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User experience with cybercollaboration technologies

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Rochester Institute of Technology

College of Liberal Arts

Department of Psychology

USER EXPERIENCE WITH CYBERCOLLABORATION TECHNOLOGIES

By

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A Thesis in

Applied Experimental and Engineering Psychology

Submitted in partial fulfillment of the requirements for the degree of

Master of Science

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Abstract

This study focused on evaluating the usability of technologies for cybercollaboration via determining if traditional usability testing methods capable of evaluating virtual team collaboration among professionals and scientists of different disciplines. Exploration of this research was conducted via online survey administered to 72 participants from varied professional and scientific disciplines. This study explored several themes related to computer mediated collaboration, collaboration in science in general, usability of collaboration technologies, and usability testing. Past research was divided on whether software tools or processes are more important to team success. This research suggests that both together are important. Further, usability of cybercollaboration technologies cannot be evaluated by traditional software usability testing methods because the completion of collaborative tasks is intimately related to group dynamics and other areas of group collaboration such as social and work-process norms cannot be impacted by improved software utility. Improved cybercollaborative group work can come from ensuring efficient communication and decision-making processes within a software toolset that is not distracting to natural group or individual work dynamics and that provides basic affordances for document and data sharing.

Table of Contents

Acknowledgments.....	iii
Abstract.....	iv
Table of Contents.....	v
List of Figures.....	vii
List of Tables.....	viii
Introduction.....	1
Collaboration in Sciences.....	3
Technologies for Collaboration.....	4
Diverse Sciences, Diverse Technologies.....	6
Usability of Collaborative Technologies.....	8
Challenges for Usability Testing and Evaluation.....	10
Purpose of the Research.....	11
Participants.....	12
Apparatus.....	12
Survey.....	12
Procedure.....	14
Results.....	16
Participants.....	16

Analysis.....	17
Collaboration in Sciences	18
Technologies for Collaboration	20
Diverse Sciences, Diverse Technologies	23
Usability of Collaborative Technologies	25
Discussion	37
The Collaborative Nature of the Scientific Enterprise.....	38
Telecommunication Technologies in Scientific Collaboration.....	39
Variety of Collaborative Needs and Technologies	39
Usability of Collaborative Technologies	40
Conclusions.....	43
References.....	45
Appendix A – Tables	50
Appendix B – Survey.....	70

List of Figures

Figure 1. Preferences in Collaborative Tools for Geographically Dispersed Teams to Enhance Organization & Simulated Co-Location.	22
Figure 2. Aggregated Communication Methods Rated as Most Beneficial	24
Figure 3. Differences Developing Relationships and Gauging Contribution with Co-Located and Remote Colleagues	28
Figure 4. Percent of Respondents Seldom or Never Experiencing Cybercollaborative Difficulty	31
Figure 5. Importance of Datatype Sharing Functionality Types.....	35

List of Tables

Table 1. Frequency Ranking of Collaborative Methods.....	18
Table 2. Usage of Asynchronous Communication Methods for Co-Located Teams	25
Table 3. Success Influencers in Geographically Separated Teams.....	29
Table 4. Success Detractors in Geographically Separated Teams	30
Table 5. Frequency of Difficulty with Cybercollaboratory Environments.....	32
Table 6. Presence and Importance of Cybercollaborative Environment Features.....	34
Table 7. Importance of Datatype Sharing Functionality in Cybercollaborative Environments ...	35

Introduction

Scientific collaboration can be defined as two or more people collaborating on a project using scientific methods of data collection, manipulation, and analysis, typically involving professors, students, or scientists. Two minds are better than one, and when people collaborate they (a) accomplish more, (b) benefit from each other's experiences and expertise, and (c) influence each other and develop a greater understanding of the topic than when they work individually (Shah, 2008).

The nature of the scientific community is that it tends towards collaboration. Whether it is Chadwick and Rutherford collaborating to discover the neutron in 1932, the Manhattan Project during World War II, or today's huge fragmented co-authorship networks, scientists of the modern era have been and are currently working together to share and advance ideas. However, this was not always the case—before the 20th century, the tendency was towards individual contributors. This is apparent by the multitude of important ideas with particular names such as the Pythagorean theorem, Newton's laws of motion, and Einstein's theory of relativity. Dating back to Roman times, it is documented that even collaborative efforts such as the *Encyclopédie* was a result of combining many individuals' work rather than generating work from direct mutual labor on the same subjects (Beaver & Rosen, 1978). Even throughout the 19th century, the pervasiveness of collaborative work was stagnant, and it was not until the early 20th century that collaborative work became more widely adopted and began serious growth (Wagner-Döbler, 2001).

So why the recent tendency towards collaboration? Surely early contributors such as Newton and Einstein were immensely successful working in relative isolation, so what instigated this major change in the dynamic of the scientific enterprise? The answer is simple: complexity. As

our collective scientific knowledge has advanced, the questions we seek to answer are also more advanced, and in turn, science is more specialized. Whereas scientists like Charles Darwin explored (by today's standards) basic principles in a number of fields, evolution, psychology, ecology, and botany, a modern scientist is more likely to focus on one very specific topic – like what happens when you collide two atoms together at high speed. Scientific knowledge has expanded to such a degree that developing the necessary expertise to conduct innovative research represents an extremely large commitment of time and effort. In fact, lack of expertise is the primary reason that people collaborate when seeking information (Spence, Reddy, & Hall, 2005). Additionally, the resources and tools necessary to work on the cutting edge of science are immensely more complex, and come with substantial learning curves. According to Wuchty, Jones, and Uzzi (2007), the shifts toward teamwork follow from the increasing scale, complexity, and costs of scientific projects.

By the numbers, a trend towards increasing collaboration in sciences is quite clear. The team size in science/engineering has doubled from 1.9 to 3.5 authors per paper over the past 45 years (Wuchty et al., 2007). In social sciences back in 1955 only 17.5% of papers were written by multiple authors; in 2000, that percentage had risen to over 51.0%. In the United States Patent and Trademark Office, the average team size from 1975-2000 rose from 1.7 to 2.3 inventors per patent, and continues to grow. According to Newman (2004), the average number of collaborators on biology papers is 18.1, and the average number of authors is 3.75. Physics weighs in with 9.7 and 2.53 collaborators and authors respectively, and mathematics ends up with 3.9 and 1.45 collaborators and authors on average. These averages indicate that there is more than one person working on virtually every scholarly paper.

It is apparent that there are many reasons to collaborate, and many drivers of the trend towards larger collaborative groups and more effective research through cross-functional teams. Complexity, cost, team-building, helping underdeveloped nations, and increased research impact are all great reasons to engage in collaboration. However, large-scale collaboration is only made possible by supportive tools and technologies that enable scientists separated by distance to be as successful as proximal teams. In the next section we will discuss the scientific enterprise trending towards collaboration, the tools that afford distributed collaboration, and the social and psychological implications and concerns surrounding both.

Collaboration in Sciences

Premise 1: *The scientific enterprise is predominantly collaborative.* There are many reasons for collaboration. According to Spence et al. (2005), lack of expertise is the primary reason that people collaborate when seeking information. Shah (2008) stated that collaboration allows users to accomplish more, benefit from shared experiences/expertise, and develop a greater understanding of the topic than when working individually. Alternatively, Frame and Carpenter (1979) cited lack of resources as a strong driver of collaborative behavior among scientists, especially internationally. Similarly, suboptimal political climates can prevent proximal teams from forming and may require distance collaboration (Sooryamoorthy & Shrum, 2007).

Although costs and benefits must be weighed when making decisions to collaborate with people from other institutions or from other disciplines, the scientific community is trending toward increased collaboration over time (Cummings & Kiesler, 2005). Wuchty et al. (2007) attributed this shift to the increasing scale, complexity, and capital costs of science. Barabasi et al. (2001) gathered that scientists develop stronger bonds and more meaningful research relationships over time by observing that the average degree of separation between groups of co-authors of papers

is decreasing. Increased emphasis on team projects for university students in recent years may also be a contributing factor to increased collaboration. Students of science are required to work in teams specifically to develop collaboration skills, presentation skills, and enhanced social interaction skills (Gersting & Young, 1997). We can assume that it is natural for these students to have a higher affinity towards collaboration when they join the workforce.

Regardless of the reasons, the transition towards greater collaboration is noticeable. Wuchty et al. (2007) found that the team size in science/engineering doubled, and the percentage of papers written by multiple authors almost tripled over the past five decades. With respect to international scientific collaboration, data shows a constant upward trend in the amount of papers having affiliations in multiple countries from 1 in 10 papers in 1977 to nearly 4 in 10 papers by 2007 (Lorigo & Pellacini, 2007). As a general rule, basic fields such as physics and mathematics have higher levels of international collaboration than applied or clinical fields while chemistry falls somewhere in the middle (Frame & Carpenter, 1979). Regardless of disciplinary or geographic differences, one unmistakable driver of distributed scientific teamwork is technology, and the varied ways and methods that two or more people can interact with each other and their project data.

Technologies for Collaboration

Premise 2: *Telecommunication technologies have made scientific collaboration possible in (near) real time regardless of geographical distances between collaborators.* Technology is an enabler of scientific collaboration. Advanced networking enables people, tools, and information to be linked in ways that reduce barriers of location, time, institution, and discipline (Atkins et al., 2003). Workman (2007) found that virtually networked teams reduce costs and enable the uses of specific expertise regardless of geographic location. Further, advanced computing is no

longer restricted to a few research groups in weather prediction and high-energy physics but is now present in many other fields including engineering, biology, chemistry, social sciences, environmental science, and medicine (Atkins et al., 2003). International organizations are increasingly using virtual teams where members collaborate through technology-mediated interaction—however, even when people are located in the same building, most organizations these days seem to work by email and telephone (Stewart, 2007; Workman, 2007). The initial reaction may be to think that virtual collaboration is not an effective replacement for face-to-face collaboration, but Curtis and Lawson (2001) found that behaviors in face-to-face situations such as planning, contributing, seeking input, reflection/monitoring, and social interaction are also found in asynchronous, computer-mediated situations. Also, Ocker and Yaverbaum (1999) stated that computer-mediated collaboration is an effective replacement for face-to-face collaboration, specifically for learning, quality of solutions, solution content, and overall satisfaction with the solution quality. Even though traditional methods of communication are ranked higher in media rankings and preferred for collaboration in general, they may not be ideal for the specific projects that exist within the scientific enterprise (Spence et al, 2005; Sullivan, 1995).

