UNIVERSITY OF MINNESOTA
LIBRARIES

Understanding Research Behaviors, Information Resources, and Service Needs of Scientists and Graduate Students: A Study by the University of Minnesota Libraries

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I. PROJECT OVERVIEW

In September 2006, the Libraries embarked upon a series of studies of University of Minnesota scientists and graduate students in the sciences in order to understand and incorporate their unique information needs into projects already underway at the Libraries, and to develop new services and tools where needed. Through focus groups and interviews with over 70 deans, faculty members, and graduate students representing departments on the Twin Cities' campuses, from the Institute of Technology (a college that includes physical science departments and engineering), the College of Biological Sciences, the College of Food, Agricultural, and Natural Resource Sciences, and the Academic Health Center (which includes six health sciences schools and colleges and the University of Minnesota Duluth department of Pharmacy), the study concluded in May 2007.

The assessment of science research behaviors focused on the full range of research and scholarly activities, including the elements of infrastructure that support the discovery, use and management of information sources and data, as well as the personal and often idiosyncratic repertoires and preferences of individual scientists. How do scientists share work with colleagues, both internal and external to the University? What kinds of collaborative workspaces are used or needed, both physical and virtual? Are they exploring new forms of electronic publication? How do scientists collect, manipulate, mine, and preserve their data? How do scientists use libraries? And how can the libraries better facilitate research in the sciences?

The study will inform current and future library planning, and will assist academic leadership in understanding how libraries can maximize the increasingly expansive nature of scholarly inquiry in the sciences. Within the library, the results of the study allow us to identify how the needs of scientists differ from those of other scholars, as well as how the scholarly process across the disciplines is characterized by an increasing dependence on a wide array of electronic resources and tools.

1. Context

The University of Minnesota Libraries received funding in 2005 from the Andrew W. Mellon Foundation, and support from the College of Liberal Arts (CLA), to develop a model for assessing research behaviors of faculty and graduate students in the humanities and social sciences. The goals were to explore the needs and relationship between physical and virtual services, improve library services that directly support research, and identify discipline-specific needs and areas of common interest. Project staff interviewed CLA department chairs and faculty, conducted a survey and held focus groups with graduate students. [See http://www.lib.umn.edu/about/mellon.]

One outcome of the assessment of graduate students and faculty members in the humanities and the social sciences was a model of assessment that was applicable to studying the scholarly practices of scientists. As a result, both studies share a focus on the research process in general—the everyday activities of the researcher and the trajectories of research projects—rather than on researcher's specific behaviors and practices that directly relate to the library and to library research. Using the framework of the Library's earlier study of scholarly research practices, the assessment of scientists' research processes focused on three main components: information resources, infrastructure services, and research behaviors and repertoires.

The University's strategic positioning process, underway since 2004, also served as an impetus for studying the research practices. That initiative brought forward a number of issues that are relevant to research infrastructure and interdisciplinary and collaborative e-science. This project complements work proposed by the Knowledge Management Technology Task Force, one of the strategic positioning task forces of the Academic Health Center. In the Knowledge Management Technology Task Force Final Report (May 2006), the authors write:

> The ability to manage, analyze, and utilize the continuously expanding body of information is vital for health professionals and for the realization of this vision. Knowledge management, as it commonly appears in the literature, is a concept representing the systems, processes, and personnel used to acquire, organize, store, access, retrieve, teach, and disseminate information. … For the health practitioner, knowledgeable practice is based on how information is acquired, evaluated, synthesized, and applied using the most up-to-the-minute data. It is essential that health practitioners, researchers, educators/communicators, and managers in the health sciences are able to demonstrate the capabilities to create, identify, capture, and distribute the right knowledge to the right people at the right time, in the right form.[1]

The importance of understanding the processes by which scholars engage in the practices of knowledge management cannot be underestimated when attempting to develop the services, tools, and technology that best serves scholars' research needs. This study was an attempt to do just that in the context of library resources, services, and infrastructure.

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[1] Olson, Debra and Linda Perkowski (2006). *Transforming the University: A Final Report of the Knowledge Management Technology Task Force*, 7. http://www1.umn.edu/systemwide/strategic_positioning/tf_final_reports_060512/ahc_km_final.pdf

2. *Project Team*

The co-principal investigators of the project were Karen Williams, Associate University Librarian for Academic Programs, and Linda Watson, Director of the Health Sciences Libraries. Both played lead roles framing the project to respond to institutional and cross-organizational goals, and served as the main liaisons with the deans representing the multiple institutes and colleges participating in the study. Cecily Marcus served as project coordinator, and was responsible for the project's planning, execution, and reporting. Graduate Research Assistant Stephanie Ball contributed to the data collection and analysis, and served as a liaison to graduate students across the university. Jennifer Tantzen and Shane Nackerud, from the University of Minnesota Libraries Digital Library Development Lab, provided technical/web support, and the staff at the Bio-Medical Library, Arlys Totushek and Gina McKenzie in particular, provided valuable administrative support.

