planned and fluid experiment modes, as the NRC suspected.

Tuck and Earle (1996) explore the communication modes of different group sizes in the corporate environment, relying on classical cultural anthropology studies to conclude that group size is always a determining factor in group communication structures (Johnson and Earle 1987, Earle 1987, Schmookler 1984, Johnson, 1982). While each individual's role and behavior within the group is determined by inherited nature, upbringing, and training, two communication modes: the egalitarian and the hierarchical, and four universal subgroup structures: the working group, the camp, the tribe, and the state, naturally exist whenever people live or work together in groups.

The two communication modes and their size-based substructures are:

Egalitarian, arising from the belief in equality among all, includes

- The **working group**, which is a temporary association of two to six people, each with useful skills, who come together for a specific purpose, work democratically, organize quickly and informally, and disband when the problem is solved. Leadership of working groups arises from within the group by consensus. Members function at the innate behavior level, meaning that no new or dramatically different communication skills or rules are necessary; and

- The **camp,** which is made up of six to thirty people who have little specialization, and whose job is to make decisions. Although the camp itself may deny having a leader, the camp is lead by a facilitator who is respected for knowledge judgments and skills in organizing opinion. The facilitator leads rather than commands the camp by focusing the decision-making process. The camp does not solve problems, merely makes decisions about how and what problems will be solved (once a decision is made about a problem, the camp delegates the work and smaller working groups, which solve the problem.) When the decision making process of the camp is disrupted, camps often split, forming new camps. Individuals are frequently members of both a working group and a camp, as is the case with most small businesses or companies.

Hierarchical, a system of ranks, one above another, including

- The **tribe**, which is made up of fifty to one hundred people and usually encompasses several camp-size groups. The tribe has a clearly defined leader, many strata, and clear lines of authority. It has well defined rules and patterns of behaviors, and is lead by a chief, who makes decisions for and gives orders and edicts to the tribe. Tribes solve the problem of instability in large organizations, but at the cost of personal and group autonomy. The purpose of the camp is bureaucratic to facilitate relations

with other camps (including conducting commerce and war), for conducting religious observations, and to allow occupational specialization; and

- The **state,** which is made up of one hundred or more people, and includes multiple tribes, camps, and working groups. Like the tribe, the purpose of the state is bureaucratic. A camp-like council (which, in the corporate structure, is the Board of Directors) leads the state.

The purpose of Tuck and Earle's research is to determine why Chief Executive Officers, or CEOs, fail. They find that CEOs frequently fail when a communication structure appropriate for one scale is used for groups of other sizes, as when, after promotion from the ranks, a CEO continues to use egalitarian communication modes when hierarchical modes are appropriate. They also find that that CEOs fail when they do not shift gracefully between modes, as when they move from communicating with their employees (hierarchical) to communicating with their board of directors (an egalitarian working group).

The universal differences Tuck and Earle find in communication modes attributed to group size might also be reflected in the culture of the Collaboratory, and could explain the slight but remarkable difference in preference for either informal, unstructured communication and flexible experiment planning within a

larger, structured environment, or more formal communication modes and well-planned experiments, and within them, informal and adaptive behaviors.

Conceivably, collaboratory participants might function in all four group sizes simultaneously: as a member of a working group (as on a specific experiment); as a member of a camp (in their role as a researcher associated with a specific collaboratory); as a member of a tribe (as in collaboratory management or administration within a larger laboratory environment); and as a member of a state (as in their place with larger U.S. National Laboratories or with government funding agencies.) Each collaboratory implementation might also need to support all four group sizes. Clearly, a keener understanding and mapping of the different communication modes and group sizes as they relate to the various collaboratory configurations, and on size-crossing participant roles, will shed light on the preference differences uncovered in the "rules of the road" portion of this Delphi. Such studies would also be useful for configuring automated collaboratory expert systems where the answer to a problem might be significantly different depending on which group size originates the problem, and from which size group a solution or opinion is offered.

"Skills Valued in Prospective Participants" - Discussion

In Round One of this Delphi, participants generated thirteen thoughts about skills they value in prospective collaboratory participants. Five of the thirteen thoughts were presented to the group using the same five-point Likert scale used in the "rules of the road" section. Participants were asked to indicate their level of agreement with each thought and were given the opportunity to make further comments and additions. Eight specific skills were also presented so participants could indicate on a scale of one to ten the level of value they had for each skill, with one being an unnecessary skill and ten being a mandatory skill.

Participants agreed unanimously and without further comment with two of the first eight thoughts generated in Round One. Those thoughts are:

1. Anyone who has a real project in mind (something they want to get done that is cumbersome using travel, email, fax) probably has the right mindset to go forward (trading difficulties of real-world interactions for the reduced difficulties of working via collaboratory).
2. Anyone looking for the perfect solution will probably be disappointed.

Three of the thoughts received substantial, though not unanimous agreement (although none of the statements was disagreed with). Those statements, with participant comments, are:

3. Know why the problem is important to study…enough so to get people interested in helping as well as justifying the time spent on the study.
4. Have some basic knowledge of the science. You don't have to be an expert, but you must be able to discuss it and provide appropriate support at your end to do what is necessary on your part.

> The fact that collaboratories can allow anyone, e.g. grade school students to access the best instruments in the country should not lead to the expectation that they will start winning most of the peer-reviewed time allotments.

5. Be willing to participate/help with other problems of appropriate nature. Don't expect to be helped without returning the favor at some time in the future, for some arbitrary participant.

Eight specific skills identified by participants in Round One were presented for ranking in value on a one-to-ten scale (one being an unnecessary skill, ten being a mandatory skill). One of the eight received a unanimously low ranking. The remaining seven skills, on average, were ranked 5.5 and above. None of the skills were ranked mandatory, and none were ranked unnecessary. Following is the ranking of those skills, in descending order of value, with mean rank on the one-to-ten scale in parentheses:

6. Tolerance for evolving technology and practices (7.5)
7. Good communication skills (7.0)
8. Good to expert scientific knowledge (6.5)

9. Experience in the (scientific) techniques used (6.25)
10. General team skills (6.25)
11. Familiarity with Internet technology and software (not at a programmer level, but someone who uses a desktop PC on a daily basis and is familiar with spreadsheets, data processing software, etc.) (5.75)
12. Good computer skills/computer literacy (5.5)
13. No one is an expert at everything but everyone has some expertise in something. We expect you to offer to share it when the right time comes (1.25).

"Skills Valued in Prospective Participants" - Analysis

Collaboratory Pioneers value a balance of social, technological, and scientific skills in prospective participants over a superior expertise in any one of them. Social skills identified include tolerance for evolving technologies and practices, good communication skills, team skills, adaptability, and willingness to share and contribute equally. Scientific and technological skills valued include good to expert scientific knowledge, familiarity with scientific techniques, and personal computer applications and Internet fluency. In addition, Collaboratory Pioneers value in prospective participants the ability to identify and articulate the importance of a particular scientific problem, to engender interest and

participation in that problem, and to recognize and be able to articulate the value of collaboratory work in excess of the impediments it might present without creating an inflated perception of collaboratory capabilities.

"Testing Perceptions" - Discussion

The final eight thoughts presented in the skills section were statements derived during Phase One of this research, and were not generated by the Delphi participants. These statements were included to test participant perceptions of these findings. Participants were asked to indicate whether they agree with, disagree with, have no comment on, or to indicate that the statement did not apply to the collaboratory.

Eight findings were generated during Phase One of this study. In Phase One, quantitative, taxono-bibliometric analysis of the library literature reveals a relatively equal contribution to collaboratory publications from the hard and soft sciences, and that the collaboratory is, by example, motivation, principles of interaction, and terminological heirarchy (Klein 1990, 56) an inherently interdisciplinary environment. Synoptic analysis of twenty-two Theory-Type Research publications produced four additional collaboratory principles:

- integration and adaptability are necessary and good
- change, choice, and personal power are requisite

- consensus, sharing and exchange are positive and practiced
- individuality and collectively are distinctly and respectfully maintained.

The absence of traditional male social and scientific behaviors, coupled with the traditionally female characteristics of these findings led to the emergent theory that the collaboratory is an ungendered environment, a theory that confirms, in part, the basic assumption that the collaboratory will fundamentally change the way science is done.

Two of these statements received unanimous agreement from Collaboratory Pioneers. Along with the comments, those statements are:

1. The collaboratory fundamentally changes the way science is done.

   Yes and no--science is still science, but I think Collaboratories do represent a revolution in flexibility and the ability to solve complex problems rapidly.

2. Integration and adaptability are necessary and good.

   Scientific experiments are by definition unique--collaborative problem solving software must be able to adapt to constantly changing procedures.

All but one participant (who had no response) disagreed with the statement "The collaboratory has been built from a relatively equal contribution from the hard and soft sciences." The statement generated only one comment:

> I think the deployment of Collaboratories is being driven by technologists and physical/biological scientists with collaboration needs. The soft sciences need to contribute more -- real world insights and advice,

> predictive models that help abstract the results of psychology, cognitive, group dynamics and other studies in controlled setting to the real world.