Obviously there are trade-offs to virtual collaboration, but some technologies provide additional benefits that cannot be duplicated in-person such as asynchronicity: email and voicemail enable conversations to be carried out effectively without any parties ever being in contact at the same time (Stewart, 2007). However, a number of studies have found that face-to-face collaborators achieve higher performance scores (via testing) than those who collaborate online (van Joolingen, et al., 2005). Interestingly though, Spence et al. (2005) reported that collaborative information seeking activities are usually more successful than individual ones. Given these differing viewpoints, we can assume that virtual collaboration performance depends

on the task/project at hand. Different technologies also afford different benefits, and are in turn suited to different collaborative scientific projects. In the next section we will explore the relationship between the scientific task at-hand and the effectiveness of using a cybercollaboration to accomplish that task.

Diverse Sciences, Diverse Technologies

Premise 3. *Given the breadth of science (the number of differentiable disciplines and the number of different problems scientists work on) and the individual differences among scientists, there is a huge range of ways of scientific collaboration and preferences for tools and techniques to assist in them.* Since scientific problems have become more complex in recent years, a broad range of competencies is required to deal with technically and socially complex issues (Dewulf, Francois, Pahl-Wostl, & Taillieu, 2007; Wuchty et al., 2007). Moreover, cross-disciplinary knowledge is often necessary because many real world problems are not limited to one particular discipline or expertise but scientists from many fields may come together to work on one particular project and that the project becomes one of the only commonalities between them (Dewulf et al., 2007).

There are varying theories on what is necessary for collaborative success within a virtual workgroup. Kraut and Egidio (1998) believed that communication tools, coordination/management tools, and task-oriented tools were necessary for success. Nearly 10 years later, Greenberg's (2007) research indicated that task-technology fit, cultural differences, computer-mediated communication, team role preferences, team life cycles, incentives, conflict management, and trust are the factors that most influence the success of virtual teams. The differing theories depend on whether technologies or behaviors are the primary driver for

success. Dewulf et al. (2007) supported the behavioral theory by suggesting that reconciling of differences in concepts and meanings is crucial for project success.

Clearly there are a number of barriers to the success of a scientific virtual team working in collaboration. Some barriers are related to scientific teams in general, some are related to virtual teams in general, and some problems arise specifically with teams that are both scientific *and* virtual. In scientific teams, achieving consensus on the hypothesis, establishing methodologies, accessibility of cross-disciplinary data/publications, competitive nature, and ingrained unwillingness to trust others from outside disciplines are common barriers (Jordan, Ory, & Sher, 2005). Within scientific teams, Dewulf et al. (2007) showed that scientists' different backgrounds clashed in many ways, including (1) how the central project concepts are framed and defined, (2) the choice of research methods, and (3) ways of looking at ambiguity and uncertainty. Within virtual teams, Greenberg (2007) reported that when team members operate remotely from each other, familiar social and cultural norms are not available for influencing attitudes and encouraging cooperative behavior. Similarly, Kraut and Egidio (1998) stated that when team members are remotely located, the likelihood of high-quality communication involving more than one sensory channel is diminished. This type of interaction is especially important during the initiation and planning stages of a project when the need for rich communication modality is strongest (Kraut & Egidio, 1998). In the intersection of scientific and virtual teams problems such as only a small proportion of scientific data structures have been decoded for use in high-throughput data repositories (Duke, Day, Heery, Carr, & Coles, 2005). Also, other researchers have found that when scientists in particular get bad results sets from a search function, they will abandon the entire system in favor of another system, in-person collaboration, or offline (print) resources (Vibert, Rouet, Ros, Ramond, & Deshoullieres, 2007).

There are more barriers to technology-enabled collaboration than the ones integral to the tools. Psychological and sociological behaviors and differences also contribute to the success or failure of a collaborative project. Furthermore, these challenges can vary from project to project and from scientist to scientist.

Usability of Collaborative Technologies

Premise 4. *Usability of cybercollaboration technologies must be founded on two equally important principles: First, cybertechnologies should meet the existing needs of collaborators and provide affordances for new and more effective collaborative behaviors. Second, technology should not make exercising of existing, ingrained, collaborative techniques and behaviors difficult or impossible.*

Cybercollaboratory environments must both afford scientists the ability to use their trained research methods, and also provide features that encourage behaviors conducive to collaboration. Beca (2002) stated that these collaborative environments must provide the framework for interaction with the software application, and indirectly, with other group members. There is a fundamental problem with collaboratory systems in that they are intended to mimic/enable existing smoothly functioning work practices, but putting these behaviors into a computer system requires coordination from members above and beyond what they are accustomed to (Rogers & Ellis, 1994). Therefore, it is critically important that these interfaces take concepts from real life and are built around them, so as to limit the amount of information the user must remember (Beca, 2002). When information tasks are cognitively economical, they require less conscious attention to complete them successfully (Jones, 2005).

There are a number of challenges that arise when a cybercollaboratory system tries to meet the existing needs of scientists. Most of these challenges stem from differences between

members of a collaboratory group, both in terms of behaviors and work/method preferences. Per Mandviwalla and Olfman (1994), supporting multiple work methods may be the most challenging requirement. Groups seldom follow predefined work processes and their work methods cannot be predicted by a model. Mandviwalla and Olfman (1994) argued that behavioral characteristics may also come into play. If we use the example of a “choosing” task, that is, a number of collaborators required to decide on one method, process, etc., some scientists may prefer to choose privately and anonymously, while others may prefer to push for their choice publicly (Mandviwalla & Olfman, 1994). Each person (scientist or not) behaves differently when it comes to their commitment to projects, how they deal with stress, how they view their relationship with the group, and how they prefer to use their time. This makes it very difficult for any virtual environment to afford the best possible workspace for everyone. It is a challenge to even aggregate members’ behavioral preferences into a “lowest common denominator” system, because it is difficult to evaluate each behavioral characteristic’s relative importance (Mandviwalla & Olfman, 1994). Collaborative work activities are rarely straightforward actions as conceived in the cognitive sense—instead, they are fragmented by being both intertwined with each other and also heavily affected by social interaction (Rogers & Ellis, 1994).

McGrath (1984) further suggested that fitting unique scientific tasks to a common virtual collaboratory environment is difficult because of the differences between disciplines. Surely, the way a botanist thinks about and provides data will be very different from a water quality expert, or a chemist. In the same vein, information cannot be considered solely in terms of discrete content units but it is often edited and manipulated as a project progresses (Rogers & Ellis, 1994).

Any scientifically oriented cyberenvironment should support working in collaborative groups, but there are other issues that also factor in to the usability of such environments (van Joolingen, et al., 2005). For example, they should provide appropriate behavior and awareness information to support collaboration (Pankoke-Babatz & Syri, 1997). Furthermore, any modification of collaborative material must be made recognizable to others sharing the environment, and a history of the most recent changes, reasons for change, and discussions around change must be readily available (Pankoke-Babatz & Syri, 1997). Additional requirements include affording scientists their ingrained habits of communicating with members of the scientific community, and the ability to switch communication methods in response to the group dynamic or an increase in task criticality (Jones, 2005, Mandviwalla & Olfman, 1994). Perhaps the most crucial usability consideration for scientific group collaboration is user control, that is, providing scientists with highly flexible and programmable systems so that they can modify the software to their individual behavioral and work preferences (Mandviwalla & Olfman, 1994).

It is inadequate to simply incorporate “best practice” tools into the functionality of a cybercollaboratory environment. To ensure that the environment meets the needs of the scientists it is intended to support, testing must be done to validate proper/intended usage and identify potential gaps in functionality or ease-of-use.

Challenges for Usability Testing and Evaluation

Premise 5: *Traditional usability testing methods are unsuitable to evaluate the current and future cybercollaboration technologies.* Historically, usability testing methods on cybercollaboratory environments have been questioned because they use the proxy of an individual user performing an isolated task to study collaborative work processes. Clearly, for

testing to hold up under scrutiny, it must accommodate and recognize the importance of the fragmented characteristics of work activity (Rogers & Ellis, 1994). Since conventional usability testing can be cost prohibitive, it is ideal to use some amount of automation to capture a range of standardized information that can be analyzed and flexibly used (Au, Baker, Warren, & Dobbie, 2008). All usability testing methods require that participants do real tasks, and the participants represent real users (Dumas & Redish, 1994). For testing scientific cybercollaboratory environments, the latter is easily achieved by using real scientists. Imitating real tasks will prove to be difficult though, given that so much of scientific collaboration is made up of behavioral and individual nuances. Furthermore, formal statistics may not be of value in analyzing certain behaviors, because “numbers” do not capture the intangible nature of these activities (Daft & Lengel, 1996).

One solution to gathering meaningful behavioral data are surveys. Surveys can be used to gather information about opinions, attitudes, and preferences (Dumas & Redish, 1994). Although surveys do not directly observe and record what users are doing within the environment, they do follow the characteristics of usability testing by recording data, which can be analyzed and diagnosed. Additionally, questions based on participants’ previous experiences can often improve the accuracy and validity of survey data (Dumas & Redish, 1994).

Purpose of the Research

The purpose of this research was to evaluate current tools and technologies for cybercollaboration and also methods of testing their usability directly pertaining to the five individual premises described above. The research addressed collaborative nature and technology use as indicated in premises 1 and 2, preferences and affordances as indicated in premises 3 and 4, and evaluation of a survey as a usability testing method per premise 5.

Method

Participants

Participants were solicited by email to respond to an online survey. Emails were sent to all faculty at Rochester Institute of Technology (RIT), scientists who worked on the NSF HydroSynthesis Project, the NSF Long Term Groundwater Monitoring Project, the TeraGrid User Portal, the caGrid Portal, the Climate Collaboratorium at MIT, and the WATERS Network Planning Project, personnel of a digital advertising agency with a national presence, and other business professionals. The responses were collected between May 14th and June 18th, 2010.