As in the earlier assessment, project staff recruited the expertise of subject librarians to identify possible participants and to develop and test interview and focus group questions. In a departure, though, this project also depended on subject librarians to lead the discussions, thus bringing new dimensions and perspectives to the collection and preliminary analysis of data. Three librarians, Leslie Delserone (Science and Engineering Library), Amy Hribar (Magrath Library), and Wayne Loftus (Bio-Medical Library) participated not only in the collection of data, but also in its formal analysis. The full roster of participating librarians includes:

- Jim Beattie, Bio-Medical Library, Moderator
- Elaine Challacombe, Bio-Medical Library, Moderator
- Chad Fennell, Bio-Medical Library, Moderator
- Cindy Gruwell, Bio-Medical Library, Moderator
- Wayne Loftus, Bio-Medical Library, Moderator (2), Data Analysis
- Kevin Messner, Bio-Medical Library, Advisory
- Kathy Allen, Magrath Library, Advisory
- Philip Herold, Forestry Library, Moderator
- Amy Hribar, Magrath Library, Advisory, Data Analysis
- Julie Kelly, Magrath Library, Moderator
- Leslie Delserone, Science and Engineering (Walter) Library, Moderator, Data Analysis
- Gary Fouty, Science and Engineering (Walter) Library, Moderator
- Janice Jaguszewski, Science and Engineering (Walter) Library, Advisory, Moderator
- Kristi Jensen, Science and Engineering (Walter) Library, Moderator (2)
- Meghan Lafferty, Science and Engineering (Walter) Library, Moderator (2)
- Julie Mitchell, Science and Engineering (Walter) Library, Moderator

3. *Target Communities*

The scope of the study included all departments, excluding those that are primarily clinical in nature, in the Institute of Technology, the College of Biological Sciences, the Academic Health Center (including the College of Pharmacy at UMD), and the College of Food, Agricultural, and Natural Resource Sciences. We also contacted directors of a number of institutes and centers (see below) as well as the heads of labs and their staff members. A total of 54 faculty and 18 graduate students participated in focus groups or interviews. Units included in the study were:

Department	Faculty	Grad Students	Unrepresented Departments
CBS/AHC			
Biochemistry, Molecular Biology, and Biophysics	2		Microbial Biochemistry and Biotechnology
Genetics, Cell Biology, and Development	1		Microbiology
Physiology	1		Molecular Biology
Pharmacology	1		Integrative Biology and Physiology
Neuroscience	1		Veterinary and Biomedical Sciences
International Medical Education	1		Diagnostic and Biological Sciences (Dental School)
Bioinformatics	1		Medicinal Chemistry
Veterinary Medicine Grad Program		2	Pharmaceutics
Veterinary Population Medicine	1		Biostatistics
School of Nursing	4		Maternal and Child Health
Environmental Health	1	5	Public Health Nutrition
Epidemiology	2	2	Veterinary Public Health
College of Pharmacy (UMD)	2		Regulatory Biochemistry
Public Health Administration	1	2	
Total	**19**	**11**	

Department	Faculty	Grad Students	Unrepresented Departments
Institute of Technology			
Astronomy	1		Biomedical Engineering
Chemistry	3	1	Biobased products
Civil Engineering	2		Mechanical Engineering

Computer Science	3		Mathematics
Digital Technology Center	1		Institute for Mathematics and its Applications
Aerospace Engineering	1		
Earth Sciences/Geology	9	4	
Physics	2		
History of Science	2		
Total	**24**	**5**	

Department	Faculty	Grad Students	Unrepresented Departments
CBS/CFANS			
College of Biological Sciences	1		Plant Biology
Ecology, Evolution and Behavior		1	Animal Science
CFANS	1		Entomology
Agronomy and Plant Genetics	1		Food Science and Nutrition
Applied Economics	1		Plant Pathology
Fisheries, Wildlife, and Conservation Biology	2		
Forest Resources	1		
Horticultural Science	2		
Soil, Water, and Climate	2	1	
Total	**11**	**2**	
Total for Study	**54**	**18**	

Centers and institutes included in the study were:

- Biomedical Engineering Institute
- Cancer Center
- Center for Diabetes Research
- Center for Immunology
- Center for Infectious Diseases & Microbiology Translational Research
- Center for Magnetic Resonance Research
- Center for Micro Electro Mechanical Systems (MEMS)
- Center for Minimally Invasive Surgery
- Clinical Outcomes Research Center
- Deborah E. Powell Center for Women's Health: A Nationally Designated Center of Excellence
- Developmental Biology Center
- Diabetes Institute for Immunology and Transplantation
- Institute of Human Genetics
- Institute of Rock Magnetism

- Laboratory for Computational Science and Engineering
- Lillehei Heart Institute
- Nanotechnology Initiatives
- NSF National Center for Earth Surface Dynamics (NCED)
- Stem Cell Institute

4. Methodology: Interviews and Focus Groups

Interviews and focus groups were the primary method of gathering data about the research processes of scientists. With the help of deans, associate deans, and librarians, we conducted 18 focus groups and seven individual interviews with faculty and graduate students. Each focus group had a minimum of two participants and a maximum of six. Focus groups generally lasted one hour and fifteen minutes, and the majority was held during the lunch hour with lunch provided. Interviews averaged 40 minutes in duration.