All but one participant (who disagreed) agreed with the statement "Change, choice, and personal power are requisite":

> Not requisite, but I think Collaboratories allow more change, choice, and personal power.

Two participants agreed with and two said the statement "consensus, sharing, and exchange are positive and practiced" did not apply.

> I agree, but Collaboratories are not communes--people share just as they did without a Collaboratory, except that Collaboratories make sharing easier, so (it) more naturally occurs, as appropriate.

Two participants agreed with, one had no response to, and one responded that the statement "Individuality and collectivity are distinctly and respectfully maintained," did not apply:

> Collaboratories do not change people's ideals about sharing, respect for individuality, etc., but by lowering barriers, they may bring practice closer to ideals.

All but one participant (who responded "does not apply') agree with the statement "The collaboratory is an interdisciplinary environment."

> Agree, although I think it used to be mainly one discipline and is perhaps still somewhat skewed that way. It is easier to get going in it if one is collaborating with remote colleagues in the same discipline.

> Collaboratories lower the barrier to interdisciplinary work, that's all. The drivers for interdisciplinary work come from outside (brought by researchers, sponsors, the public, etc.)

The statement, "The collaboratory is an ungendered environment" received the greatest variety of responses, a different response from each participant, including an agree, disagree, no response, and does not apply, but only one participant added a comment, "Agree, probably more so than a local environment."

"Testing Perceptions" - Analysis

The statements generated from Phase One of this study, and the reaction to them from collaboratory pioneers do not bear the weight of more than superficial analysis. Nevertheless, that collaboratory pioneers are unanimously unaware of the level and extent of social sciences' published contribution to the theoretical and practical research leading to collaboratory implementation warrants some comment and inference. First, the use of the word "built" in the question may have been misleading. Participants may have thought "built" meant actual, physical construction of the environment, and not theoretical or conceptual contributions to its development. Part of the knowledge gap these findings reveal is undoubtedly due in part to the library's failure to make collaboratory-related literature easily accessible (as discussed in Phase One) as well as to scientists' habit of reading and publishing in publications that are predominately within their own disciplines and specialties.

While it is not appropriate to project to the entire Collaboratory population from this thin study of collaboratory pioneers, it is appropriate to infer to the environment that an information opportunity exists within the Collaboratory for librarians and information specialists and researchers; that including librarians in collaboratory environments would benefit collaboratory participants and enhance online collaboratory resources; and that a general understanding of collaboratory practices and culture will position librarians, as educators, to prepare prospective participants, and prepare for prospective participants' information needs.

That the "ungendered" statement received a different response from each Delphi participant is significant. The range of responses could be because the concept of "ungendered" is difficult, highly subjective, and perhaps cannot be disassociated from the multifaceted definitions and perceptions of feminism as discussed in Phase One. The range of responses may also be based on individual personal experience, situational perceptions, or lack of interest in the issues it raises. Certainly, the theoretical ungenderedness of the Collaboratory developed in Phase One warrants testing in the functioning work environment of the collaboratory and should be explored along with group size communication modes and experiment planning preferences.

Conclusion of Phase Three

Phase Three of this study constructs an intersubjective reality of the collaboratory by engaging Collaboratory Pioneers in a Delphi Study to determine the "rules of the road" for the collaboratory and identify skills they value in prospective participants. Six Collaboratory Pioneers associated with collaboratories meeting the CIRAL criteria for inclusion developed in Chapter Five, who have "big picture" positions within those collaboratories, and who are also practicing collaboratory scientists, where solicited for this Delphi and agreed to participate.

The first round of the Delphi asked two questions: "What are the 'rules of the road' for the collaboratory, a question raised in NRC's (1993) *National Collaboratories: Applying Information Technology For Scientific Research,* and "What skills do you value in prospective collaboratory participants?" Four of the six participants responded. The Round One questionnaire generated twenty thoughts about "rules of the road" and twelve thoughts about "skills valued in prospective participants." Eight statements developed during the qualitative and quantitative analysis in Phases One were added, and a forty item web-based Round Two instrument was developed and resubmitted to participants. The instrument asked participants to indicate their level of agreement with thirty-two of the items, and to rank the value of eight items on a one-to-ten scale. A

comment box allowed participants to expand, explain, or add new items to the study. Four participants responded to the Round Two instrument. No further reduction to consensus or stasis was necessary to preliminarily identify the "rules of the road" for the collaboratory and the skills Collaboratory Pioneers value in prospective participants, which are enumerated below.

Based on the four responses, following are the "rules of the road" for the Collaboratory:

1. **Be direct in your communication**. If you have an idea, complaint, or any comment, say it. If you need something you must ask. Don't expect anyone to read your mind.
1. **Get involved** and get someone in the collaboratory interested in working with you on a problem.
2. **Have a real problem** that the collaboratory can help solve. Be able to articulate the problem and accurately express to others how the collaboratory can be used to resolve it.
3. **Understand the opportunities and limitations of collaboratory work.**
4. **Stay flexible** within a formal framework of meetings and experiments. Collaboratories must include a balance of planned, regular collaboratory meetings, experiment sessions, and formal project meetings, and unscheduled, informal meetings and spontaneous experimentation.

5. **Make frequent contributions** to collaboratory data repositories.
6. **Working in a collaboratory is not the same as being physically present in a laboratory.** Remote collaborators need to find ways to contribute to and share the "chores" of collaboratory work to compensate for their physical absence.

Following are the skills Collaboratory Pioneers value in prospective participants, in descending order of agreement:

1. Tolerance for evolving technology and practices
2. Good communication skills
3. Experience in the scientific techniques used
4. Good to expert scientific knowledge
5. General team skills
6. Computer application and Internet competence.

It was tempting to continue the Delphi beyond two rounds just to probe more deeply into the individual perceptions and opinions revealed in the comments, but given the number of participants, such a probe would reveal more about the individual participants than it would about the cultural environment of the collaboratory generally.

Four themes that warrant further research surfaced during Round Two. The first, a statement derived from Phase One's findings that the collaboratory has

been built from a relatively equal contribution from the hard and soft sciences, generated general disagreement from Delphi Pioneers. As discussed, this disagreement may stem from differing interpretations of the word "built." The respondents may consider "built" to mean physically constructed and technologically implemented, rather than conceptually designed or theoretically explored, as Phase One's exploration and interpretation of the literature implies. It may also reflect the exact opposite attitude Wulf warned about in his *White Paper* : instead of theoretical researchers having problems accepting the value of practical, technological research, perhaps practical, technological researchers do not recognize the value of theoretical, conceptutal research work.

The second and third themes that warrant additional research are closely related, if not intertwined, and concern the balance between informal communications and flexible experiment planning, and formal communication and rigid experiment planning. Group size is suggested as a possible reason for the differences of opinion and preferences. The fourth theme concerns finding a balance of contribution to or a new sharing ethic between on-site and remotely located collaborators.

That collaboratory pioneers underestimate the contribution that social sciences have made to collaboratory research is a knowledge gap that may also be attributed to shortcomings in the library's indexing and classification practices,

and to scientist's tendency to maintain disciplinary focus in their reading. The issues of preferences in level and mix of communication modes, experiment flexibility, and the collaboratory sharing ethic may be attributed to group size. Expansive research in each of these four areas will be useful during continued design of collaboratory interfaces and will shed light on the information needs of collaboratory scientists.

The emergent population of collaboratory scientist may also be fertile ground for future investigations. Since each of the pioneers is first a disciplinary scientist, and second an implementing technologist, this population may hold clues about the changing nature of the role of scientist, and the impact of technology not only on the way they do their science, but the division of their labor between their science and technology.

CONCLUSION OF THE STUDY

Many different influences impinge on the creation of knowledge. Evolutionary-cybernetic epistemology as explored by the Principia Cyberneticia Project (http://pespmc1.vub.ac.be/) is concerned with the broad domain of cybernetics and general systems theory (Bertalanffy 1968), and specifically the transdisciplinary study of organizations, communication, control and modeling (Heylighen 1993, 1997). Their metasystem design theory identifies three "super classes" of influence that embody understanding and development of holistic knowledge: the objective, subjective, and intersubjective.

Objective knowledge is derived from an external object, is measured by the reliability of predictions to which it leads, and is judged by the criteria of distinctiveness, invariance, and controllability. Subjective knowledge is the measure of ease with which knowledge is individually accepted, and is judged by individual utility, coherence, complexity, and novelty. Intersubjective knowledge is a measure of fitness of knowledge with respect to the community of carriers, and is measured by formality, conformity, infectiousness or publicity, expressivity, collective utility, and authority (http://pespmc1.bub.ac.be/KNOWSELC.html).

This study explores the information environment of the collaboratory from each of these perspectives, in linear sequence. In Phase One, an objective

reality of the collaboratory is constructed using quantitative taxono-bibliometric analysis of collaboratory-specific publications (n=86) made available through the world's libraries, and synoptic content analysis of the subset (n=22) Theory-Type Research publications. Phase One determines that the collaboratory literature reflects a relatively equal contribution from the hard and soft sciences, and that theoretically, the collaboratory, as an environment, is inherently interdisciplinary and ungendered.