Apparatus

The thirty-two question usability survey was administered through RIT's Clipboard online survey tool. Clipboard is a web-hosted survey platform that allows for creation, collection, and export of surveys with multiple question types and response sets. The tool utilizes a click-to-create interface that allows for advanced question types including ranking, multiple select, and write-in responses. Participants are not required to login to access the survey and can access it easily from persistent web link distributed via email.

Survey

The participants were first given a nine-question background questionnaire to gather information about them and their experience with computers and collaboration online (Appendix B). This background covered gender, age, information about technologies used to collaborate with others, whether they collaborated in the academic, government, or private sector environments, and one open-ended question about typical collaboration behaviors. The purpose of the background survey was twofold, (1) to verify that the sample is reasonably normal with

respect to age/gender, and (2) to allow segmentation of future questions by participant background.

Questions following the background survey (questions 10-17) covered current cybercollaboration experiences ranging from the reasons for collaborating to specifics on the tools used. This section's primary focus was to quantify preferences and reasons for collaboration as discussed in the third premise thereof this research. This section began with categorical tool preferences and reasons for collaboration to address the research of Spence, Reddy, and Hall (2005), then extension of face-to-face interaction and perception of co-location per Wheeler, Dennis and Press (1999) and Brooks (1996) respectively.

Questions 18 and 19 were intended to generate data to examine privacy concerns when collaborating online. The theory tested with this question was that modern cybercollaboration users are less concerned in present day with privacy when collaborating and are less likely to allow their privacy concerns to affect their online collaboration behavior.

Question 20 was related to Workman and Stewart's (2007) statement that even co-located teams use asynchronous communication sometimes rather than face-to-face interaction.

Questions 21-24 were aimed at the fourth premise in that they required participants to self-report on their perceptions and opinions of their virtual team experiences. These questions addressed the more psychological aspects of virtual team participation such as building both formal/informal work relationships and perception of effort as well as requiring the participants (in 23 and 24) to choose between tools/accessibility and team dynamics as the main drivers of virtual team success or failure. The intent of these questions was to either provide support for or against Greenberg's (2007) and Kraut and Egido's (1998) similar theories that familiar social and cultural norms and high-quality communication are impeded by virtual teams. Forcing the

participants to stack-rank cultural/human interaction items with technology/functional items would show which they felt were most critical to ensure virtual team success and provide data to address a major point of research disagreement, whether it is technology or behaviors that are most important.

Questions 25-31 were focused on the fourth and fifth premises, more specifically the functional and usability requirements of cybercollaboratory environments. Question 25 addressed change indicators and how much history/detail is preferred when changes take place per Pankoke-Babatz and Syri (1997). Question 26 was written to uncover errors and common gaps in virtual collaboration usability and question 27 was intended to capture different communication preferences for escalation and handling difference of opinion within virtual teams—things that must be afforded to ensure successful collaboration. Questions 28-30 pursued the various functional requirements set forth by Mandviwalla and Olfman (1994) and Rogers and Ellis (1994) regarding customization of the cyber work environment and handling disparate data sets. The last question in the set addressed the breakdown of virtual environments directly and asked the participant to report an open-ended “pet peeve”. This question, similar to questions 23 and 24 was written to add more color to the technology vs. behavior issue, in this case, whether the participant reported a usability/functionality (technology) gripe or a team dynamics/social interaction (behavioral) gripe would indicate which category is most crucial.

Procedure

The participants were introduced to the survey by a descriptive email with a link to the RIT Clipboard survey administration platform. They were given a basic introduction to the survey via text description at the top of the webpage:

“Cyberenvironments and Technologies (CET) consist of a variety of software tools that allow researchers to communicate and share data and analyses regardless of their physical

whereabouts, hence fostering scientific collaboration on a global scale. To realize these benefits, however, researchers must willingly embrace the CET tools and integrate them in their daily use.

The purpose of this survey is to verify results we have found within existing research literature on the topic, settle controversies in past research, and solicit answers to questions that have not yet been asked before. Obtaining these measures from a wide range of CET users is critical to the continual development of CET. Your sharing of your experiences with these tools is greatly appreciated.”

After the collection of the survey responses, the dataset was downloaded in digital format and analyzed in Microsoft Excel using table functionality to tally the response set for each individual question, and where appropriate, basic statistics were calculated. In more advanced cases, the filtering functionality was used to limit descriptive statistics to a specific response set for a question.

Results

Participants

The participant population was relatively normal with respect to gender split (35 male, 37 female, 1 unanswered). Removing the participants who preferred not to answer, the male/female ratio was 94.6 which is very much in line with “Male-Female Ratio by Race Alone or in Combination and Hispanic or Latino Origin for the United States” which cites the same metric at 96.3 (U.S. Census Bureau, 2001).

The population was also normal with respect to age with M=36.5 and “Annual Estimates of the Resident Population by Sex and Five-Year Age Groups for the United States” census estimate of 36.8 years (2009). The only exceptions were the 25-34 age group having significantly higher representation at 31.5% (N=23) than the census estimate of 18.6% and the 65+ age group having a very limited representation of 1.37% (N=1) compared to the national estimate of 17.7% (U.S. Census Bureau, 2009)..

With respect to work/scientific domain, 56.9% of participants were members of the Rochester Institute of Technology (N=41). Of the remaining respondents, 16.7% were employed by Razorfish, a Publicist Agency (N=12), 2.8% were part of other academic institutions (N=2), and 2.8% were involved with formal scientific collaboration by way of the TeraGrid User Portal and MIT Climate Collaboratorium (N=2). The final 20.8% of participants were from other organizations or disciplines (N=15).

It should be noted that this survey anticipated a greater response from formal scientific participants. From six separate populations of collaborating scientists, only two people responded. As a result, this study (in some cases) is inadequate to support or refute previous

research narrowly specific to formal scientific collaboration. However, in most cases adjacent conclusions are presented and discussed.

Analysis

Simple counts of participants and percentage of population statistics were calculated for questions that required participants to select single or multiple categorical answers. Questions involving preference of multiple items were assigned a numerical weight based on the rank in which they were ordered, and then the mean was calculated for each item to determine the aggregate weighted ranking of all participants. All questions having responses on scales of “never” to “always”, “strongly disagree” to “strongly agree”, or “unimportant” to “very important” were first tallied normally for each selection of sentiment, then each response category was assigned a numerical value of 1-5 and an aggregate sentiment score was calculated for the question. For example, a 3.5 average sentiment score would fall between undecided and agree on the second scale example mentioned.

There were two notable exceptions to the general analysis guidelines, question 16 and 29. Question 16 generated many different combinations of responses so it was necessary to not only tally unique combined selections of functional preferences but also the individual preferences were tallied to indicate their overall popularity independent of the specific function grouping.

Question 29 asked participants to report in what proportions (adding up to 100%) they used four different types of data in collaboration. These proportions were averaged for each of the types of data. Because of the possibility of error in this question (not adding up to 100%), any responses that did not add to 100% were excluded from the calculation.

Collaboration in Sciences

The focus of this section relates to usage and frequency of usage for basic collaborative methods as well as collaborative team size and geographic dispersion. The distribution of the usage of collaborative technologies indicated that Email was the most prevalent collaborative technology used among the participants of the survey with 94.5% usage (N=69). Email was closely followed by Telephone with 93.2% usage (N=68), and then by voice teleconference with 76.7% usage (N=56). Video/data teleconference, wikis (N=40), internet groups, and instant messaging all averaged out between 50 and 60% usage with video/data teleconference being the most used at 58.9% (N=43) and instant messaging being the least used at 50.7% (N=37). These results suggest that the overall survey population was very familiar with the technologies as over half the participants had used each individual technology.

Table 1

Frequency Ranking of Collaborative Methods

Collaborative Method	Mean Frequency Rank
Email	1.8
Face-to-face	1.9
Telephone	3.3
Teleconference (voice only)	4.2
Teleconference (video and data)	5.2
Online groups (e.g., Google groups, Yahoo groups, &c.)	5.7
Wikis	6.0

Examination of the frequency of collaborative method usage, the data suggests that email is the most frequently used collaborative technology followed closely by face-to-face

communication. The ranking of between 1 and 2 indicates that these methods were used either most frequently (1) or second most frequently (2). Examining relative frequency, the data suggests that email is used 1.3% more often than face-to-face communication, 40.4% more than telephone, 394.8% more than online groups, and 505.3% more than wikis (see Table 1). Examination of free text responses related to patterns of collaboration validated the information in Table 1.

The vast majority of respondents at 91.8% (N=67) had never before participated in a study on collaborative technologies. Examining the participant areas of collaboration, the data indicates that the population has over twice as many participants (67.1%; N=49) who collaborate in the academic sector than in the private sector (31.5%; N=23).

Examination of participant-reported collaborative team sizes, the data indicates that the majority at 57.5% (N=42) typically participate in collaboration within teams of 3 or less. $M_{teamsize}=3.7$ collaborators, and the median team size is 3 which suggests that a collaborative team size of 3-4 is the best approximation of this population's overall team size. In terms of frequency, team sizes of 1 (N=15) and 3 (N=15) were most common, followed by team sizes of 2 (N=12) and 4 (N=11). Teams of 5 (N=8) and over 6 (N=10) were less common.

Interpreting the next team size question, the data suggest that maximum collaborative team size is most often less than 10 members with 53.4% of participants falling into the 1-5 and 6-10 maximum team size categories. The mean maximum team size removing any outliers ± 3 standard deviations is 20.6, and the median maximum team size is 10. This indicates that collaborative team sizes of 10-20 are the best approximation of this population's maximum collaborative group. In terms of frequency, maximum team sizes of 1-10 (N=39) were most common followed by 11-20 (N=15), 21-30 (N=8) and over 31 (N=7).

Examining the ranked frequency of collaboration at the same institution, at other institutions in the United States, and at international institutions suggests that the participants most often collaborate with people at their same institution. A full 78.1% (N=57) of participants chose this as their most frequent collaboration type. Compare this to only 16.4% (N=12) of participants who most often collaborated with other US-based institutions, and 5.5% (N=4) who most often collaborated internationally.