In order to assure the highest possible number of participants, focus groups were held in the library closest to the participants' home departments. A small number of focus groups were held on-site in labs, or, in the case of the UMD's College of Pharmacy, in Duluth. Interviews were held in the participant's offices or location of choice.

Librarians conducted all focus groups and nearly all interviews. Project staff served as note-takers. Every discussion was also tape-recorded (with permission) for verification purposes. In order to prepare librarians for leading discussions, the project coordinator provided them with a prepared text to introduce the project, discuss logistics, and lay out the trajectory of the conversation. Additionally, the coordinator provided librarians with written "tips for leading focus groups" as well as links to further resources on the topic (see Appendix).

The purpose of the interviews and focus groups was to capture the practical and conceptual challenges of research in the sciences. Participants were first asked to describe their current research, as well as the physical locations in which they work during different stages of a research project. They were also asked how they go about finding information and resources for a new area of research or a new project, and how they keep current in their field/s more generally. Participants discussed how they organize research and data, both primary (produced by them) and secondary. Additionally, we discussed what defines interdisciplinary research as well any challenges interdisciplinary and collaborative work presents to researchers. We asked researchers how they share information and ideas, and to describe any physical or virtual research spaces that they find conducive to collaborative research projects.

The final portion of the discussions focused on the role the library plays in research, the role of mentors and/or advisors for graduate students, factors researchers consider when selecting a journal for publication, and lastly, any ideas the researcher had about a tool that would magically make their research easier. What would it allow them to do?

All notes from discussions were compiled by the project coordinator and organized according to major topics: focus of research, resources used, methods of keeping current, digital resources and tools, interdisciplinary research, challenges of interdisciplinary/collaborative research, research space, assistance, role of library, criteria for publication, and “magic tool.” Notes were shared with the librarian who led the discussion so that he/she could add his/her comments and corrections.

Focus groups and interviews commenced in October 2006 and were completed in May 2007.

II. FINDINGS AND ANALYSIS

From conversations with over 70 faculty and graduate students, we were able to construct a general picture of scholarly practices that takes into consideration the many stages, often simultaneous, of scientific research at the University of Minnesota.

- Information Discovery and Access: Identifying and finding secondary research materials, including data sets that inform active research projects.
    - Keeping Current: Scientists’ research skills are often stretched by the need to keep up to date with new and longstanding research questions. The constant proliferation of research in the sciences, and the often inherent interdisciplinary nature of scientific research, makes it difficult for scientists to keep current.
    - Online Resources: Scientists are generally comfortable with a wide array of technological tools and demand access to online resources—journal articles, reports, conference proceedings, data sets, and more. Online resources are now seen as indispensable to effective research, especially for collaborative research and fieldwork.
- Interdisciplinary and Collaborative Research: For many scientists, interdisciplinary research is defined by collaboration with scholars working in a different field or sub-field.
    - Challenges: The benefits, and challenges, of interdisciplinary and collaborative research are many—scheduling, working across physical distance, language/vocabulary, and negotiating expectations. Younger scholars also note the importance of establishing credibility in a core field, and the competing need to

engage in innovative research that takes them to the fringes of their core discipline.
  - Implications for Libraries: The classic organization of libraries—with subject-based collections grouped together, often in library buildings that are also devoted to a particular subject or set of subjects (Architecture, Science and Engineering, Fisheries and Wildlife, etc.)—runs counter to interdisciplinary research that engages the literature of multiple collections. The potential for digital collections to mitigate physical boundaries is great.
  - Communication and Virtual Space: Scientists rely most heavily on email and email attachments for communication with researchers across the globe or across the hall. Some researchers are beginning to use applications like Google Docs that allow for collaborative authoring and version control. The use of virtual spaces (conference calling, video-conferencing, blogs, and wikis) is highly dependent on a researcher's personal knowledge about such tools. Many researchers are unaware of the array of tools available to them and lack the assistance or resources to use such tools easily.
- Gathering, Organizing, and Sharing:
  - Data Curation: Researchers' practices regarding data curation and preservation are idiosyncratic, haphazard, and in great need of attention. A lack of clear standards for data preservation and assistance to implement and maintain standards results in a messy combination of data stored on hard drives, in offices, on servers, and in the published form of journals.
- Role of Library in Research: Scientists make heavy and regular use of library resources available electronically, but regard the physical library buildings as a place of last resort -- where you go when you have no other way to find something. Library buildings are places of "disclosure" rather than "discovery," inasmuch as researchers go to libraries to retrieve what they have already identified. At the same time, many scientists speak nostalgically about the lost art of browsing and serendipitous discovery in libraries and depend on technology to provide browsing proxies.
- Graduate Student Research: Graduate students experience many of the same research challenges as faculty. Graduate students also enjoy a beneficial and highly structured relationship with their advisors that affects how they do research, secure funding, develop projects, and publish.