Phase Two constructs a subjective reality of the collaboratory based on prolonged immersion in the online environment. Phase Two determines that the collaboratory is an instrumentally-determined social environment comprising unique and individual configurations that variously combine modes of communication and media, and generate unique combinations of data stores.

Phase Three constructs an intersubjective reality of the collaboratory via a Delphi among collaboratory pioneers. Phase Three identifies the "rules of the road" for the collaboratory and the skills Collaboratory Pioneers value in prospective participants. It finds intersubjective cognitive dissonance with Phase One's objective, theoretical findings of relative equality of contribution, and ungenderedness, and determines that in the collaboratory, size matters and explores groups size is a determinant in the subtle yet distinct differences in

preference for mix of informal and formal communication modes, and flexible and rigid experiment planning.

Traditionally, the objective, subjective, and intersubjective routes to knowledge construction are linear and sequential. The traditional academic route is from literature analysis, to laboratory experience, to interaction with peer groups though conferences and the peer review publication process. Implicit in the assumption that the collaboratory will fundamentally change the way science is done is the notion that the objective, subjective, and intersubjective will somehow fuse online, ideally resulting in new ways of knowing, and more pragmatically in a quickening in time of the thought-to-finish process. McLuhan observed that, at first, new technologies are always used to do old tasks until some driving force causes those technologies to be used in new ways. This study finds the collaboratory at the juncture of old tasks and driving forces.

Phase One's analysis of the library holdings reveals objectively that the collaboratory, as measured by collaboratory-specific publications generally and by Theory-Type Research publications specifically, has been built, at least theoretically and conceptually, from a relatively equal contribution from the hard and soft sciences. However, Phase Three's Delphi among collaboratory pioneers reveals a near unanimous perception that the opposite is true. This gap in understanding, or cognitive dissonance, can be variously attributed. First, the

dissonance can be attributed to the use of and possible misinterpretation of the word "built" in this research. Second, the comprehensive identification and collection of the collaboratory literature as described in Phase One reflects the libraries' general failure to provide or facilitate adequate and easy access to the emerging body of knowledge, either because of shortcoming in cataloging, classification, and indexing and abstracting schemes that perpetuate disciplinary separation and lack of consilience, or its failure to develop access tools that overcome the disciplinary focus and isolating tendency of periodical publishers and database services.

The subjective reality created in Phase Two reveals no direct or continuing involvement by librarians and information professionals in the design and configuration of collaboratory interfaces and information resources, and a remarkable lack of standard electronic librarianship. Collaboratories have been built, that is, physically constructed, by collaboratory scientists, that is, scientists with a primary discipline like materials science, physics, or molecular biology, who have been motivated by need or interest to take their science online. The **CIRAL** criteria for inclusion as a functioning collaboratory developed in Chapter Six includes digital library resources and services. While each of the collaboratories explored in Chapters Seven and Eight provide links to external information resources, not one includes the services of a librarian, nor do the

resources appear to have been developed by human information needs-centered professionals.

Despite the collaboratory's promise of new ways of doing science, Phase Two of this study finds that collaboratory work reflects the traditional ways of doing science, but that it is done with the new medium of computerized networks. Like the laboratory, the collaboratory is a "place to go" to do aspects of traditional science, namely experiments, but is not yet a holistic, integrated information environment capable of supporting new ways of doing science. Scientists must still "go" elsewhere (even if electronically) to conduct literature searches, they must still relate their experiment and results to a disconnected and scattered body of knowledge, and they must still write and publish their findings elsewhere, they must still manually search and retrieve relevant and pertinent information to support their work, for themselves. Beyond overcoming the problem of space, that is, the necessity to be physically present at an instrument in order to participant in an experiment, the unique capabilities of the computer have not been exploited to maximize the information efficiency of the collaboratory. The processes of constructing a consilient objective, subjective, and intersubjective knowledge environment are in their very elementary stages. The potential information flows to support collaboratory work have not been automated to the

collaboratory interface, and the extensive data stores generated by collaboratory activity have not been made accessible for expansive research.

Research Needs

The collaboratory was formally visioned by William Wulf in 1988 and first fully implemented in 1997. The environment is young. Collaboratory Science is now widening its focus from technological implementation to include cultural and psychosocial aspects of collaboratory work. The opportunity to address the information needs identified by this research is at hand.

This study identifies several areas of needed research:

1. The preliminary findings of this study need to be confirmed with more experts and in different collaboratories.
2. Evaluation and analysis of existing collaboratory data stores with an eye toward:
    - exploiting those stores to provide automated, intelligent information flow to the collaboratory interface, and
    - consilient, expansive studies of collaboratory work practices.
    - mapping and modeling the actual work practices and information needs of collaboratory participants as they relate to trust building according to collaboratory size toward

- informing the design of collaboratory interfaces, and
- developing a Delphi-based Collaboratory Expert System.

3. Evaluation and analysis of extra-collaboratory information practices of collaboratory scientists as they relate to the library toward
   - developing a collaboratory science library, and within it,
   - discipline-, instrument-, and experiment-specific information resources pertinent to practicing collaboratory scientists.

These specific areas of research can be tackled from a variety of perspectives, both on-site and virtually. The perspective and question raised by Wulf (1988) and reflected in the National Science Foundation's current Knowledge and Distributed Intelligence (KDI) research agenda, "*Why* do scientists collaborate online?" will provide knowledge about motivation and insights into new tools that might be developed. The perspective "*How* do scientists collaborate online?" will provide knowledge about existing practices and how the current generation of tools might be improved. Each perspective generates a unique set of research questions, all of which can be tackled with both quantitative and qualitative information studies techniques. The purpose of this study is to create a foundation on which such expansive research might rest.

As the collaboratory continues its evolution from old science with new tools, to new science, and as the collaboratory becomes more widely available, careful

attention to the emergence of new rules and the need for new skills is necessary. An expansion of this study's Delphi to a larger population will allow the rules and skills identified to be more widely extrapolated will allow keener investigation of the size issue, and inform the development of Collaboratory Expert Systems. However, rules and skills are reflections of a culture in time, and care must be taken that the rules of one group are not imposed by perceived authority on subsequent groups.

The collaboratory is a new culture, inhabited by new class of scientist, the Collaboratory Scientist, who brings disciplinary expertise to the virtual environment. This study finds the cultural and organizational rules of Collaboratory Science remarkably, if not dramatically, different than those of traditional science, and supports Wulf (1988), and Lederberg and Uncapher's (1989) assumption that the collaboratory will bring fundamental changes to the way science is done. Certainly, the change is technological, in that what was once done in person is now done via computer networks, but there is also theoretical evidence that the change is sociocultural and might be linked to the ungenderedness of the environment and the need to incorporate traditionally female behaviors. But, while this study finds no evidence of gender bias in either behavior or presentation of the online collaboratory, it also finds no compelling evidence that collaboratory participants agree. Of course, this could be because

they are part of the system, a position that keeps them from seeing the system in its entirety (Bertallanfy 1968).

The collaboratory is a purposively designed and executed virtual scientific information environment executed from within the traditionally male-dominated environments of science and technology. It is remarkable, and to the credit of those scientists and technologists, that theoretically the collaboratory, by design, requires collaboratory scientists to practice traditionally female behaviors such as cooperation rather than competition, and group rather than individual work.

As a new and yet largely unpopulated environment the collaboratory is now available for use by scientists, technologists, and educators worldwide. Armed with the "rules of the road" and knowledge of the skills valued in prospective participants, educators, librarians, and other information professionals are positioned to assist and facilitate the transition toward and evolution of this newly constructed information and knowledge environment.

As the driving forces that lead to the new science of the collaboratory emerge, library information science has new opportunities to be of service. With its unique and specialized knowledge of the delicate nuances and proclivities of human information-seeking behaviors, and its special ability to recognize and mediate information needs, library information science is uniquely positioned to inform development of new tools and interfaces, and faces a grand challenge in

organizing digital library and information resources and service in support of Collaboratory Science. The day of the Collaboratory Librarian has arrived.

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APPENDIXES

Appendix A: The Collaboratory Literature Retrieval Set, Annotated

Appendix B: CIRAL Matrix for Inclusion as Collaboratory

Appendix C: Phase Two Consent Form

Appendix D: Phase Three Consent Form

Appendix E: Delphi Round One Questionnaire

Appendix F: Delphi Round Two Instrument

APPENDIX A

The Collaboratory Literature Retrieval Set, Annotated

♦Bulleted articles are the theory-type research articles (n=22) analyzed in Chapter Five.

Agarwal, D.A., S.R. Sachs, W.E. Johnston. 1998. The reality of collaboratories. *Computer Physics Communications.* 110(1-3) : 134-141.

General introduction to Spectro-Nmicroscopy Facility of the Advanced Light Source, Lawrence Berkeley National Lab. Presents design of prototype, lessons learned, software architecture and components.

Allen, William H. 1993. The rise of the botanical database. *Bioscience* 43(5) : 274-279.

Advice on use of botanical database presented, new way of asking questions.