Technologies for Collaboration

The focus of this section relates to collaboration preference, the reasons for geographically dispersed collaboration, cybercollaboration as a means to extend face-to-face meetings, specific collaborative methods, and the complexity of team interactions as a means to inform discussion of affording collaborative behaviors within virtual teams. Results on preferred collaboration methods indicate that 76.7% of survey participants utilize face-to-face communication as a preferred method, followed by 52.1% who selected email as a preferred method. The next most preferred method was phone, but much less pervasive at 15.1%. Phone was followed by instant message at 12.3% and wiki at 6.9%. A small proportion (5.5%) of participants selected “other”.

Results on the primary reason for collaboration indicated that the most pervasive reason for collaboration was to utilize others’ expertise. In looking at the raw data, a substantial 52.1% (N=38) of survey participants selected this reason as their primary reason for collaboration, pushing this reason to the top of the weighted rank list with a rank of 1.9. The second and third highest weighted ranks for reasons for collaboration were to accomplish more (rank=2.4), and to benefit from shared experiences (rank=3.8), respectively. In stark contrast, distribution of cost ranked either last or second to last in reasons for collaboration for 86.3% (N=63) of participants

giving it the lowest weighted rank of 7.2. Rounding out the least popular reasons for collaboration is accommodating larger projects with an also low weighted rank of 6.1.

An examination of the responses on complexity of interactions limiting online collaboration revealed that the majority (60.3%; N=44) of participants did not feel that any of their projects were too complex to collaborate on using their preferred means of cybercollaboration. A minority (10.1%, N=8) of participants reported that they needed to share complex diagrams and schematics that were difficult to share digitally, and 16.4% (N=12) indicated that their work required live collaboration. Examination of the 12.3% (N=9) of “other” responses revealed that the majority of the limitations described in free text response could be solved by having live synchronous collaboration, so in aggregate, 28.8% (N=20) of participants either by actual selection or inferred free-text write-in indicated that their interactions require live synchronous collaboration.

Results on reasons to extend face-to-face meetings via online collaboration indicated that there were two major reasons for using cybercollaboration in this manner, “to more easily share information/data without scheduling another meeting” and “to ask questions asynchronously”. Almost all (90.4%, N=66) of survey participants reported that they extended face-to-face meetings with cybercollaboration to share information and data, and 54.8% (N=40) reported that they used cybercollaboration to ask questions asynchronously. The other two reasons, “to use online voting for issue resolution” and “to manage work deadlines with a digital timestamp” received very little support at 6.9% (N=5) and 9.6% (N=7) of participants, respectively.

Examination of results on participant preference in organizational tools for geographically dispersed teams suggested that audio/phone conference and archived email were most commonly preferred, each being reported as a preference by 53.4% (N=39) of survey participants. Meeting

specific software tools such as LiveMeeting, WebEx, and Adobe Connect were the third most reported preference with 26.0% (N=19) of participants followed by video conferencing and archived chat/instant message with 21.9% (N=16) and 16.44% (N=12) respectively. Only 6% (N=7) of participants selected “other” and wrote in tools such as wikis and Google docs (see Figure 1).

Figure 1. Preferences in Collaborative Tools for Geographically Dispersed Teams to Enhance Organization & Simulated Co-Location

Responses (N=42) to the open-ended question asking how the tools in Figure 1 enabled feelings of simulated co-location and organization revealed a distribution into three major themes: Duplication of face-to-face communication inputs, organization/archiving, and time/convenience improvements. The majority of responses at 61.9% (N=26) cited the archival

and organizational benefits of asynchronous communication, 40.5% (N=17) of responses cited a duplication of face-to-face communication themes such as tone of voice and live conflict resolution/discussion, and 14.3% (N=6) mentioned time and convenience related benefits.

Diverse Sciences, Diverse Technologies

The focus of this section is on specific combinations of tools and functionality to be included in an ideal cybercollaborative environment. The results show differences in specific tool preference and an affinity for asynchronous communication as well as general lack of central passionate concern for privacy.

An analysis of data related to the most beneficial online collaborative methods/tools to include in a single useful cybercollaborative technology indicated large variation in both preference and number of tools. The largest group of participants which agreed on the specific set of tools to include as part of a single cybercollaborative technology only accounted for 8.2% (N=6) of the respondents. Further, there were 37 different combinations of tools among only 73 survey participants suggesting a definite absence of consensus (see Appendix A, Table 15).

A separate examination of aggregated responses to the same question regarding which tools to include in a single, useful collaborative technology is more definitive. File sharing, voice conference and email were top rated at about 40% of responses, for each. The next tier of tools was screen sharing and video conferencing, each netting about 30% of responses while chat/IM ranked close behind (see Figure 2). Less popular choices were posting/commenting, wiki, and voting, each with less than 14% of respondents voting them into their definition of a single useful collaborative tool.

Figure 2. Aggregated Communication Methods Rated as Most Beneficial

An examination of the open-ended question addressing the reason for inclusion of these specific tools in an ideal cybercollaborative environment revealed responses that were similarly fragmented. While 23.8% of responses cited either visual/voice plus data, and 14.3% cited ease of use, the majority of responses at 61.9% cited other disparate reasons.

Examining response data on frequency of asynchronous communication methods such as email and chat/IM for co-located teams indicated similar affinity towards these methods. The majority of respondents used asynchronous communication methods over 50% of the time, many coming from those who reported using asynchronous communication “almost always” at 75% or more of the time. A very low number of respondents reported that they used asynchronous communication with their co-located teams “rarely” (see Table 2).

Table 2

Usage of Asynchronous Communication Methods for Co-Located Teams

Frequency	N	% Responses
>75% (Almost Always)	18	24.66%
51-75% (Often)	30	41.10%
25-50% (Sometimes)	10	13.70%
< 25% (Rarely)	12	16.44%
Not Answered	3	4.11%
Total	73	100.00%

Examination of self-reported data on online privacy concerns as related to cybercollaboration revealed that a full 57.5% (N=42) of participants were not concerned with their privacy, while the remaining participants were more or less evenly divided with 23.3% (N=17) having concerns about their privacy and 19.2% (N=14) not giving it any thought.

Examination of open-ended responses toward online privacy indicated that 62.5% of those who had not thought about or were not worried about privacy were not transmitting information they deemed confidential, and 35.0% felt that security measures with the tools or systems they used were adequate to ensure the safety of their data.

Usability of Collaborative Technologies

The next set of questions queried the difficulty of forming both task and non-task related relationships as well as gauging project contribution with co-located and remotely located colleagues. The results show effects of proximity on both types of relationships and perception of contribution.

Results on developing informal non-task related relationships with co-located colleagues indicate that 89.0% (N=65) of participants agreed or strongly agreed that it was easy, while only 6.9% (N=5) disagreed or strongly disagreed. Only 2.7% (N=2) of respondents were undecided, indicating that the overwhelming majority of survey participants had a definitive opinion.

When presented with the same statement related to remote/geographically separated colleagues, the majority of participants at 56.2% (N=41) indicated that they disagreed or strongly disagreed that developing non-work related relationships was easy. Notably, 24.7% (N=18) were in agreement or strong agreement and substantially more participants were undecided at 17.8% (N=13). This suggests that sentiments were not as strong about the difficulties of creating informal non-work related relationships for the remote team statement as compared to the co-located team statement.

Comparing both statements, the frequency of those who agree and strongly agree that it is easy to develop informal relationships is N=41 for remote colleagues and N=65 for co-located colleagues suggesting that it was substantially more successful to develop informal relationships in person.

Results on developing formal task related relationships with co-located colleagues indicate that 91.8% (N=67) of participants agreed or strongly agreed that it was easy, while only 1.4% (N=1) disagreed or strongly disagreed. Only 2.7% (N=2) of respondents were undecided, indicating that the overwhelming majority of survey participants had a definitive opinion.

When presented with the same statement related to remote/geographically separated colleagues, the majority of participants at 75.3% (N=55) of participants agreed or strongly agreed that it was easy, while only 8.1% (N=6) disagreed or strongly disagreed. The 11.0%

(N=8) of undecided participants suggests that again sentiments were not as strong for the remote team statement as compared to the co-located team statement on task-related relationships.

Comparing both statements, frequency of those who agree and strongly agree that it is easy to develop formal task-related relationships is N=55 for remote colleagues and N=67 for co-located colleagues suggesting that it was only slightly more successful to develop formal task-related relationships in person.

Results on gauging the team contribution of co-located colleagues indicates that 84.9% (N=62) of participants agreed or strongly agreed that it was easy, while only 5.5% (N=4) disagreed or strongly disagreed. Only 6.9% (N=5) of respondents were undecided, indicating that the overwhelming majority of survey participants had a definitive opinion. When presented with the same statement related to remote/geographically separated colleagues, the slight majority of participants at 50.7% (N=37) of participants agreed or strongly agreed that it was easy, while 30.1% (N=22) disagreed or strongly disagreed. The 16.4% (N=12) of undecided participants suggests that again sentiments were not as strong for the remote team statement as compared to the co-located team statement on team contribution. Comparing both statements, frequency of those who agree and strongly agree that it was easy to gauge team contribution is N=37 for remote colleagues and N=62 for co-located colleagues suggesting that it was more successful to gauge team member effort in person.

Distilling this section's data, in Figure 3, we can see that the greatest difference can be seen in developing informal non-task related relationship, which the data suggests is much easier in person. Also notable is the difference in ease of gauging team contribution, where 34% more participants felt that team contribution was more successful in person. The smallest difference, however, was in developing formal task-related relationships.

Figure 3. Differences Developing Relationships and Gauging Contribution with Co-Located and Remote Colleagues

Participant-ranked data on success influencers for virtual teams suggest that communication and communication tools were the most important influencers of team success in geographically dispersed teams (see Table 3). Also weighing heavily were trust, coordination/management tools and team/role preferences. Less influential aspects were incentives, cultural differences, and team life cycle.