A more detailed look at findings related to **Information Discovery and Access**; **Interdisciplinary and Collaborative Research**; **Data and Resource Storage, Organization, and Preservation**; and **Graduate Student Research** are discussed below.

1. *Information Discovery and Access*

Digital Resources

Researchers depend 100% on online resources. The greatest common concern among scientists is the online availability of everything they need, whenever they need it, wherever they are. In short, it's all digital all the time for all participants.

- Online resources are highly desirable and used ubiquitously: "If it's not online, it's not visible" (Digital Technology Center faculty member). Researchers rely heavily upon the Libraries' online presence both at work and at home to access a variety of indexes, databases, journals, and subject guides: "I am just a click away from something good" (History of Science professor); "I threw away all my paper journals. They are fancy wallpaper as far as I am concerned. Everything is available online anyway" (Genetics/Cell Biology professor).
- Researchers find online resources with full text links the most useful.
- Non-library resources used included websites of professional societies, researchers' personal websites, pre-print archives (arXiv from Cornell University Library and SLAC, Stanford University Linear Accelerator Center), Google (for images and video clips for teaching, as well as hot topics), Google Scholar, personal libraries, Amazon.com (to read table of contents and receive notification of when a book will be published), and personal subscriptions to databases.
- There is some concern that the availability of online content limits the purview of literature read and consulted: "I notice from the references in students' papers that there's nothing that's not online, as if nothing happened before 1975" (Soil, Water, and Climate professor).
- At the same time, researchers would like increased access to electronic content: "It would be great if the Library had ways to put online obscure papers, papers from conferences, or chapters in a book" (Horticulture Science professor).
- Conference proceedings and gray literature are difficult to locate because these are not always online.
- Some complain there is "too much clicking" on the new Libraries website to get to services/resources. This problem is exacerbated for Academic Health Center scholars working at the University of Minnesota - Duluth, who have to go through extra "clicks" to access Interlibrary Loan, full-text electronic resources, and other library holdings.
- There are varied opinions on the recommendation features of some online resources: "I look for the most results possible. I would rather be the filter" (Pharmacology/Neuroscience professor).
- Some researchers comment that the success of the Library's virtual services and online resources also renders the Library invisible: "The Library has become successful by becoming invisible" (Nursing faculty member).

Library Use

- Scholars still use the physical library to check out older books, journals, and conference proceedings that are not online, but the overwhelming preference is to access resources electronically because of it is efficient, easy, and convenient. Physicists, geologists, and history of science scholars depend on microfiche, but find it problematic that it can't be checked out of the library.
- If the Library doesn't have something a researcher needs, s/he will use interlibrary loan, connect to another university via electronic access (VPN), or go to a researcher's personal website to try to obtain the material.
- Although researchers tend to use mostly online materials, they do appreciate discovering "gems" in the stacks (in the form of books and conference proceedings), and some lament no longer having the time to come to the physical library and browse.
- Researchers who rely on older, non-electronic materials find it inconvenient to have to request material from remote storage, which can take several days to arrive (when they might need it immediately).
- Library resources tend to be used more at the beginning and ending phases of research.

Keeping Current

- Researchers use a variety of methods to keep current with research in their field, including reading theses and dissertations; attending departmental, college, and campus presentations and seminars, as well as national and international conferences; listening to podcasts of seminars from across the country; reading gray literature; regular (daily/weekly/monthly) manual and automated searches of various indexes and databases; browsing the library shelves; attending smaller, subject-specific conferences; enrolling in journal table of contents email alerts; obtaining recommendations of colleagues, students, advisors, librarians, and fellow research group members; tracking bibliographic citation trails; browsing subject websites; reading papers in top journals and from top conferences; reading review articles; receiving email newsletters; reading textbooks (if researching a new area); holding teleconferences; and using Skype (free online phone service) to talk about new ideas and developments.
- Keeping up to date is difficult for many researchers: "Keeping current is very hard" (Agronomy/Plant Genetics professor); "The hardest thing about my job is keeping up to date. I work in three areas, and there's not enough time" (Soil, Water, & Climate professor); "Staying current is the biggest challenge. There is too much information" (Nursing Professor)
- A major motivator is applying for grants: "Funding is so bad right now that I am writing more and more grants. I am more up-to-date than ever" (Pharmacology/Neuroscience professor).