Allman, William F. 1993. Pioneering the electronic frontier. *US News and World Report* 115 (December) : 56-63.

News feature about people and how they use technology to collaborate. Rich description.

♦Andersson, Jan, and Jerker Ronnerg. 1996. Collaboration and memory: Effects of dyadic retrieval on different memory tasks*. Applied Cognitive Psychology* 10 (February) : 171-181.

Experiment, collaborative retrieval - 2 experiments: how different types of memory tasks were affected by two individuals working together compared to working on their own.

♦Ashton, Sarah, and Philippa Levy. 1998. European research letter: Networked learner support in higher education: Initiatives in professional development and research for a new role. *JASIS* 49 (July) : 850-853.

Libraries in support of networked learning, cultural change, professional development needs - teacher training, NLS - Networked learner support. U of Sheffield.

Banks, Peter M. 1993. "Collaboratory" principles. *Science* 262 (November) : 974.

Pre-Wulf history of collaboratory, rebuttal to Wulf 1993.

♦Barua, Anitesh, Ramnath Chellappa, and Andrew B. Whinston. 1995. Creating a collaboratory in cyberspace: Theoretical foundation and implementation. *Journal of Organizational Computing* 5(4) : 417-442.

Complementarity theory development. implementation description, theory-based approach to the development of collaboratories on the Internet based on complementarity theory. Provides conceptual foundation for designing to maximize users' value through judicious choice of complementary design factors, document-centric, multimedia iterations between users http://cism.bus.utexas.edu Univ of Texas MIS collaboratory

♦_____. 1996-1997. The design and development of Internet- and intranet-based collaboratories. *International Journal of Electronic Commerce* 1 (Winter) : 32-58.

Web deployment, calls for shift from proprietary to open standard collaboratory tools, and integration with databases. Enumerates and analyzes requirements for three types of collaboratory: individuals with overlapping interests but no formal ties, special-interest groups, organizations with interdependent workgroups. Reports results of a survey of the first collaboratory's users, which supports the theoretical platform shift for integration.

Birrell, James R., et al. 1998. Cooperative learning returns to college: What evidence is there that it works? *Change* 30 (July/August).

Report, what is cooperative learning? Theoretical roots, history, research report, differences among theories.

Bradley, Diane, and Janet Frederick. 1994. The Clinton electronic communications project: An experiment in electronic democracy. *Internet Research* 4 (Spring) : 64-70.

Research report. Determines degree to which White House material posted to net is more current and comprehensive than info available through more traditional means. Virtual vs. print currency.

Briefs: ARDIS e-mail support. 1995. *Computerworld* (December 11): 59.

Wireless multimedia collaboratory development.

Burns, Sara L., and Stephen E. Laubach. 1997. Virtual collaboratory, frac city, facilitates geoscientific collaboration and technology transfer. *Proceedings of the Geoscience Information Society* 28 (46): 111-115.

Design, report of implementation, problems inherent in distributed collaboration. describes "virtual collaboratory" web-based, database, hosted by 3rd party, for quick deployment and retirement, to promote the research to the interested public (113), http://www.frac-city.org

Casper, T.A., B. Howard, R. Hunt, et. al. 1989. Remote experimental environment: Building a collaboratory for fusion research. *Computers in Physics* 12 (May/June) : 220-226.

Implementation - testbed - description of. advanced computing, control, and collaboration DIII-D Tokamak, interactive remote participation in experiments. 1987-development, magnetic-fusion-energy research. Are the infrastructure and reports hidden in the physics literature, inaccessible by keyword? See bib for url Lawrence Livermore, LLNL, General Atomics, Oak Ridge National Laboratory (ORNL) and Princeton Plasma Physics Lab (PPPL). Hidden history in journal titles that don't use the word.

Chellapa, Ramnath, Anitesh Barua and Andrew B. Whinston. 1997. An electronic infrastructure for a virtual university. *Communications of the ACM* 40 (September) : 56-58.

Education implementation, goal-oriented. Virtual university- lacks conferencing.

Clement, John. 1992. Constructing the K-12 collaboratory on the NREN. *Educom Review* 27 (May/June): 18-20.

Column. Scalability, types of projects, need for communication among K-12.

♦Citera, Maryalice. 1998. Distributed teamwork: The impact of communication media on influence and decision quality. *JASIS* 49(9) : 792-800.

Research - media effects of communication, decision-making, evaluation apprehension, dominant communicators retain, regardless of media (face-to-face, telephone, computer); less dominant had higher levels of influence on phone, computer.

Computers seen revolutionizing research labs. 1991. *The Scientist* 5(18) : 1-2.

News type article wish list of visionary scientists. "Except it's not really a place, it's a distributed electronic environment."

Cooper, Jim. 1993. "Collaboratory" hopes to drive superhighway. *Broadcasting and Cable* 123 (December) : 58.

"Collaboratory on Information Infrastructure" formed to form superhighway, Bellcore and media companies...video transmission over copper wires.

Dede, Chris. 1996. Emerging technologies in distance education for business. *Journal of Education for Business* 71 (March) : 197-204.

Report of research, "collective good" social network capital, knowledge captial, knowledge webs, communication, edu for business, disinhibition, CoVis

_____. 1997. Rethinking: How to invest in technology. *Educational Leadership* 55 (November) : 12-16

Education application. "distributed learning."

Denley, Ian, and Andy Whitefield. 1998. A case history in applying task analysis in the design of a multimedia cooperative document production system. *JASIS* 49 (July) : 817-831.

Describes design and analysis work in development of a multiauthor, multimedia document production system (MAMMDPP)

Dessy, Raymond E. 1997. Der Wir Prinzip. *Analytical Chemistry News and Features* 69 (December) : 741A-742A.

Review of web configurations and considerations, lots of URLS. Refers to NetMeeting, mostly about conferencing. Change. "Bayesian" approaches

Edelson, Daniel C, Pea, Roy D., Gomez, Louis M. 1996. The collaboratory notebook. *Communications of the ACM* 39 (April) : 32-33.

CoVis software- url provided

Edelson, Daniel C., et al. 1995. A design for effective support of inquiry and collaboration. *CSCL '95 Proceedings* 36 (October) : 107-111.

Examines the design goals of the collab notebook….software. (shared hypermedia databased to provide scaffold for students as they learn to collaborate). Reviews studies in sociology of knowledge.

Eroom 2.0: The easy way to collaborate. 1998. *PC World* 16 (July) : 84.

Eroom 2.0 collaboration software introduction.

Finholt, Thomas A. 1995. Evaluation of electronic work: Research on collaboratories at the University of Michigan. *SIGOIS Bulletin* 16 (December) : 49-51.

Research update (NSF supported), historical. Role of behavioral sciences. implications for studying digital libraries, UARC description. Medical collaboratory. Design philosophy, Role of behavioral science, implications for studying digital libraries

Finhold, Thomas A. and Gary M. Olson. 1997. From laboratories to collaboratories: A new organizational form for scientific collaboration. *Psychological Science* 8 (January) : 28-37.

General article. Examines collaboratories in physical sciences and potential impact on psychological science, collaboratories will not themselves change science, authors from umich. Contains TABLE OF ADDRESSES OF ONLINE COLLABORATORIES, 5 medicine, one humanities, 2 chemistry, 3 biology, 2 space. Includes MOOs as collabs. Research "has not been guided by a grand plan" (29).

♦Fox, Geoffrey C. and Jojtek Furmanski. 1995. The use of the national information infrastructure and high performance computers in industry. In *Proceedings of the Second International Conference on Massively Parallel processing Using Optical Interconnections.* Los Alamitos, CA: IEEE Computer Society Press : 298-312.

Infrastructure, future of the web. Open technologies. Application areas: business, health care, defense, education, collaboratory, manufacturing.

♦Glasner, Peter. 1996. From community to 'collaboratory'? The Human Genome Mapping Project and the changing culture of science. *Science and Public Policy* 23 (April): 109-116.

Research, culture. Attempt to conceptualize scientific communities in sociology, virtual has no real impact on accepted views of the culture of science, environment may be better for small, rather than "big science." Why some scientists don't use. Double-blind situations "Cyberplatonic Dream." Based on research of Human Genome Mapping Project Worm Community System nice definitions of science, 4 levels of published information (112).

♦Haga, Hirohide. 1996. Generic model of collaboration*. The Science and Engineering Review of Doshisha University* 37 (July) : 34-44.

Theory. Model of collaboration based on participant and commitment functions by providing values to attribute to information flow. Model of asynchronous collaboration proposed. Five typical examples of new collaboration types, 4 elements: information flow with attributes, a set of participants, a function from one information flow to the subset of

participants (participant function), and a function from one participant to the subset of information flows (commitment function).

Hardin, Steve R. 1998. Michael Schrage and collaboration: Delivering information services through collaboration. *Bulletin of the American Society for Information Science* 24 (August/September) : 6-8.

Interview with Michael Schrage: information, relationships, augmentation, automation.