Examination of participant-ranked data on success detractors for virtual teams suggested that [failure to achieve] consensus on the hypothesis with a 2.9 weighted rank average was the most important detractor of team success in geographically dispersed teams. Also weighing heavily were [failure to] establish methodologies and [improper] framing and definition of concepts (see Table 4). Less influential were [poor] accessibility of data/publication, competitive nature, and

unwillingness to trust. The least influential detractors to the success of geographically distributed teams were ways of looking at ambiguity and uncertainty, choice of research methods, and lastly “familiar social and cultural norms are not available”. A total of 67.1% (N=49) of participants ranked “familiar social and cultural norms are not available” eighth or ninth out of nine possible rankings suggesting that the overall sentiment on social and cultural norms is that their presence is largely unimportant to the success of geographically separated virtual teams.

Table 3

Success Influencers in Geographically Separated Teams

Team Success Influencers	Mean Rank
Communication	2.2
Communication Tools	3.2
Trust	3.7
Coordination/Management Tools	4.0
Team/Role preferences	4.2
Incentives	5.9
Cultural differences	6.0
Team Life cycle	6.9

Table 4

Success Detractors in Geographically Separated Teams

Team Success Detractors	Mean Rank
Achieving consensus on the hypothesis	2.9
Establishing methodologies	3.4
How concepts are framed and defined	4.4
Accessibility of data/publications	5.1
Competitive nature	5.1
Unwillingness to trust others	5.5
Ways of looking at ambiguity and uncertainty	5.6
Choice of research methods	6.1
Familiar social and cultural norms are not available	7.0

An examination of open-ended responses relating to the most difficult aspect of communicating remotely suggests that time—whether from different time zones, different work schedules, or scheduling—is the most prevalent issue with 48.1% citing that reason. The other reasons were fairly fragmented, with 13.5% relating to general lack of communication, 9.6% relating to misunderstanding due to tone, cultural, or language barriers, and the rest relating to various issues from lack of relationship building to not being able to physically see the person who is speaking.

Analyzing counts of respondents that preferred specific awareness indicators within a cybercollaborative environment revealed that 63.0% (N=46) of survey participants desired an indicator that changes have been made, while 54.8% (N=40) desired history of most recent

changes and the reasons surrounding a change. Only 30.1% (N=22) of participants indicated that they would want to also see the discussions surrounding a change.

The next section of responses queried the frequency with which participants experienced different forms of difficulty and utility while using cybercollaborative tools.

Figure 4. Percent of Respondents Seldom or Never Experiencing Cybercollaborative Difficulty

In Table 5 and Figure 4 we can see that the majority of participants at 86.3% (N=63) seldom or never had difficulty sending particular types of messages, and 80.8% (N=59) seldom or never had difficulty uploading particular types of data. A substantive 70.4% (N=54) of participants seldom or never generated error messages, and 60.3% (N=44) seldom or never experienced frustration with cybercollaborative tools. There does not appear to be a correlation between error frequency and frustration among this population, however these results may indicate that there is

another source of frustration other than difficulty in sending/uploading data and generating error messages.

Table 5

Frequency of Difficulty with Cybercollaboratory Environments

	Seldom or Never	About Half the Time	Usually or Always
Difficulty sending specific types of messages to team members	86.30%	2.74%	2.74%
Difficulty uploading specific types of data to team members	80.82%	2.74%	5.48%
Error messages generated when using cybercollaborative tools	73.97%	10.96%	2.74%
Frustration when using cybercollaborative tools	60.28%	20.54%	9.59%

Survey data related to task completion rate indicated that 61.6% (N=45) of participants usually or always completed tasks on the first try (Appendix A, Table 32). This suggests a possible inverse correlation with frequency of error messages as discussed in Table 5. Further, almost half the participants at 48.0% (N=35) felt that familiar technology norms were usually or always present in the cybercollaborative environment.

The next set of questions explored the particular tools and features critical to successful cyberenvironment use. First in the framework of urgency, escalation and conflict resolution, and then relating to specific features of the cyberenvironment. Examining free text responses relating to the escalation of urgent tasks within cybercollaborative groups revealed that 83.9% of respondents used email to alert their groups to an increase in urgency. Of those, 14.9% flagged the message as high importance.

The free text responses addressing conflict resolution within virtual teams were categorized into several general themes: 28.8% of responses indicated that phone or audio conference was necessary, 26.9% of responses indicated that face-to-face communication was crucial for conflict resolution, and 21.1% of responses indicated that email was adequate to resolve conflict. The three most frequently mentioned tactics were having further discussion, voting, and weighing pros and cons.

Data collected on the presence of a function to set update frequency preference when using cybercollaborative tools indicated a definite skew toward the function being present, with 41.1% (N=30) of participants reporting that they either agree or strongly agree that the tool they used included that function. Conversely, 24.7% (N=18) of participants were either undecided, disagreed, or disagreed strongly that the function was available.

Data collected on the presence of a function to customize the homepage/dashboard when using cybercollaborative tools indicated a slight skew toward the function being present, with 35.6% (N=26) of participants reporting that they either agree or strongly agree that the tool they used included that function. Alternately, 30.1% (N=22) of participants were either undecided, disagreed, or disagreed strongly that the function was available.

According to Table 6, 41.1% of participants reported that the function to update frequency preference in the cybercollaborative tool was available, while 57.5% indicated that the function was important. This suggests a functional gap between the percent of participants that believe the feature is important vs. the percent of participants that are confident that their environment has the feature present.

Alternately, when examining the difference between percent of participants reporting the ability to customize the homepage/dashboard and the percent of participants indicating that the

feature was important, the result was zero. The proportion of participants that had access to homepage customization within their cybercollaborative environment was exactly the same as the proportion of participants who felt that the feature was important.

Table 6

Presence and Importance of Cybercollaborative Environment Features

	Agree or strongly agree		
	Feature Available	Feature Important	Difference
Ability to update frequency preference	41.10%	57.54%	-16.44%
Ability to customize homepage/dashboard	35.62%	35.62%	0.00%

The final section of the survey explored types of shared data, the frequency with which it was shared, and the importance of each data type. Results on the information types shared between colleagues using cybercollaborative environments indicates that, in aggregate, the most common type of shared data was text at an average of 60.5% of total information. This was followed by data at 28.2% of total information, and both algorithms and computational resources weighed in at 5.1% and 6.3% of total information, respectively.

With regard to the availability of particular data types within the cybercollaborative environment, we can see by examining Table 7 that the majority of participants felt that scholarly articles, team generated documents, and data were important. Conversely, the same participants reported that the ability to share processes for generating and analyzing data was less important—only 37% (N=27) and 45.2% (N=33) of participants respectively felt that these functions were important or very important.

Figure 5. Importance of Datatype Sharing Functionality Types

Table 7

Importance of Data type Sharing Functionality in Cybercollaborative Environments

	Unimportant or of little importance	Moderately Important	Important or very important
Share scholarly articles	9.59%	16.44%	64.38%
Share team-generated documents	2.74%	4.11%	83.56%
Share data	1.37%	15.07%	72.60%
Share processes for generating data	17.81%	24.66%	36.98%
Share processes for analyzing data	16.44%	17.81%	45.20%

By applying a quantitative weighting to the response data in Table 7, it can be determined that the aggregate rank of sentiment on sharing different data types is (from most important to least important) self or team generated documents, self or team generated data, scholarly articles and technical reports, data analysis processes, and finally data generation processes.

Discussion

Examining the data generated by survey responses yielded several key findings directly related to the main premises of this research. Some data was found in favor of existing bodies of work, and other data supported alternative views.

The mean team size among collaborators was found to be 3.7 with mean maximum team size of 20.6 indicating that team sizes are larger today than as reported in 1962 and 2007 (Wuchty et al., 2007). The preferred overall communication method was indicated to be face-to-face, but email appears to have overtaken phone as the second most preferred method of collaboration and was also used most often to enhance organization in geographically dispersed teams. The majority of collaborators cited utilization of others' expertise as the primary reason of collaboration, while increasing scale, complexity and costs of projects were least cited.

Cybercollaborative technologies were utilized by the large majority of collaborators to share information and data and/or to ask questions asynchronously, except in instances where live synchronous interaction was necessary, or complex diagrams or schematics were needed. Asynchronous communication methods such as email and chat/IM were utilized by the majority of collaborators even with teams working at the same location. Opinions on specific technologies to include in a robust cybercollaborative environment were varied; however file sharing, voice conference and email emerged as top themes.

Comparison of in-person collaboration to remote collaboration shows that it was much easier to develop informal non-work related relationships, slightly easier to develop task-related relationships, and moderately easier to gauge team member effort in-person than in remote collaborative settings. To ensure success of a virtual team, it is most important to have good communication as well as achieve consensus on the research hypotheses. Respective to

technology function, change awareness indicators and the ability to set preferences related to change awareness is strongly desired by the majority of collaborators as well as the ability to share (in order of importance) documents, data, and scholarly articles/reports. The majority of cybercollaborative environment users do not find the tools frustrating and are able to complete tasks on the first try and without errors.

The Collaborative Nature of the Scientific Enterprise

Findings from this survey do not support Wuchty et al. (2007) results that the increasing scale, complexity, and capital costs of science are primary drivers of collaboration. For this particular sample, our results suggest that those are actually the least selected reasons for collaboration, and instead supports research by Spence et al. (2005) and Shah (2008), which indicate that utilization of others' expertise, accomplishing more, and benefiting from shared experiences are the most important drivers. Over half at 52.1% of survey participants selected utilization of others' expertise as their primary reason for collaboration. It should be noted however, that this sample was made up predominately of members from a U.S. college community and corporate professionals who by definition would not have the same motivations for collaboration or the same capital structure, complexity, or scale of projects.

The mean size of collaborators in participants' "typical" work groups was 3.7 members, which does support Wuchty et al. (2007) findings showing growth in science/engineering team size of 1.9 to 3.5. The mean number of collaborators in participants' largest work groups was 20.6, also supporting the large team sizes and collaborative growth rate as defined by Newman (2004). This may indicate that while motivations for college community and corporate professionals to collaborate were different than those in established science, their team sizes are closely aligned.

Although research shows a four-fold growth in international collaboration, and 4 in 10 papers having multiple country affiliations (Lorigo & Pellacini, 2007), 8 in 10 of the present survey participants ranked international collaboration as least frequent potentially indicating less growth within this facet of collaboration. It is probable that this sample is not an accurate representation of international scientific collaboration, so these results do not allow any conclusions to support or dispute previous findings.