- Many faculty members rely on graduate students to keep them up-to-date with the newest research because, "Graduate students have to know what is going on" (Chemistry professor).
- Access to conference proceedings are very important for staying current, especially as books and journal articles often are viewed as out of date by the time they come out.
- Portrait of a Physiology professor:
    - "I don't have a lot of opportunities to work in a new field, but there are many chances to learn about related topics."
    - Varied literature searches: Ovid, PubMed, Google ("surprisingly good, but also lamentably good…I mean, I know I shouldn't use Google, but it's too good not to.")
    - Runs literature searches every few months; receives a few journals and table of contents regularly
    - Does not go to library but uses electronic resources regularly

<u>Interdisciplinary Discovery</u>

- Researchers find it difficult to find resources outside of their discipline (as a result of different languages/vocabularies used, not knowing which resources are most reputable or core to a field): "The hardest thing about my job is keeping up to date. I work in three areas, and there's not enough time" (Soil, Water, and Climate professor).
- The organization of libraries make interdisciplinary discovery challenging: "It's always so much harder to search outside your discipline, but no one knows who to ask. The structure for librarians is disciplinary. Collections are disciplinary. It would be great if you could have a collection that was for multiple disciplines, but…" (Computer Science professor). Another comments, "Compartmentalization of knowledge based on discipline can be problematic in libraries" (Public Health professor).
- "The more fields you have to cover, the harder it is to keep up. The more there is to know and find out and it can be hard to find things" (Geology professor).
- "It's harder when you are looking at journals outside your own area. You can find them, but you don't know which ones are the best or what you are missing" (Soil, Water, and Climate graduate student).
- Portrait of computer science professor: "Given the vast area of research, you can't be a master in everything." As a result, this professor:
    - Reads books, talks to colleagues, goes to conferences
    - Tries to focus on a specific number of areas or problems
    - Reads papers from most recent top conferences. "Conference papers and proceedings are good because they are not so polished that there aren't more things to pursue. Conferences present the most cutting edge research, when books and articles are always a few years behind."

2. Interdisciplinary and Collaborative Research

Definitions

There are many definitions of interdisciplinary research, but in the sciences, it is most commonly the practice of scholars from different departments, or with different interests, working together on a shared project. Often, interdisciplinary research is "micro-disciplinary": projects that involve scholars who may share a department, but who have difference specialties or areas of concentration. A physics professor comments, "I work with people who work at different wavelengths." Another physicist says, "I am never really starting from scratch. Interdisciplinary research in physics is still physics, broadly, but involves sub-specialties; work isn't interdisciplinary as far as some are concerned, but it is to those doing it (experimentalists with theorists, etc.)."

Other definitions include using methods developed in other areas, or projects that require multiple methods and literatures, as well as approaches. Interdisciplinary research is often driven by funding imperatives or by inquiries that demand multiple approaches. In the words of scholars:

- "Interdisciplinary research means going and interacting in realms that are outside your area of expertise. It has to be problem-driven—you have a question that demands that you enlist the help of others… a biochemist, a plant geneticist" (Forest Resources professor).
- "Interdisciplinary research doesn't necessarily mean a physicist working with a biologist" (Public Health professor).
- "The only thing that makes my research interdisciplinary is that I have to put it in my grant applications to get funding. Feedback is used in so many mechanisms: biological, physical, etc.- systems biology, mechanics, robots, etc., so it is a naturally interdisciplinary area. It can be hard to find someone who is a 'jack of all trades'" (Aerospace Engineering professor).
- "Neuroscientists are in 15 different departments work[ing] together on a project" (Pharmacology/Neuroscience professor).
- "I might have more commonality with a geographer or someone from civil engineering than I do with other geologists" (Geology graduate student).
- "I work collaboratively so I don't need to take five years to learn or become an expert in a new area" (Soil, Water, and Climate professor)
- "I work with colleagues who bring to the table what I can't do or don't want to do" (Horticulture Science Professor).

Challenges of Interdisciplinary and Collaborative Research

Common obstacles to effective interdisciplinary research include the use of different vocabularies, the difficulty of coordinating the work of multiple colleagues, not knowing the core journals/texts/researchers in a given field, not knowing where to publish, and having trouble finding the right collaborators to work with.