♦Harper, Richard, and Abigail Sellen. 1995. Collaborative tools and the practicalities of professional work at the Internatinoal Monetary Fund. *CHI '95 Proceedings Papers*. http://www.acm.org/sigchi/chi95/Electronic/documnts/papers/rh_bdy.htm

Cultural inertia argument for need for paper. Accessed 9/98. Which info good for paper, which for digital. Reuse of information. Media richness. Judgement.

Henline, Pamela, Compiler and Editor. 1998. Eight collaboratory summaries. *Interactions* 5 (May) : 66-72. NY: Association for Computing Machinery.

Brief summary of eight implementations with URLS and funding info. Book listing.

♦Huang, Milton P. and Norman E. Alessi. 1996. The Internet and the future of psychiatry. *American Journal of Psychiatry* 153 (July) : 861-869.

Psychiatry model of Internet: four layers of people and technology that work together, must be grasped in entirety to be understood, factors.

IBM Develops Virtual City Web Site. 1997. *Newsbytes News Network* (May 16).

IBM forms institutional collaboratory http://www.ieg.ibm.com

♦Jeffay, K, J.K. Lin, J. Menges, et. al. 1992. Architecture of the artifact-based collaboration system matrix. *CSCW 92 Proceedings* (November): 195-202.

Describes a component of the UNC collaboratory project, argues need not new tools but better infrastructure for using single-user tools collectively. Design of software systems as a single whole. NSF funding.

Johnson, David W. 1998. Collaboration, communities, and Covey: A Model for personal and professional change. *Clearing House*. 71 (July/August) : 359-362.

Establishing collaborative relations, uses Stephen R. Covey's (1989) "The 7 Habits of Highly Effective People" as framework for initiating and sustaining teacher education reform in one elementary school within Brigham Young University Public School Partnership.

♦Karamuftuoglu, Murat. 1997. Designing language games in Okapi*. Journal of Documentation* 53 (January) : 69-73.

Information retrieval from perspective of semiotics (signs). Two conflicting speech acts: "detonation" transmits info from database to user. "prescriptives" can be used to invent new connections between documents, thus create new knowledge.

Keis, Jonathan K., Robert C. Williges, and Mary Beth Rosson. 1998. Coordinating computer-supported cooperative work: A Review of research issues and strategies. *JASIS* 49(9) : 776-791.

Review of research issues and strategies, roles different communication channels play in coordinating work in cooperative systems. Match to task, computer as a communication medium / outlines advantages, presents relevant socio-technical consideration, describes research methods available , Research issues and strategies for implementing CSCW.

Kiernan, Vincent. 1997. All the world's a lab. *New Scientist* 154 (April): 34-7.

Feature article. Description of various collabs -- good narrative, Tonner at Uwisc-Madison / Lawrence Berkeley Nat'l Lab , X-ray beam - spectro-microscopy facility.

Kilman, David G. and David W. Forshund. 1997. An international collaboratory based on virtual patient records. *Communications of the ACM* 40(8) : 110-117.

Describes collaboratory patient virtual records. See TeleMed (Online), concept of collab, rich description of use. http://www.acl.lanl.gov/TeleMed Concept, culture of collab, international.

Kling, Rob. 1991. Cooperation, coordination and control in computer-supported work. *Communications of the ACM* 34(12): 24.

Conjunction of technology, users, and worldview, CSCW --- C words.

Kouzes, Richard T. 1995. Creating the cyberspace laboratory. *The World and I* 10. Washington, DC: The Washington Times Corp.

Collaboratory basics. Author is PNL molecular science lab collaboratory.

_____. 1997. Collaboratories: Can we work together apart?. *Scientific Computer and Automation* 14 (January): 52-54.

Conceptual introduction. Complex intertwining. the sociology of collaboration, groupware, functional requirement. See list of URLS to collab resouces on the web. http://www.scamag.com

Kouzes, Richard T, James D. Myers, and William A. Wulf. 1996. Collaboratories: doing science on the Internet. *Computer* 41 (August) : 40-46.

Overview, technical aspects, progress report. Technical, sociological challenges, barriers to adoption Prototypes, collaboratory types: peer-to-peer, mentor-student, interdisciplinary, producer-consumer.

Kovacs, Laszlo. 1998. Discovery of resources within a distributed library system. *Communications of the ACM* 41 (April): 78-79.

Technical limits, aims, expectations, intro, history of computational science, digital library, VRML color and spatial organizational structure. See URL for Digital Library collaboratory Working Group.

♦Kydd, Christine T. and Diane L. Ferry. 1991. Computer supported cooperative work tools and media richness: An integration of the literature. *Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences* IV(5) : 324-332. Eds. Jay F. Nunamaker, Jr. and Ralph H. Sprague,

Jr. Organizational Systems and Technology Track. Los Alamitos, CA: IEEE Computer Society Press.

Literature review. tools evaluation, presents an evaluation of the successes and failures of computer supported cooperative work tools in terms of a behavioral theory which suggests that information processing occurs during group work to 1. Reduce uncertainty and 2. Resolve eqivocality., Matching the situation with the appropriate tool is important to implementation success. If uncertainty is the issue, tools that transmit large amounts; if equivocality, those which are media rich. Surprising results of actual tools use.

Lepkowski, Wil. 1993. Information revolution offers policy challenges to researchers, other users*. News Edition of the American Chemical Society* 71(21) : 25-26. Easton, PA: The Society

Think tank reports from Council of Competitiveness and NRC 1993, Clinton agenda, dark side of the revolution: social polarization between information haves and have-nots.

Lewin, David I. 1996. An interview with Mark Ellisman: Building an imaging collaboratory. *Computers in Physics* 10 (Sep/Oct): 414-5.

Interview, report of project, molecular- and cellular-imaging collaboratory, National Center for Microscopy and Imaging Research (NCMIR) at UCSD. No url given.

Lyman, Peter. 1996. What is a digital library? Technology, intellectual property, and the public interest. *Daedalus* 125 (Fall): 1-33.

Visualization, collab= "a form of living textuality" see footnote 19. Digital library, social aspects, description. See footnote #4 re literacy. Reading. Space. "Is it possible to create public institutions in cyberspace?"

♦Mantovani, Giuseppe. 1995. Virtual reality as a communication environment: Consensual hallucination, fiction, and possible selves. *Human Relations* 48(6) : 669-683.

Virtual reality as a communication environment from point of view of social psychology. Reviews research on quality of current VR systems integrated

into self-identity theory. "technologies nurture specific political, ideological, and also mystical beliefs as essential aspects of their moral foundation."

McCune, Jenny C. 1998. Working together, but apart. *Management Review* 87 (September).

Intro to collaboration, collaboration gap - reasons for success and failure; need trust, technical and personal issues for failure.

McNamara, Sean. 1992. Australia: Cray and Swinburne form research center. *Newsbytes News Networks* (July).

Announcement of Australian Computational Research collaboratory (ACRC) for business and industry

Metcalfe, Bob. 1997. Electronic Taj Mahals might reduce travel to and from session breaks. *InfoWorld* 19 (January) : 44.

ACM collaboratory initiative, questions on design concepts, Wulf calls collabs "time machines." See urls and email addresses.

Lecture Notes in Computer Science. 1995. Migrating towards an European scientific collaboratory. Berlin: Springer-Verlag. 889(38) : 190-197.

"Tell me and I forget, show me and I remember, involve me and understand" -Chinese proverb (190) E-collaboratory in Europe. Explores migration steps to provide functionality.

♦Mitchell, Will, and Kulwant Singh. 1996. Survival of businesses using collaborative relationships to commercialize complex goods. *Strategic Management Journal* 17 (April) : 169-195.

Research - effects of collaboration on businesses delivering complex goods,

NTIS DIALOG(R)File265:FEDRIP#00343290. 1998. *Molecular interactive collaborative environments (MICE).* Principal Investigator: Bourne, Philip. 84. UC San Diego.

Research grant award announcement - continuing, abstract.

Olson, Gary M..1995. An appreciation of Laurence Rosenberg. *Communications of the ACM* 38(4) : 75.

Obiturary NSF collaboratory pioneer.

Olson, Gary M., Daniel E Atkins, Robert Clauer, et al. 1998. The Upper Atmospheric Research Collaboratory. *Interactions* 3 (May): : 48-55. NY: Association for Computing Machinery.

Feature Article. About Upper Atmospheric Research collaboratory. (UARC). Graphics of screen, traffic patterns, etc. information article.

Page, Heather. 1998. Remote control. *Entrepreneur* 62 (October): 149-153.

Overview of products, RULES. netmeeting, other software,

Paton, Graham. 1997. 'Information system' as intellectual construct--its only valid form. *Systems Research and Behavioral Science* 14(1) : 67-72.

Critique of the meme of information systems. proposes "holon" instead. Information and system deconstructed. Information is a particular parcel of knowledge acquired at a particular moment in time. Objects themselves are NOT information. Info system is an intellectual construct, its only valid form; computers are the tool. Layers, like ISO layers for internetworking...depends on what layer you are whether data is information, etc.

PNL plans environmental research on Internet. 1994. *Science* 265(5181) : 90.