Telecommunication Technologies in Scientific Collaboration

Data related to breadth of collaborative technology usage clearly supports Workman's (2007) and Stewart's (2007) argument that most organizations work via email and telephone. Interestingly, the same percentage of respondents selected both email and telephone/audio conference as preferred tools for organizing geographically distributed teams, however in terms of overall preference in communication method over three times the number of participants (52.1%) selected email versus the number who selected telephone (15.1%). This could indicate that although telephone is preferred for organization, there are other factors that reduce its overall value in collaboration.

Asynchronicity as a benefit of cybercollaborative technologies as presented by Stewart (2007) is strongly supported by results on extending face-to-face meetings. A full 54.8% of respondents indicated that they used email and/or chat/IM to ask questions asynchronously. Further, 61.9% of free-text responses indicated asynchronous and organizational benefits as the greatest contributor simulated co-location in cybercollaborative environments.

Variety of Collaborative Needs and Technologies

The data gathered by the survey strongly supported the argument that there are a huge range of tools and techniques used to assist scientific collaboration. When participants were asked to

assemble a custom cybercollaborative environment from 9 separate tools, one unique environment was created for every two survey participants with the most agreed-upon environment supported by a mere 8.2% of the participants. Additionally, when participants were asked the *reason* for including those tools, the two most widely chosen reasons only accounted for 38.1% of responses, leaving 61.9% of responses distributed among fifteen other themes.

One major point of argument in research on collaborative success of virtual teams is whether technologies or behaviors are the primary drivers and barriers for virtual team success. While Kraut and Egidio (1998) maintain that tools/technologies are most important, Greenberg (2007) as well as Dewulf et al. (2007) indicated that behavioral items such as cultural differences, team role preferences, conflict management, and trust are more important. This study does not generate clear support in either direction. Of the top four success factors, two are tools (communication tools and coordination/management tools) and two are behavioral (communication and trust). In looking at barriers to virtual team success, however, the data most closely supports Jordan et al, (2005) findings that consensus on the hypothesis and establishing methodologies are the most significant barriers.

Usability of Collaborative Technologies

A key theme in the fourth premise is that cybercollaborative environments must meet the existing needs of collaborators. The difficulty is that some of these “needs” are not specific deliverables in support of the collaborative project goal. Several of these needs are related to team dynamics and maintaining rapport or camaraderie with colleagues as well as gauging members’ effort. The results suggest a substantial disparity in developing informal relationships when working remotely versus in-person, with significantly more participants indicating that informal relationships were easier to develop in person. Similarly, the difference of being able to

gauge team member contribution was significant when compared to sentiments about in-person collaboration versus remote collaboration. These large differences indicate that affording all nuances of collaboration in a cybercollaborative environment is very difficult, especially when faced with trust and communication as major factors in virtual team success per Greenberg (2007).

Another major theme is collaborative norms as translated into cybercollaborative environments. Pankoke-Babatz and Syri (1997) and Mandviwally and Olfman (1994) indicate that awareness indicators as well as highly flexible systems that cater to different users' work preferences are critical. The survey data may refute some of this claim in that while only about half of participants reported that the tools offered familiarity to technology norms that the majority completed most tasks on the first try, seldom or never generated error messages, and were seldom frustrated. Further, only a handful of participants had difficulty sending messages or uploading data to their team members, respectively. With less than half of participants categorizing their cybercollaborative environments as having familiar technology norms, logically these percentages should have been lower. This may suggest that familiarity to technology norms does not have as large an impact on task completion or frustration levels.

Survey data on change indicators supported Pankoke-Babatz and Syri's (1997) contention that awareness indicators for changes, a history/change log, and the reasons for change should be maintained, with more than half the participants indicating preference for each—however, only one-third marked a preference for the discussions surrounding a change, indicating that level of change awareness may not be necessary. Additional data on change awareness show that the majority of survey participants indicated that the ability to set preferences as to frequency of change indication is important, while only one-third of participants indicated that customizing a

“dashboard” was necessary. There are two ways to interpret this: either change awareness and dashboard customization are not as important as Pankoke-Babatz and Syri (1997) indicate, or preferences depend significantly on the individual collaborator.

Examining the survey information collected related to data storage reveals that these participants do not value the storage of either algorithms or computational resources which suggests that cybercollaborative environments’ inability to store these types of data may not be significant. On the other hand, this population of survey participants does not include many scholarly authors or collaborators working on highly technical diagrams/equations so if another survey were administered to a different (more scholarly/technical) audience the results may come back drastically changed.

The data collected is in strong support of premise five indicating that traditional usability testing methods with individual users performing isolated tasks is unsuitable for evaluating collaboration technologies. As indicated in Table 15 (Appendix A), there are drastic material differences in what similar groups of collaborators view as useful—some collaborators may use the same or different technologies for the same or different tasks. The span of what was deemed useful or necessary affordances by this participant group were not telling of any particular theme, and in fact some data indicated (in premise four) that familiar functionality norms, although listed as important for most participants, were not necessary for them to successfully utilize the cyberenvironment without error or frustration. Additionally, tables 19-24 (Appendix A) indicate that there may be inherent social/group dynamic shortcomings inherent with the online collaboration framework. That is, the natural social and group environment in a cybercollaboratory group may make informal non-work relationship building as well as gauging each group members’ contribution extremely difficult. According to Beca (2002) and Rogers and

Ellis (1994), cybercollaboratory environments must afford interaction with applications as well as other group members, so an inherent disconnect would consequently make measuring the success of any such environment very difficult in a traditional usability study. Most importantly, Table 3 indicates that communication and trust are two main influencers of geographically separated virtual team success, but there are no traditional usability tests that evaluate the success and magnitude of things like communication or trust. Team dynamics and building social structure cannot be easily achieved in general, and certainly cannot be achieved by placing a group of random participants in a usability lab to perform isolated tasks. If cybercollaboratory environments are intended to enable geographically separated members to efficiently perform work, then the study of that efficient work must come by gathering data from participants who are *actually* working together, *actually* performing tasks that are important to them, and *actually* developing formal, informal, task and non-task related relationships that frame the team dynamic. This is the only way that the participants can be representative of real users per Dumas and Redish (1994). To measure the effectiveness of the intangible nature of collaboration, this research deems it necessary to survey group members and aggregate their sentiments. Trust is intangible and not something that can be measured by a particular rate or metric—therefore, the most effective way to develop a measurement is to require the survey participants to self-select levels from a quantifiable scale.

Conclusions

There was no participant consensus on what tools to include in “ideal” cybercollaborative environments. The largest group of participants which agreed on the specific set of tools to include as part of a single cybercollaborative technology only accounted for a very small minority of the respondents. Further, there were many different combinations of tools among a

relatively small population survey participants suggesting a definite absence of consensus and strong support that the inclusion or exclusion of specific tools and functionality are not critical to team success provided that basic affordances for document and data sharing are provided. Even beyond tool selection, the *reasons* for tool selection were fragmented as well with the majority of responses distributed among over a dozen disparate themes.

Traditional usability issues were not widely cited as the main reason for a virtual team to be unsuccessful. Free text responses intended to gather qualitative data on primary difficulties or “pet peeves” revealed mostly communication issues, personality differences, or complaints about disparity in effort put forth towards the project.

The most critical aspects to ensure virtual team success (and mitigate project risk) were general communication and achieving consensus on the hypothesis. Therefore, “usability” in the broad sense of affording the effectiveness of collaboration through virtual environments can be best achieved through providing specific decision frameworks to enable team-wide accountability, participation in, and documented acceptance of the hypothesis and specifically addressing critical communication issues that are most likely to break down. This can be achieved with certain processes and/or virtual workspace functionality:

First, (a) the delegation, assignment, and time-bound completion of project tasks. Second, (b) expectation setting for project participation and standard message response times—reasonable time constraints, appropriate escalation steps, and mutually agreed-upon actions in the event of non-compliance by any group member. And (c), the assignment of one or more team members to a project/process management role to act as an impartial intermediary keeping other members in communication, on task and providing a vehicle to anonymously address any points of disagreement or difficulty with individual personalities or work habits.

Within the sample of academic and professional survey participants, cybercollaborative usability cannot be evaluated with traditional software usability methods and metrics because completion of collaborative tasks is intimately related to group dynamics. Differences in social and work-process norms between group members and virtual perception of team member effort towards the project goal are not areas that can be significantly impacted by improved software utility. Instead, cybercollaborative technologies must simply allow normal interaction and communication between group members so as to not be distracting, while the true affordance of efficient collaborative work comes from setting processes that preemptively improve communication and decision-making where they are most likely to erode.

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Appendix A – Tables

Table 1

Gender of Survey Participants

Gender	N	% Responses
Female	37	50.68
Male	35	47.95
Prefer not to answer	1	1.37
Total	73	100.00

Table 2

Age of Survey Participants

Age	N	% Responses
18 - 24	2	2.74
25 - 34	23	31.51
35 - 44	14	19.18
45 - 54	12	16.44
55 - 64	8	10.96
65 +	1	1.37
Null Response	13	17.81
Total	73	100.00

Table 3

Usage of Collaborative Technologies

Collaborative Technology	N	% Respondents
Email	69	94.52
Telephone	68	93.15
Teleconference (voice only)	56	76.71
Teleconference (with video and data)	43	58.90
Wikis	40	54.79
Internet groups (Google Groups, Yahoo Groups, etc.)	37	50.68
Instant messaging	37	50.68
other	14	19.18

Table 4

Frequency Ranking of Collaborative Methods

Collaborative Method	Frequency Rank
Email	1.8
Face-to-face	1.9
Telephone	3.3
Teleconference (voice only)	4.2
Teleconference (video and data)	5.2
Online groups (e.g., Google groups, Yahoo groups, &c.)	5.7
Wikis	6.0

Table 5 (question 6)

Participation in Collaborative Technology Usability Study

Response	N	% Responses
No	67	91.78
Yes	6	8.22
Total	73	100.00

Table 6 (question 7)

Participant Colleague Areas of Collaboration

Colleague Area	N	% Responses
Academia	49	67.12
Private sector	23	31.51
Not Answered	1	1.37
Total	73	100.00

Table 7 (question 8)