- A lack of shared vocabulary: There is a general agreement that language and terminology are among the great challenges to effective interdisciplinary collaboration: “Sometimes people are doing the same thing, but they are calling it something different” (Public Health professor).
- Knowing whom to work with: Identifying and approaching appropriate collaborators – even locally – is another great challenge. Most meetings are serendipitous: at a conference, sitting on search committee, etc.: “It would be good to work with people from mechanical engineering, but it’s hard to find contacts” (civil engineering researcher).
- Maintaining credibility in the core field, especially at the start of a career: “You have to be tenured in a department. When your work moves outside of [your] discipline, it can be a real problem, especially for junior faculty and graduate students” (Genetics/Cell Biology professor).
- Learning in a new area/staying current: Researchers often find it quite difficult to stay current in their core field. Those practicing in multiple fields find that problem magnified.
- Knowing enough: “The challenge of interdisciplinary research is “balancing casual versus comprehensive knowledge. As a researcher, you have to demonstrate comprehensive knowledge of your area, but sometimes your casual knowledge is more important—being broad, rather than having depth” (Bioinformatics professor). At the same time, a newcomer to a field may not be as aware of perceived limitations as a veteran: “Not knowing all the dogma...and not being constrained by what people think can or can't be done is very helpful” (Chemistry professor).
- Space: Interdisciplinary efforts frequently involve individuals from geographically dispersed units, even within the same university. This can raise a whole host of logistical problems, not least of which is the frequent remoteness of appropriate library resources: “No one knows where to physically put our lab" (chemistry graduate student).
- Equal access to shared resources: The inability of researchers at other institutions to access the same breadth of resources is a commonly cited difficulty. Open access, however, does not figure prominently in the discussion of factors faculty use to determine where to submit their own articles for publication: “Sometimes you can access [articles], sometimes not, and sometimes your colleagues at other places can’t because of subscriptions, copyright, etc.” (Fisheries and Wildlife professor). Access to electronic resources for colleagues, and in the case of scholars working in the Academic Health Center but who are housed at UMD, for graduate students and pre-med/pre-pharmacy students, is a pronounced challenge. UMD scholars frequently complain that their work is hampered by a lack of uniform access to electronic resources by their students.

- Communication: Researchers have a wide variety of preferred communication methods. Any service intended to support this work should support as many people and ways of doing things as possible: “The most successful researchers are the ones willing to get on the phone and get something done” (Physics professor). A professor in Agronomy/Plant Genetics says, “Video conferencing is hard to do, and expensive. But it’s better than email or phone calls.” A geologist comments, “When it’s physically possible, it’s better to meet in person.” Scholars in the College of Pharmacy at UMD largely consider the most important collaborations to take place with scholars in the Twin Cities, but “Getting people from the Twin Cities to come up to Duluth is like pulling teeth” (College of Pharmacy professor). “We used to meet halfway in Hinckley, but even that got too complicated,” the professor adds.
- Identifying appropriate communication tools: Finding and knowing how to use chat clients to video conferencing to collaborative word-processing is often a challenge to researchers. Researchers need these resources, but don’t have the time to find the best ones. Scholars at UMD are highly dependent on access to ITV capabilities, teleconferencing, and other technologies that allow for remote access and participation. Likewise, UMD scholars are often frustrated by the lack of such capabilities for conferences, lectures, and some courses held for Academic Health Center scholars in the Twin Cities: “What we most need in Duluth is a seamless connection to the Twin Cities—library interface, course, lectures, collaborations, events, all of it. Research is probably more seamless than administrative duties and other things, but it needs to be better. That is the only way you are going to build a real research culture in Duluth” (UMD College of Pharmacy professor).
- Sharing work: New collaborative tools such as Google Docs are beginning to be used by scholars, but many struggle with the common problems of version control when working collaboratively. “I am always coming close to losing the most up-to-date version of things. Changes I know I made end up disappearing” (Geology/Geophysics professor).

To sum up the many challenges of interdisciplinary research, a professor in Veterinary Medicine says: “Picture a diagram with overlapping circles. You have to do research that bridges between 2 and 4 disciplines. And you can’t just contribute in one specific area. You have to take the disciplines and integrate them somehow to create something new. Most of us are trained in a single field, so it’s hard to take what we know and take it to a different level. It’s hard to keep up-to-date, be fluent in different vocabularies, and to coordinate all the different efforts. There is motivation to do this—from NIH, USDA—not just to be multi-disciplinary but interdisciplinary.”

3. Data and Resource Organization, Storage, and Preservation

<u>Definitions of Data</u>

- Astronomical or mapping coordinates

- “Text” in the sense of genomic sequence (A-T-G-C) or proteomic data
- Matrices (e.g., that used in statistical analyses)
- Spectra (e.g., of molecules, compounds, crystals)
- Images, including photomicrographs and x-rays (physical films as well as electronic derivatives)
- Specimens of microorganisms, insects, plants or animals (whole organisms; tissues fixed on glass microscope slides, others not)
- Computer code
- Soil or rock samples
- Geological core samples
- Written protocols for experimental design, materials and methods, data collection and analysis

<u>A Definition of Resource</u>

- Research literature that supports scientists’ inquiries that represents the analysis of ‘processed’ raw data, presented in an organized fashion with conclusions drawn and suggestions for future research.
- Format varies from microfilm, to the print copy of a journal or a research article, to pdfs stored in a researcher’s own personal computer. Some researchers also consider their email records to be a valuable resource.

<u>Data Organization</u>

Data need to be organized in such a way that one can find and do something with it. In general, data organization practices are highly idiosyncratic and often depend on the particular skills (or lack thereof) of a given researcher. Many scientists discuss lapses and difficulties in these two areas.