Pacific Northwest Laboratories announcement

Reed, Daniel A., Roscoe C. Giles and Charles E. Catlett. 1997. Distributed data and immersive collaboration. *Communications of the ACM* 40 (November) : 38-48.

Feature article: technical limits, aims, expectations, introduction to concept. History of computational sciences follows same path as experimental science

♦Rice, Ronald E., Elizabeth More, and John D'Ambra. 1995. Cross-cultural comparison of organizational media evaluation and choice. *Proceedings of the 58th ASIS Annual Meeting Vol 32: Forging New Partnerships in Information*. Ed., Kinney, Tom. Medford NJ: Information Today, Inc.: 189-193.

Research, statistics, analyzes correlation among richness, eqivocality, and preferences, and differences among means and relationships across four countries.

♦Robbin, Alice. 1995. SIPP ACCESS, An information system for complex data: A case studying creating a collaboratory for the social sciences*. Internet Research* 5 (November) : 37-66.

Review of NRC 1993 report. Report of infrastructure implementation, report of human resources in design and implement. and education of users. evaluates selected aspects of one implementation, examines obstacles to collaboratory development for the social sciences uses relational database, overview of pre-Wulf collaboratory. "c-cubed" = communication, cooperation and collaboration.

Roe, Eunice M. 1993. Current affairs and contemporary issues collaboratory: Criteria for selecting resources. *14th National Online Meeting Proceedings* (May). Medford, NJ: Learned Information : 355-364.

Proposed collab for current affairs and contemporary issues, new skills for librarians. Sets librarian's criteria for selecting resources to support collab work...electronic. Develops collaboratory learning model (sphere in pyramid)…"because of the cognitive nature of the collaboratory, in which information is not just received, but where it is evaluated and manipulated and knowledge is constructed, usability factor takes on special importance."(361) Suggests that librarian needs to develop additional knowledge and skills.

Rome, James A.. 1998. Science from a distance: Molding a virtual laboratory. *The World and I* 13 (October) : 182.

Implementation. social issues, MMC use of telemicroscopes, Author from Oak Ridge National Lab see URL in body of article,

Rosenberg, Lawrence C. 1991. Update on the National Science Foundation funding of the "collaboratory". *Communications of the ACM* 34 (December) : 83-88.

Three programs: Coordination Theory and Collaboration Technology Special Initiative (CT2), Scientific Databases, Gigabit Network Project. collaboratory, cooperation, convivial, conflict, control, coercion, counter-productive conformity. "Need a more substantial shift from technological utopianism to social realism in the CSCW literature."(87).

Ross-Flanigan, Nancy. 1998. The virtues (and vices) of virtual colleagues. *MIT's Technology Review* 101 (March) : 52-59.

Collaborators may generate more ideas, but trust is hard to develop. Human aspects of working in Collab. Personal benefits and behaviors See URLS for Collabs.

♦Rugelj, Joze and Viktor Svigelj. 1997. Computer supported multimedia environment for the support of long-distance collaboration in medicine. *Tenth IEEE Symposium on Computer-Based Medical Systems*. Los Alamitos, CA: IEEE Computer Society Press : 215-260.

Architecture of medical collaboratory is designed to enable close ties between the collaborating partners, to accelerate the development and dissemination of basic knowledge, and to minimize the time-lag between diagnosis and corresponding treatment.

Ruhleder, Karen and John Leslie King. 1991. Computer support for work across space, time, and social worlds. *Journal of Organizational Computing* 1(4) : 341-355.

Examines the assumptions of the model of collaborative work behind the collaboratory. Success WOULD be worthy prize; challenge is daunting. Two functions: processing and communication of information. Need integrated functions, to understand social and organizational factors. "fuzzy social organization" of academic collaboration….human glue.

♦Schooler, E.M. Casner, S. and Postel, J. 1991. Multimedia conferencing: Has it come of age? 83. USC, Marina del Ray, Information Sciences Institute.

Research report, multimedia teleconferencing as key component of collaboratory, abstract.

Schrage, Michael. 1991. Computer Tools for Thinking in Tandem. *Science* 253 (August) : 505-7.

Report...state of the art, articles that get published are really historical things, creating copresence. the most important mode of collaboration is the literature interact dynamically and dialectically author of "Shared Minds." More like dialogue than set of soliloquies, "information cliques," "now the reader can structure the knowledge."

Science from a distance: security and collaboratories. 1998. *The World and I* 13(87).

Sheridan, Cormac. 1997. Come into the collaboratory. *Technology Ireland* 29 (September) : 32-4.

General report from UCD chemistry dept.

♦Swanson, G. A., Kenneth D. Bailey, and James Grier Miller. 1997. Entropy, social entropy and money: A living systems theory perspective. *Systems Research and Behavioral Science* 14(1) : 45-65.

Research paper, entropy as a measure of system disorganization. How entropy occurs and is measured in social systems. Role of money-information markers in the recurring organization and disorganization of social entities is identified as an aspect of social entropy, integrates living systems theory social entropy theory and macro accounting theory.

Thomas, Susan Gregory. 1996. Software that turns kids on. *US News and World Report* 121 (December) : 96-97.

Software. Children.

Towards a national collaboratory: The role of the electric library. 1989. *Information Intelligence, Online Libraries, and Microcomputers* 7 (December) : 1-4.

Report on role of Libraries in collaboratory: resources that would use telecommunications and computer technology to provide remote access to scarce and expensive national scientific assets as well as provide improved communications among the scientific community. three-fold research approach for Libraries proposed. Role of libraries in computer technology, telecommunication infrastructure and tools which would allow researchers to work with remote facilities (co-laboratory) and each other (collaborat-ory) as if they were in physical proximity.

♦Travica, Bob. 1995. Culture of collaboration: An exploration into the accounting industry. *Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences* IV(5) : 194-199. Eds. Jay F. Nunamaker, Jr. and Ralph H. Sprague, Jr. Organizational Systems and Technology Track. Los Alamitos, CA: IEEE Computer Society.

Research, exploratory study. "Culture of collaboration" among professionals in accounting firm, dimensions of exchange: knowledge exchange, reliance on colleagues in gathering information, sharing of accountability within work teams, sharing of trust among office colleagues, communication over team boundaries, reliance on IT in everyday work (194).

Wehrwein, Peter. 1998. US National Cancer Institute creates Cancer Genetics Network. *Lancet* 352 (August) : 460.

Announcement. of new network, cancer-bio. Databased. Internet provided: speed progress.

Weintrab, Hal, et. al. 1995. Through the glass lightly. *Science* 267 (March) : 1609-1618.

Scientists share their ideas of the future….to 2005. Genetics, biology, biochemistry, chemistry, physics.

♦Wilson, Paul. 1991. Computer supported cooperative work (CSCW): Origins, concepts and research initiatives. *Computer Networks and ISDN Systems* 23(1-3) : 91-95.

Report . Origins, concepts and research initiatives, origins of CSCW. components of CSCW. CSCW products. networking requirements and opportunities. Applicability of collaboratory to Europe.

Wulf, William A. 1989. Government's role in the national network. *Educom Review* 24(2) : 22-16.

Background of NSFNet development, why collaboratory is important, report following Rockefeller U workshop. "Analog wet lab" analogy

_____. 1993. The collaboratory opportunity. *Science* 261 (August) : 854-855.

Visualization…rehash of *White Paper* and Lederberg and Uncapher *Report*. See Banks (1993) for rebuttal about history of collab.

Zaluzec, N.J. 1996. Tele-Presence Microscopy/LabSpace: An interactive collaboratory for use in education and research. *Microscopy and Microanalysis Conference* 85 : 382-383.

Collab as merely an exercise in computer programming and digital control. Needs for "real collaboration" to happen.

Ziemba, Stanley. 1996. Ameritech Gives NU $1.8 Million. *Chicago Tribune* August 21. North Sports Final Edition.

Newspaper article, funding announcement, collaboratory. Northwestern University, Chicago.

APPENDIX B

The CIRAL Matrix for Inclusion as a Collaboratory

CIRAL (Criteria for Inclusion as a Collaboratory)	Issues and Factors							
	Individual				**Institutional**			
	Social	Organization	Technical	Practical	Social	Organization	Technical	Practical
Distributed Computing								
Networked Instruments & Tools								
Support Resources								
Data Archives								
Digital Libraries								

APPENDIX C

Phase Two Consent Form

From: http://www.intertwining.org/dissertation/consent/p2consen.htm

From: joanne twining, Doctoral Candidate
School of Library and Information Studies
Texas Woman's University
twining@texoma.net

To: Collaboratory Gatekeeper:

Request for Access to Collaboratory for Environmental Research

I am a Doctoral Candidate in the School of Library and Information Studies at Texas Woman's University. I am conducting dissertation research about the Collaboratory. My research uses Naturalistic Inquiry and has three intertwined phases. I seek your consent to enter your Collaboratory to gather environmental information for PhaseTwo of my study.

Phase Two creates a subjective reality of the Collaboratory based on immersion in the online ENVIRONMENT. Information gathering for Phase Two will include prolonged engagement with, and persistent observation of the online ENVIRONMENT of the Collaboratory.