Typical Team Size for Collaboration

Typical Number of Collaborators	N	% Responses
1	15	20.55
2	12	16.44
3	15	20.55
4	11	15.07
5	8	10.96
6 - 10	8	10.96
11+	2	2.74
None	2	2.74
Total	73	100.00

Table 8 (question 8)

Maximum Team Size for Collaboration

Maximum Number of Collaborators	N	% Responses
1 - 5	21	28.77
6 - 10	18	24.66
11 - 20	15	20.55
21 - 30	8	10.96
41 - 50	2	2.74
51+	5	6.85
None	4	5.48
Total	73	100.00

Table 9 (question 9)

General Proximity of Participant Colleagues

Institution	Frequency Rank
The same institution I am at	1.32
Other institutions in the United States of America	1.93
Other institutions outside of the United States of America (international)	2.75

Table 10 (question 10)

Preferred Methods of Collaboration

Communication Method	N	% Respondents
Face-to-face	56.0	76.71
Email	38.0	52.05
Phone	11.0	15.07
Instant message	9.0	12.33
Wiki	5.0	6.85
Other	4.0	5.48

Table 11 (question 11)

Primary Reason for Collaboration

Reasons for Collaboration	Reason Rank
To utilize others' expertise	1.9
To accomplish more	3.4
To benefit from shared experiences	3.8
To utilize others' resources (other than expertise)	4.1
To develop a greater understanding of the topic	4.4
To accommodate more complex projects	5.2
To accommodate larger projects	6.1
To distribute some of the costs	7.2

Table 12 (question 12)

Complexity Limitations of Using Primary Collaborative Communication Preference

Reason	N	% Respondents
I do not have any projects that are too complex	44	60.27
My work requires live instantaneous (synchronous) collaboration	12	16.44
I need to use complex diagrams/schematics that are difficult to share digitally	8	10.96
Other	9	12.33

Table 13 (question 13)

Reasons for Online Collaboration to Extend Face-to-Face Meetings/Projects

Reason for Online Collaboration	N	% Respondents
To easier share information/data without scheduling another meeting.	66	90.41
To ask questions asynchronously	40	54.79
To use online voting for issue resolution.	5	6.85
To manage work deadlines with a digital timestamp.	7	9.59
Other	2	2.74

Table 14 (question 14)

Preferences in Collaborative Tools for Geographically Dispersed Teams to Enhance Organization

Collaborative Tools for Organization	N	% Respondents
Audio/Phone Conference	39	53.42
Archived email	39	53.42
Meeting-specific Software (Livemeeting, WebEx, Adobe Connect)	19	26.03
Video Conference	16	21.92
Archived chats/instant messages	12	16.44
Other	7	9.59

Table 15 (question 16)

Most Beneficial Specific Communication Methods to Include in a Single Collaborative Technology

Combined Collaboration Technologies	N	% Respondents
No Response Given	16	21.92
Email File Sharing	6	8.22
Voice Conference Screen Sharing	4	5.48
Email	4	5.48
Chat/IM Voice Conference Video Conference	2	2.74
Email Voice Conference	2	2.74
Voice Conference Video Conference	2	2.74
Email Voice Conference File Sharing	2	2.74
Chat/IMVoice ConferenceVideo ConferenceScreen Sharing	2	2.74
Video Conference	2	2.74
Video ConferenceFile Sharing	2	2.74
EmailChat/IMVoice Conference	2	2.74
Voice ConferenceScreen SharingFile Sharing	2	2.74
EmailChat/IMVoice ConferenceVideo ConferenceScreen SharingFile SharingPosting/Commenting	1	1.37
EmailVoice ConferenceVideo Conference	1	1.37
EmailVoice ConferenceFile SharingPosting/Commenting	1	1.37
EmailChat/IMVoice ConferenceVideo ConferenceScreen SharingFile SharingVotingWikiPosting/Commenting	1	1.37
File SharingWikiPosting/Commenting	1	1.37
EmailChat/IMWiki	1	1.37

Voice ConferenceFile Sharing	1	1.37
Chat/IMVideo ConferenceScreen SharingPosting/Commenting	1	1.37
EmailVoice ConferenceFile SharingWikiPosting/Commenting	1	1.37
Chat/IMScreen Sharing	1	1.37
EmailVoice ConferenceVideo ConferenceScreen SharingFile SharingWiki	1	1.37
Chat/IMVoice ConferenceScreen SharingFile Sharing	1	1.37
Chat/IMVideo ConferenceScreen Sharing	1	1.37
EmailVideo ConferenceFile Sharing	1	1.37
Video ConferenceScreen SharingFile SharingWikiPosting/Commenting	1	1.37
EmailChat/IMVideo Conference	1	1.37
EmailChat/IMVoice ConferenceVideo ConferenceScreen SharingFile SharingVoting	1	1.37
EmailChat/IMVideo ConferenceScreen SharingFile SharingVotingPosting/Commenting	1	1.37
Voice ConferenceScreen SharingFile SharingPosting/Commenting	1	1.37
Voice ConferenceScreen SharingFile SharingVoting	1	1.37
Voice ConferenceScreen SharingFile SharingWiki	1	1.37
EmailFile SharingPosting/Commenting	1	1.37
Chat/IMFile Sharing	1	1.37
Voice ConferenceVideo ConferenceScreen SharingFile Sharing	1	1.37
EmailScreen SharingFile Sharing	1	1.37
Total	73	100.00

Table 16 (question 16)

Most Beneficial Aggregated Communication Methods to Include in a Single Collaborative Technology

Collaborative Technology	N	% Respondents
File Sharing	31	42.47
Voice Conference	31	42.47
Email	29	39.73
Screen Sharing	23	31.51
Video Conference	22	30.14
Posting/Commenting	10	13.70
Chat/IM	17	23.29
Wiki	7	9.59
Voting	4	5.48
Other	1	1.37

Table 17 (question 18)

Participant Sentiment Towards Online Privacy

Response	N	% Responses
No	42	57.53
Yes	17	23.29
Haven't thought about it	14	19.18
Total	73	100.00

Table 18 (question 20)

Usage of Asynchronous Communication Methods for Co-Located Teams

Frequency	N	% Responses
>75% (Almost Always)	18	24.66
51-75% (Often)	30	41.10
25-50% (Sometimes)	10	13.70
< 25% (Rarely)	12	16.44
Not Answered	3	4.11
Total	73	100.00

Table 19 (question 21)

Developing Easy Informal Non-Work Related Relationships with Co-Located Colleagues

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable
N	41	24	2	4	1	1
% Responses	56.16	32.88	2.74	5.48	1.37	1.37

Table 20 (question 21)

Developing Easy Informal Non-Work Related Relationships with Remote Colleagues

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable
N	1	17	13	31	10	1
% Responses	1.37	23.29	17.81	42.47	13.70	1.37

Table 21 (question 21)

Developing Easy Formal Task Related Relationships with Co-Located Colleagues

Values	Strongly Agree	Agree	Undecided	Disagree	Not Answered	Not Applicable
N	39	28	2	1	2	1
% Responses	53.42	38.36	2.74	1.37	2.74	1.37

Table 22 (question 21)

Developing Easy Formal Task Related Relationships with Remote Colleagues

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Answered	Not Applicable
N	14	41	8	5	1	2	2
% Responses	19.18	56.16	10.96	6.85	1.37	2.74	2.74

Table 23 (question 21)

Ability to Gauge Team Contribution in Co-Located Colleagues

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable
N	29	33	5	3	1	2
% Responses	39.73	45.21	6.85	4.11	1.37	2.74

Table 24 (question 21)

Ability to Gauge Team Contribution in Remote Colleagues

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable
N	11	26	12	19	3	2
% Responses	15.07	35.62	16.44	26.03	4.11	2.74

Table 25 (question 22)

Success Influencers in Geographically Separated Teams

Team Success Influencers	Mean Rank
Communication	2.2
Communication Tools	3.2
Trust	3.7
Coordination/Management Tools	4.0
Team/Role preferences	4.2
Incentives	5.9
Cultural differences	6.0
Team Life cycle	6.9

Table 26 (question 23)

Success Detractors in Geographically Separated Teams

Team Success Detractors	Mean Rank
Achieving consensus on the hypothesis	2.9
Establishing methodologies	3.4
How concepts are framed and defined	4.4
Accessibility of data/publications	5.1
Competitive nature	5.1
Unwillingness to trust others	5.5
Ways of looking at ambiguity and uncertainty	5.6
Choice of research methods	6.1
Familiar social and cultural norms are not available	7.0

Table 27 (question 25)

Awareness Indicator Preference for Cybercollaboratory Tools

Awareness Indicators	N	% Responses
An indicator that changes have been made	46	63.01
A history of the most recent changes	40	54.79
The reasons for a change	40	54.79
The discussions surrounding a change	22	30.14
other	3	4.11

Table 28 (question 26)

Difficulty Sending Specific Types of Messages to Team Members

Values	Never	Seldom	About Half The Time	Usually	Not Applicable	Not Answered
N	38	25	2	2	1	5
% Responses	52.05	34.25	2.74	2.74	1.37	6.85

Table 29 (question 26)

Difficulty Uploading Specific Types of Data to Team Members

Values	Never	Seldom	About Half The Time	Usually	Always	Not Applicable	Not Answered
N	31	28	2	3	1	2	6
% Responses	42.47	38.36	2.74	4.11	1.37	2.74	8.22

Table 30 (question 26)

Frequency of Error Messages When Using Cybercollaborative Tools

Values	Never	Seldom	About Half The Time	Usually	Always	Not Applicable	Not Answered
N	17	37	8	1	1	3	6
% Responses	23.29	50.68	10.96	1.37	1.37	4.11	8.22

Table 31 (question 26)

Frequency of Frustration When Using Cybercollaborative Tools

Values	Never	Seldom	About Half The Time	Usually	Always	Not Applicable	Not Answered
N	12	32	15	5	2	1	6
% Responses	16.44	43.84	20.55	6.85	2.74	1.37	8.22

Table 32 (question 26)

Frequency of First Time Task Completion When Using Cybercollaborative Tools

Values	Never	Seldom	About Half The Time	Usually	Always	Not Applicable	Not Answered
N	2	7	10	41	4	2	7
% Responses	2.74	9.59	13.70	56.16	5.48	2.74	9.59