A great deal of data is described as “electronic” (e.g., stored in Excel spreadsheets or in formats compatible with statistical software packages) or “digital” (e.g., photographs) in format. One professor describes training students in how to build a database for the lab’s cellular and molecular biological data, but adds that, “This kind of work is case by case across the University. The Library has a tremendous opportunity to lead this, and to provide ways to interpret, validate, and build on the data produced.”

Many researchers use the traditional paper lab book, with additional organization in file folders and loose-leaf binders.

- A faculty member in the College of Biological Sciences comments: “There are probably better ways [to organize data]. If there were a workshop on organization and file management, I would go. The Libraries do this so well.”
- A professor in the biomedical sciences describes a lab setting where everything is paper and where data organization is “pretty bad…I could

use help. Even if you took all the forms and scanned them, I would still have a messy computer…There are multiple ways to retrieve things now, but why not data? If you could do that with your data, you could find other pieces that are related to it, but still keep things organized by project, table, and descriptor. It would be great if you could create new folders with a common link, keep it in multiple formats or reassemble it…"

- A CFANS graduate student says: "It's hard to keep up with the logistics of getting data documented and graphed electronically."
- A bioinformatics faculty member needs a better way to work with data online: "If I am taking raw data—sequencing work of a genome—can I Google the data to find out what's known about it? Is there technology that will help me do it? How do you do raw data comparisons? Are there search engines just for data sets, even the ones that are constantly changing?"
- A CFANS professor summarized his views with the following: "We are trained in how to collect data, how to write it up, but not how to organize and keep track of everything."

Data Security/Storage/Sharing

As in the case of data organization, data storage is electronic and/or hard copy.

- A physiologist stores data on his personal computer and all of the laboratory's computers, then backs up the data files on three different hard drives and prints it all out.
- Others use a central departmental server, thumb drives, burn CDs or use floppy disks.
- Several researchers mention a desire to make data more accessible, but feel frustrated by a lack of standards to guide their efforts; this seems especially to be the case with cross-disciplinary data.
- An epidemiology/community health researcher remarks that granting agencies (e.g., NSF or NIH) require database development and data sharing, but that grantees often do not know procedures or have the skills to make data available. These same grants often require that data be made public, yet most is stored on closed servers.
- Members of a Biosystems Engineering lab share data among their group via a file server. Data are kept in an electronic project folder, with a subfolder for each member of the research team.
- A professor in Veterinary Medicine also uses file servers, but expresses concern about security issues

Other researchers look at data sharing/security from another perspective—proprietary rights and claims to research territory.

- From a geology postdoc: "We all collect samples together in the field, but when you come back to process the samples, people want the data without any understanding or agreement about ownership."

- Many researchers do not share data beyond what is published in peer-reviewed journals. A pharmacology/neuroscience professor considers the act of publication to be sharing. "There is hesitancy to share before publication…there's competition, you could lose control of your research if people know about it before it's completed…Information is power. You have to have a good reason to share…I don't want to be secretive, but it's wise to be cautious. You need to ask yourself if you are ready to share, why, and for what purpose."
- A CFANS professor states: "I don't send raw data around unless it's off to the journal and about to be published…"

<u>Data Preservation</u>

Practices vary widely on this topic, from preserving everything to very little, frequently with the expression of an intermediate position between the two extremes.

- A computer scientist assumes that data preservation is someone else's problem. "Am I worried it won't be there in 20 years? No. Am I worried it won't be there in 100? It doesn't matter. By that point, data become irrelevant except as historical curiosity."
- In the History of Science department, researchers express the contrary position: "We need to be able to look at the primary sources."
- Similarly, a researcher working in the Academic Health Center comments: "If I died, the data would die with me…I try to teach my students that they have to leave their lab books in such a state that if they were to walk out the door and never come back, we would still know what they were working on and how they did it…Sometimes it takes a few years to publish something. Students don't know why it's important to keep a lasting record of everything."
- A geology research associate has not seriously considered data preservation. "It's important to maintain data for two to three years—saved on disks—but after that the field moves so quickly that it's no longer relevant…I hadn't really thought much about [researchers who might be interested in the work in 10, 20 or 30 years]. But it wouldn't be good if they couldn't find the data, would it?"
- A CFANS professor states: "Data storage is fundamental to all of us, but it's not as though there is an IRS rule for keeping it for 7 years. We keep data long enough for people to know about it."
- A professor in Horticultural Science counters with this story: "In 1972 I did experiments in Scotland. Now I have a USDA grant that is related to that work, and that uses the same techniques. I gave my postdoc that lab book from 1972 so he could have all the documentation of how we did the experiments. The lab notebooks have more data than the papers that came out of the work."

Preservation of data occurs in different ways. Physical copies of lab notebooks still hold high favor.