I am NOT conducting research about individual Collaboratory participants. I am NOT seeking permission to participate in or report on ongoing Collaboratory research.

I am seeking permission to enter your Collaboratory as an ENVIRONMENTAL OBSERVER only. I will be conducting this research in several Collaboratories simultaneously in order to arrive at generalities about the ENVIRONMENT.

While I expect to interact variously with individual Collaboratory participants during Phase Two, these individuals are NOT the subject of

my study. While the names of the Collaboratories may be revealed in my research report, individual participants will NOT be identified, nor will individual behaviors or activities be investigated. All individuals with whom I interact will be informed that I am an ENVIRONMENTAL researcher and will be free to refuse contact.

Please grant permission for me to enter your Collaboratory as an environmental researcher by completing and submitting the brief consent form below. You will receive confirmation by return webpage. No further contact is necessary or anticipated.

If you prefer that your Collaboratory NOT participate in this research, or you wish to receive no further contact, please indicate by email.

If you have any questions about this request, you may contact me by email to twining@texoma.net or by phone at (903) xxx-xxxx. You may also contact my Dissertation Chair, Dr. John D'Angelo, by email at jdangelo@twu.edu or by phone at (940) 898-2617.

Texas Woman's University, Denton, Texas 76201
GATEKEEPER CONSENT TO ALLOW ACCESS FOR RESEARCH

Title of Study: A Naturalistic Journey into the Collaboratory: In Search of Understanding for Prospective Participants. Phase Two

Name of Investigator: joanne twining, email address: twining@texoma.net
Phone Number: (903) xxx-xxxx.

Name of Dissertation Chair: John D'Angelo, Ph.D., email address: jdangelo@twu.edu Phone Number: (940) 898-2617

I understand that this research study will gather information to create a subjective, interactive understanding of the online Collaboratory environment.

I understand that this research does not involve the investigation of or research into any individual Collaboratory participant.

I understand that his research does not involve the investigation of any ongoing Collaboratory research projects.

I understand that potential risk to the environment of the Collaboratory will be that the presence of the observing researcher might disrupt the normal work flow of and interaction between Collaboratory participants. I understand that the researcher will do everything possible to minimize this risk.

I understand that the researcher will keep all data securely stored on private computer and archival media. All data generated during this study will be erased immediately following completion of this study.

I understand that the personal benefits I can gain from participating in this study includes being able to provide input into research that will improve understanding about the Collaboratory by prospective participants.

I understand that participation in this study is voluntary and that I may withdraw the right of the researcher to enter the Collaboratory at any time. My refusal to participate or my withdrawal of right of entry will involve no penalty or loss of benefits to which I am otherwise entitled.

An offer has been made to answer all my questions and concerns about this study. If I have questions about the research or about my rights, I should ask the researchers. Their email addresses and phone numbers are at the top of this form. If I have questions later, or if I wish to report a problem, I may contact the researchers or the Texas Woman's University Office of Research & Grants Administration at (940) 898-3377.

The researchers will try to prevent any problem that could happen because of this research. I should let the researcher or the Doctoral Dissertation Committee Chair know at once if there is a problem and they will help me. I understand, however, that Texas Woman's University does not provide medical services or financial assistance for injuries that might happen because I am taking part in this research.

If you agree to allow access to your Collaboratory for environmental research, please provide the following information and SEND:

Name of your Collaboratory:
URL of your Collaboratory:
Your name:
Your title
Your email address
Your telephone number
Researcher access password (if required)
Please provide a verification code to confirm your consent:

Thank you!

If you prefer, you may print and return this page by postal mail to:
joanne twining
School of Library and Information Studies
Texas Woman's University
Denton, Texas 76204

If you would like to participate in a Delphi Among Collaboratory Pioneers to determine the "Rules of the Road" for the Collaboratory and identify the skills Collaboratory Pioneers value most in prospective participants, please read and complete the Delphi Consent Form.

You may also nominate other Collaboratory Projects for Phase Two of this study, or other Collaboratory Pioneers for the Phase Three Delphi by sending name, email address, or URL to twining@texoma.net

Complete information about this dissertation is at
http://www.intertwining.org/dissertation

Thank you for your help in this important research.
joanne twining
Placed May 04, 1999
-30-

APPENDIX D

Phase Three Consent Form

From: http://www.intertwining.org/dissertation/consent/p3consen.htm

From: joanne twining, Doctoral Candidate
School of Library and Information Studies
Texas Woman's University
twining@texoma.net

To: Collaboratory Pioneers

Invitation to Participate in Dissertation Research:
DELPHI AMONG COLLABORATORY PIONEERS

You are invited to participate in an electronic Delphi Among Collaboratory Pioneers

The Delphi is Phase Three of my doctoral dissertation research at the School of Library and Information Studies at Texas Woman's University. The purpose of the Delphi is to create an intersubjective reality among Collaboratory Pioneers by determining the "Rules of the Road" for the Collaboratory, and identifying skills Collaboratory Pioneers value most in prospective Collaboratory participants.

The Delphi will be conducted online using email and the web. The results of your efforts will provide useful information for future Collaboratory participants.

To protect the integrity of this study, you will be provided the names and email addresses of all participants in this Delphi. You are asked to not communicate with Delphi participants about this Delphi during the course of its execution.

You will receive three or four consecutive questionnaires by email or the web, the number depends on how easily the group moves toward consensus, or shared understanding. The goal is for consensus or

shared understanding to be reached by the end of the last questionnaire. Your responses will be tabulated after each round, themes will be determined, and your reactions to the relative importance of each theme will be solicited. You will be provided with information about how other participants responded to the questions so that you can see how your answers compared. Participant confidentiality will be maintained, however, since all identifying features, such as names, institutional affiliations, or revealing examples, will be removed from these instruments.

Your continuous participation throughout the entire process is highly desirable. If, however, extenuating circumstances require you to drop out, you may certainly do so without repercussions. It is important throughout for your participation to be completely voluntary.

Should you have any questions, please feel free to contact me by email to twining@texoma.net, or by phone: (903) xxx-xxxx. You may also contact my Dissertation Committee Chair, Dr. John D'Angelo, via email at jdangelo@twu.edu or by telephone at (940) 898-2617.

If you would like to participate in this Delphi Among Collaboratory Pioneers, please read the consent form below carefully, supply the requested information, and submit the form as soon as possible. You will receive confirmation by return webpage. Further instructions will be sent to the email address you provide.

If you prefer, you may print and sign this consent form and return by postal mail to:

joanne twining
School of Library and Information Studies
Texas Woman's University
P.O. Box 425438
Denton, Texas 76201-5438

Thank you for your consideration.

CONSENT FORM
Texas Woman's University, Denton, Texas 76201
CONSENT TO PARTICIPATE IN ELECTRONI DELPHI

Title of Study: A Naturalistic Journey into the Collaboratory: In Search of Understanding for Prospective Participants. Phase Three

Name of Investigator: joanne twining twining@texoma.net
Phone Number : (903) xxx-xxxx

Name of Dissertation Chair: John D'Angelo, Ph.D. jdangelo@twu.edu
Phone Number: (940) 898-2617

I understand that this research study will generate the "Rules of the Road" for Collaboratory and identify the skills that Collaboratory Pioneers most valued in prospective Collaboratory participants. I understand that I will be expected to complete and return three or four brief questionnaires in an attempt to achieve consensus. Each questionnaire is likely to take up to a half-hour to complete.

I understand that potential risks to me as a subject are
(a) the on-going commitment of time required and
(b) the danger of loss of confidentiality.

I realize that if I am not prepared to respond to each subsequent questionnaire, I should refuse to participate from the beginning, although if it does become necessary to back out of the study at some point due to unforeseen circumstances, I can do so without adverse repercussions. I understand that the researcher will keep all data securely stored on private computer and archival media. All data generated during this study will be erased immediately following completion of this study.

I understand that the personal benefits I can gain from participating in this study includes being able to provide input into research that will improve understanding about the Collaboratory by prospective participants. I understand that my anticipation in this study is voluntary and that I may withdraw from the study at any time. My refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled.

I understand that to preserve the integrity of the research, it will be necessary that fellow Delphi participants be aware that I am a participant. I understand that my name and email address will be included on a list of participants and that the list will be provided to all participants at the

beginning of the study. I understand that I should not communicate with fellow Delphi participants about the Delphi during its execution.

I understand that in subsequent rounds of the Delphi the names and identifying features of individual participants will be removed from any information turned back to the group so that no individual can be linked to a comment. I understand that no individual's identifying features will be included in any reports of the study.

An offer has been made to answer all my questions and concerns about this study. If I have questions about the research or about my rights as a subject, I should ask the researchers. Their email addresses and phone numbers are at the top of this form. If I have questions later, or if I wish to report a problem, I may contact the researchers or the Office of Research & Grants Administration at (940) 898-3377.

The researchers will try to prevent any problem that could happen because of this research. I should let the researcher or the Doctoral Dissertation Committee Chair know at once if there is a problem and they will help me. I understand, however, that Texas Woman's University does not provide medical services or financial assistance for injuries that might happen because I am taking part in this research.