Table 33 (question 26)

Frequency of Familiarity to Technology Norms When Using Cybercollaborative Tools

Values	Never	Seldom	About Half The Time	Usually	Always	Not Applicable	Not Answered
N	2	10	10	32	3	10	6
% Responses	2.74	13.70	13.70	43.84	4.11	13.70	8.22

Table 34 (question 28)

Ability to Update Frequency Preference When Using Cybercollaborative Tools

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	N/A	Not Answered
N	7	23	7	7	4	18	7
%Responses	9.59	31.51	9.59	9.59	5.48	24.66	9.59

Table 35 (question 28)

Ability to Customize Homepage/Dashboard When Using Cybercollaborative Tools

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	N/A	Not Answered
N	4	22	7	11	4	18	7
% Responses	5.48	30.14	9.59	15.07	5.48	24.66	9.59

Table 36 (question 28)

Importance of Setting Update Frequency Preferences When Using Cybercollaborative Tools

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable	Not Answered
N	15	27	3	4	2	14	8
%Responses	20.55	36.99	4.11	5.48	2.74	19.18	10.96

Table 37 (question 28)

Importance of Customizing Homepage/Dashboard When Using Cybercollaborative Tools

Values	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable	Not Answered
N	9	17	10	12	1	14	10
%Responses	12.33	23.29	13.70	16.44	1.37	19.18	13.70

Table 38 (question 29)

Percent Breakout of Information Types Shared in Cybercollaborative Environments

Type of Information	% Responses
Text Documents	60.5
Shared Data	28.2
Algorithms for Data Analysis	5.1
Computational Resources	6.3

Table 39 (question 30)

Importance of Functionality to Share Scholarly Articles in Cybercollaborative Environments

Values	Un-important	Of Little Importance	Moderately Important	Important	Very Important	N/A	Not Answered
N	4	3	12	15	32	1	6
%Responses	5.48	4.11	16.44	20.55	43.84	1.37	8.22

Table 40 (question 30)

Importance of Functionality to Share Self/Team-Generated Documents in Cybercollaborative Environments

Values	Unimportant	Moderately Important	Important	Very Important	Not Applicable	Not Answered
N	2	3	16	45	1	6
% Responses	2.74	4.11	21.92	61.64	1.37	8.22

Table 41 (question 30)

Importance of Functionality to Share Data in Cybercollaborative Environments

Values	Of Little Importance	Moderately Important	Important	Very Important	Not Applicable	Not Answered
N	1	11	21	32	2	6
% Responses	1.37	15.07	28.77	43.84	2.74	8.22

Table 42 (question 30)

Importance of Functionality to Share Processes for Generating Data in Cybercollaborative Environments

Values	Unimportant	Of Little Importance	Moderately Important	Important	Very Important	N/A	Not Answered
N	2	11	18	18	9	8	7
%Responses	2.74	15.07	24.66	24.66	12.33	10.96	9.59

Table 43 (question 30)

Importance of Functionality to Share Processes for Analyzing Data in Cybercollaborative Environments

Values	Un- important	Of Little Importance	Moderately Important	Im- portant	Very Important	N/A	Not Answered
N	3	9	13	22	11	7	8
%Responses	4.11	12.33	17.81	30.14	15.07	9.59	10.96

Appendix B – Survey

RIT Home | RIT A-Z Index | RIT Search | myRIT

The Wallace Center
at RIT

My Surveys
New Survey
Help

Welcome, Esa Rantanen (logout)

Usability of Cyberenvironments and Technologies: MS Thesis Research of Jessica Smagner

Cyberenvironments and Technologies (CET) consist of a variety of software tools that allow researchers to communicate and share data and analyses regardless of their physical whereabouts, hence fostering scientific collaboration on a global scale. To realize these benefits, however, researchers must willingly embrace the CET tools and integrate them in their daily use.

The purpose of this survey is to verify results we have found within existing research literature on the topic, settle controversies in past research, and solicit answers to questions that have not yet been asked before. Obtaining these measures from a wide range of CET users is critical to the continual development of CET. Your sharing of your experiences with these tools is greatly appreciated.

1. Gender

☐ Male
☐ Female
☐ Prefer not to answer

2. Age (You may leave this blank if you prefer not to answer)

3. Which of the following technologies have you used to collaborate with others?

☐ Wikis
☐ Internet groups (Google Groups, Yahoo Groups, etc.)
☐ Telephone
☐ Instant messaging
☐ Teleconference (with video and data)
☐ Teleconference (voice only)
☐ Email
☐ Other:

4. Please rank the following means of collaboration according to the frequency you use them in your research

drag the items to the desired positions

- + Face-to-face
- + Telephone
- + Email
- + Teleconference (voice only)
- + Teleconference (video and data)
- + Online groups (e.g., Google groups, Yahoo groups, &c.)
- + Wikis

5. Please describe your usual patterns of collaboration with others.

6. Have you ever participated in a usability study on collaborative technologies before?

- ☐ Yes
- ☐ No

7. I mostly collaborate online with colleagues in the

- ☐ academia
- ☐ government
- ☐ private sector

8. The number of people I collaborate with in a project (either in person or online) is

typically: the most I have ever worked with:

9. I collaborate with colleagues from (rank the answers by frequency of your interactions)

drag the items to the desired positions

- + the same institution I am at
- + other institutions in the United States of America
- + other institutions outside of the United States of America (international)

10. What type of communication method do you most prefer when collaborating with others?

- ☐ Face-to-face
☐ Phone
☐ Email
☐ Instant message
☐ Wiki
☐ Other:

11. The main reason I collaborate with others is (rank the answers in frequency of main reason)

drag the items to the desired positions

- + to utilize others' expertise
- + to utilize others' resources (other than expertise)
- + to accomplish more
- + to benefit from shared experiences
- + to develop a greater understanding of the topic
- + to accomodate more complex projects
- + to distribute some of the costs
- + to accomodate larger projects

12. Do you have any projects that may be too complex for the type of communication method you use most often when collaborating online? If so, why?

- ☐ I need to use complex diagrams or schematics that are difficult to share digitally
☐ My work requires live instantaneous (synchronous) collaboration
☐ I do not have any projects that are too complex
☐ Other:

13. Have you ever used an online method of collaboration (Email, IM, Wiki, Online Groups) to extend a face-to-face meeting or complement a project that is being done in-person? If so, how?

- ☐ To easier share information/data without scheduling another meeting.
☐ To ask questions asynchronously (i.e. you ask, someone responds later).
☐ To use online voting for issue resolution.
☐ To manage work deadlines with a digital timestamp.
☐ Other:

14. When you are working with teams in different geographic areas, what collaboration tools help your team stay organized?

- ☐ Archived chats/instant messages
☐ Video Conference
☐ Audio/Phone Conference
☐ Meeting-specific Software (Livemeeting, WebEx, Adobe Connect, etc.)
☐ Archived email
☐ Other:

15. If you selected any of the above, how specifically do these technologies help you stay organized and feel co-located?

16. Do any of your online collaboration methods combine more than one method (i.e. voice and instant message)? If so, what are the most beneficial methods to have combined into one technology?

- ☐ Email
- ☐ Chat/IM
- ☐ Voice Conference
- ☐ Video Conference
- ☐ Screen Sharing
- ☐ File Sharing
- ☐ Voting
- ☐ Wiki
- ☐ Posting/Commenting
- ☐ Other:

17. Why is it beneficial to have the tools you selected above in one integrated solution?

18. Do you worry about your privacy when collaborating online?

- ☐ Yes
- ☐ No
- ☐ Haven't thought about it

19. Please explain why or why not you worry about your privacy.

20. When working with a team in your SAME location, how often do you rely on asynchronous communication methods such as email, voicemail, and instant messaging?

- ☐ < 25% (Rarely)
☐ 25-50% (Sometimes)
☐ 51-75% (Often)
☐ >75% (Almost Always)

21. Please indicate to what degree you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Not Applicable
When working with a team IN-PERSON it is easy to develop informal non-work related relationships.	☐	☐	☐	☐	☐	☐
When working with a team REMOTELY it is easy to develop informal non-work related relationships.	☐	☐	☐	☐	☐	☐
When working with a team IN-PERSON it is easy to develop formal task/work-related relationships.	☐	☐	☐	☐	☐	☐
When working with a team REMOTELY it is easy to develop formal task/work-related relationships.	☐	☐	☐	☐	☐	☐
When working with a team IN-PERSON it is easy to gauge the amount of effort each member is putting into the project.	☐	☐	☐	☐	☐	☐
When working with a team REMOTELY it is easy to gauge the amount of effort each member is putting into the project.	☐	☐	☐	☐	☐	☐

22. What do you believe influences the success of teams you have been on where members are geographically separated? (rank answers in order of largest influence, either negative OR positive)

drag the items to the desired positions

- + Communication Tools
- + Coordination/Management Tools
- + Cultural differences
- + Team/Role preferences
- + Communication
- + Trust
- + Incentives
- + Team Life cycle

23. What do you believe are the barriers to a successful virtual team? (rank answers starting with the biggest barrier)

drag the items to the desired positions

- + Achieving consensus on the hypothesis
- + Establishing methodologies
- + Accessibility of data/publications
- + Competitive nature
- + Unwillingness to trust others
- + How concepts are framed and defined
- + Choice of research methods
- + Ways of looking at ambiguity and uncertainty
- + Familiar social and cultural norms are not available

24. What is the most difficult aspect of communicating remotely with your team?

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25. What type of behavior and awareness indicators do you prefer to receive when collaborating online and looking at information that has changed since you last viewed it?

- ☐ An indicator that changes have been made
- ☐ A history of the most recent changes
- ☐ The reasons for a change
- ☐ The discussions surrounding a change
- ☐ Other:

26. Please give your opinion about how often you agree with the following statements about the collaborative environment that you use for interaction with your group.

[illegible]

31. Please describe your "pet peeve" in collaborating on research online:

32. Please share any other experiences and thoughts that you may have about collaborating using various technologies and suggest issues or problem areas that were not part of this survey but that warrant attention in future research efforts.

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