If you agree to participate in an electronic
Delphi Among Collaboratory Pioneers,
please provide the following information and SEND this form

No additional contact is necessary or anticipated

Your Name:
Name of Your Collaboratory:
URL of Your Collaboratory:
Your email address:
Your Telephone Number:
Your Mailing Address:
Please provide a Validation Code that may be used to verify your consent in event of Audit:

Thank you.

If you would like to nominate other Collaboratory Pioneers for this study,
please send their name, email address or URL to twining@texoma.net
Full information about this dissertation research is available at
http://www.intertwining.org/dissertation

Thank you for your help in this important research.
joanne twining, Doctoral Candidate
School of Library and Information Studies
Texas Woman's University
Placed May 04, 1999
-30-

APPENDIX E

Round One Delphi Questionnaire

Subject: Delphi Among Collaboratory Pioneer
Date: Mon, 12 Jul 1999 08:52:32 -0500
From: twining <twining@texoma.net>
To: Delphi Pioneers via email

Hi. Thank you for participating in a "Delphi Among Collaboratory Pioneers." Please reply to this email by WEDNESDAY, JULY 21, 1999.

The Delphi Technique is a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with complex problems (Linstone and Turoff 1975). The Delphi is also being developed as a core technology for "Expert Collaborative Systems" (Turoff and Hiltz, in press). Delphi is accomplished though iterative rounds of individual expert responses and group synthesis.

This message is our first round questionnaire. It is an individual "brain storming" session. Please respond to the two questions below. Your responses need not be fully developed and your responses need not be justified. You do not even have to use complete sentences!

Participant responses will be synthesized and sent to the group as Round Two. You will not be identified and your responses will remain anonymous. You will have the opportunity to make comments, change your position, and make additions or deletions to Round One responses during Round Two.

Please feel free to contact me should you have questions or need more information about this research. I look forward to receiving your response soon, and hope to proceed to Round Two swiftly.

thanks again.
/s/joanne

_____

ROUND ONE "Delphi Among Collaboratory Pioneers"

The executive summary of the National Reseach Council's 1993 report, "National Collaboratories: Applying Information Technology for Scientific Research," says

"Collaboration tends to be easier on a small scale and when it is local: when a small number of individuals collaborate it is generally possible to proceed on the basis of mutual trust, but 'rules of the road' are needed for larger-scale collaboration." (NRC 1993, 3)

1. What are the 'rules of the road' for the collaboratory?

2. What skills do you value in prospective collaboratory participants?

--
joanne twining
twining@texoma.net
www.intertwining.org
-30-

APPENDIX F

Round Two Delphi Instrument

From http://www.intertwining.org/dissertation/round2.htm

Delphi Among Collaboratory Pioneers
Round Two

Thank you for your continued participation, and for sharing your time to support this dissertation research. This Round of our Delphi presents the ideas and thoughts generated in Round One. Please indicate your level of agreement with the thoughts below and freely add any comments you may have. There are 20 thoughts in the "rules of the road" section and 21 thoughts in the "skills" section. At the end of each set of thoughts you will have an opportunity to present new thoughts that we may have missed. Again, your thoughts need not be fully developed. Round Two responses will be synthesized and submitted to the group for comments.

Part One
"Rules of the Road"

Please indicate your level of agreement with each of the following thoughts by choosing one of the options provided. Please also use the comment box below each thought to explain, expand, or develop any of the thoughts (including any rules or practices, tips, or examples you may have developed for that situation).

1. Planned, regular collaboratory sessions stimulate a kind of frequent communication that colleagues "down the hall" might have.

Agree Somewhat Agree No comment Somewhat disagree Disagree

Comments:

2. Establish at the onset who will do which part of the experiment and followup analysis.

Agree Somewhat Agree No comment Somewhat disagree Disagree

Comments:

3. The difference between large and small collaboratories is not size but the informality of cross-organizational interactions.

Agree Somewhat Agree No comment Somewhat disagree Disagree

Comments:

4. Be flexible as experiments proceed, to change who does what, depending on how it goes.

Agree Somewhat Agree No Comment Somewhat disagree Disagree

Comments:

5. When researchers visit a collaboratory facility it is probably to complete an experiment resulting in publications; if a researcher pops into a virtual room/session and discusses ideas with colleagues, there may be no direct publishable artifacts.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

6. Decide how often to have a collaboratory session -- i.e. plan to have a daily, or a weekly or a bi-weekly session...to stimulate the kind of frequent communication colleagues down the hall might have.

Agree Somewhat Agree No comment Somewhat Disagree Disagree

Comments:

7. In the long run there are proven projects which can be enhanced by using a collaboratory.

Agree Somewhat Agree No comment Somewhat Disagree Disagree

Comments:

8. "Rules of the Road" are an attempt to find a balance between differing cultures.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

9. Collaborators must commit to making frequent deposits of data, notes, etc. to a shared electronic notebook or database or other appropriate repository so all collaborators can stay up to date and so progress of the research can be as efficient as stopping by a colleague's office down the hall to take a look at data.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

10. Be direct. If you have an idea, complaint, or any comment, say it. If you need something you must ask. Don't expect anyone to read your mind.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

11. In the Collaboratory the balance of trade in informal interaction may favor one person/culture/organization over another.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

12. Electronic interaction shifts work between collaborators. If a researcher goes to a facility to do an experiment, they are available to help with instrument maintenance and configuration, to get supplies from the storeroom, etc. A remote researcher is not.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

13. Trust takes time to build and the time constant is much longer when contact is less frequent due to time and/or distance.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

14. It is difficult to know what remote colleagues are doing daily since you don't pass by their office.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

15. Our inability to measure the value of informal interactions is one reason we organize--we get a common culture, i.e. people learn to provide similar amounts of informal help to each other; all the benefits of these interactions accrue to the organization; both these lessen the need to measure them.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

16. Like small-scale collaboratories, large scale collaboratories operate on trust, it just takes longer to get there.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

17. Because collaboratories are still new enough to be subsidized (we fund
development of tools and creation of virtual facilities, accept papers on these topics, etc.) buys time to get the rules right. As collaboratories become standard practice, the subsidies decrease, and the need to equalize the benefits will increase.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

18. You must get involved and get someone in the collaboratory interested in working with you on a problem.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

19. Unless collaborators embrace that collaboratory work will take extra time to get up to speed and is subject to glitches in technology and the Internet, the collaboration will be slowed down such that it will not compete as an effective alternative to traditional methods.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

20. We are at a stage where we realize that we will need 'rules of the road' but they are still ad hoc.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

Do you have new thoughts or additions to the responses to the original question, "What are the 'rules of the road' for the Collaboratory?"

Please share them here:

Part Two:
Skills Valued in Prospective Participants

1. Know why the problem is important to study...enough so to get people interested in helping as well as justifying the time spent on the study.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

2. Anyone who has a real project in mind (something they want to get done that is cumbersome using travel, email, fax) probably has the right mindset to go forward (trading difficulties of real-world interactions for the (hopefully) reduced difficulties of working via collaboratory.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

3. Have some basic knowledge of the science. You don't have to be an expert, but you must be able to discuss it and provide appropriate support at your end to do what is necessary on your part.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

4. Anyone looking for the perfect solution will probably be disappointed.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

5. Be willing to participate/help with other problems of appropriate nature. Don't expect to be helped without returning the favor at some time in the future, for some arbitrary participant.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

6. No one is an expert at everything, but everyone has some expertise in something. We expect you to offer to share it when the right time comes.

Agree Somewhat Agree No Comment Somewhat Disagree Disagree

Comments:

On a scale of one to ten (with one being unnecessary and ten being mandatory) please rate the value of the following skills in prospective participants:

7. Good to expert scientific knowledge

Comments:

8. Good communication skills

Comments:

9. Experience in the (scientific) techniques used

Comments:

10. Good computer skills /computer literacy

Comments:

11. Familiarity with Internet technology and software (not at a programmer level, but someone who uses a desktop PC on a daily basis and is familiar with spreadsheets, data processing software, etc.)

Comments:

12. Tolerance for evolving technology and practices.

Comments:

13. General team skills

Comments:

Please indicate your agreement or disagreement with the following theoretical statements as they are reflected in the actual practice of Collaboratory Science:

14. Integration and adaptability is necessary and good.

Comments:

15. Change, choice, and personal power are requisite.

Comments:

16. Consensus, sharing, and exchange are positive and practiced.

Comments:

17. Individuality and collectivity are distinctly and respectfully maintained.

Comments:

18. The collaboratory has been built from a relatively equal contribution from the hard and the soft sciences.

Comments:

19. The collaboratory is an interdisciplinary environment.

Comments:

20. The collaboratory is an ungendered environment.

Comments:

21. The collaboratory fundamentally changes the way science is done.

Comments:

Do you have new thoughts or additions to the responses to the original question, "What skills do you value in prospective participants?"

Please share them here:

Your Name: _____

Thank you! Please SEND your Round Two responses.

Responses will be synthesized and presented to the group for comments.

-30-