- "You have to keep your original data for NIH grants but what happens when your two computers crash at once? I would rather have the computer data printed out and put into lab books" (Pharmacology professor).
- A chemistry professor has hundreds of CDs burned for individual projects. Every publication has a CD burned with all data, computer runs, Excel files, utility programs, and all relevant papers, but these are generally inaccessible to the public.
- In Geology, some data are archived as part of a larger project based at the University of Arizona.
- Another geologist views the long-term preservation of data to be "the responsibility of journals, but where is the guarantee? With electronic publishing, where are the permanent archives of human knowledge going to be?...I am on the board of an online peer-reviewed journal. We archive with CDs, but already they are breaking down."
- A researcher in Genetics and Cell Biology recognizes that legacy data in paper needs to shift to electronic, but asks, "What are the standards for making such a shift?"
- In the case of sample specimens, some researchers report keeping these indefinitely, others only until the research is published, citing a lack of storage space/conditions for adequate long-term preservation.
- Several faculty mention that the University should be preserving the information, scholarship, and data produced by scholars. "The Library could facilitate the curation and preservation of data by scholars, and teach researchers how to better organize it," comments a geophysics professor.
- The geologist who earlier looked to journals for data preservation summed up the consensus opinion that all data produced by UM researchers are property of the University, "But no one really knows the rules. Lab books, for example, have to be bound, and you have to print out all the data. There are legal expectations, but what are they? What are the standards?"

Resource Organization, Storage, and Preservation

Research literature is a key resource. Organizational methods parallel those described for data, with the exception being that software for bibliographic citation management (RefWorks, EndNote) and other approaches are available and discussed explicitly.

- A physics professor prints out articles and manuscripts and files by subject, then discards these after five years or so.
- A geology/geophysics professor has an undergraduate help him to organize reprints physically (one wall filled with shelves of alphabetized, cross-referenced information) and electronically (uses RefWorks).

- A professor in Forest Resources describes the other extreme for physical organization: “In my office I employ the basic floor system of organizing things. But if someone moves something, I can’t find it.”
- Others use digital tools as virtual filing cabinets. “Electronic filing” methods are chronological, or by topic or author for some; one History of Science faculty member states, “It’s great to have pdfs sent to you on your computer then saved in a folder with an easy-to-recognize label.” A computer scientist mentions colleagues who “have zillions of pdfs on [their] desktops. I don’t know how they find anything.”
- Some faculty complain of difficulties in locating a particular paper in their computer. A geology research associate mentions that he ends up re-accessing pdfs he knows he already has but cannot find. Other faculty touted the utility of Apple Spotlight as a tool for searching the files of their personal computer-based “libraries,” and for searching within a particular document.
- Many faculty mentioned using EndNote or ProCite for organization of their literature collection. These faculty are reticent to switch to RefWorks after years of investment with another application.
- Among the faculty who are either aware of, or have an account for, RefWorks, there is not great enthusiasm. A History of Science professor explains: “I have tried two or three times to get organized and use one of these tools, but I am too impatient, too busy. Something always gets in the way.”
- Among graduate students, postdoctoral fellows, and research associates, RefWorks is recognized as an available resource, used by some, but not overwhelmingly favored.

Attitudes about preservation of research resources vary widely:

- One faculty member considers himself “horrible” at archiving, while another uses EndNote as an archiving tool.
- A public health researcher would like to save documents into RefWorks as an archive.
- A geology graduate student eventually burns CDs with all papers that are relevant to a project.
- Only one faculty member mentions the need for, and problem of, archiving emails and attachments; he finds himself requesting additional server space.

4. Graduate Student Research

Eighteen graduate students representing eight departments participated in the study. Focus groups and individual interviews were conducted with graduate students studying in the areas of: chemistry; geology; environmental health; health policy and management; epidemiology and community health; veterinary medicine; veterinary population medicine; soil, water, and climate; and ecology, evolution, and behavior. Opinions among graduate students in various areas of the study were remarkably consistent. Clear themes regarding methods of keeping current, resource and assistance needs, materials preservation, and the role of mentors are discussed in detail below.

Discovery and Keeping Current

Graduate students use a variety of sources and methods to keep current, and acknowledge that keeping current is one of the most challenging aspects of being a student. The most popular methods include online resources, and many grad students admitted to rarely stepping into a library building. One geology student confessed to never having been into the library building, and had "decided to only read things that are online."

Internet resources used most frequently are similar to those used by faculty, including: Google Scholar, E-journals (a service through the University Library system), PubMed and Medline, Google, Science Direct, Wikipedia, and websites and databases of professional societies.

Other sources of current literature and information in the field include:

- Abstracts
- Following up on bibliographies
- Review articles
- Books
- Mentors and advisors.

Finding resources is often challenging for graduate students. A chemistry student says: "Not every researcher knows how to search, and not every advisor teaches you. The body of literature necessary is huge and it's hard to find what's out there, especially when you are just starting and don't know the names and terms." A student in Public Health comments: "Wikipedia is good for a totally new topic or an overview, but since it can be changed, it's not always trustworthy." Several graduate students also mentioned that speaking with colleagues and professors, and attending conferences were important to keeping current in their fields.

Interdisciplinary and Collaborative Research

Many graduate students believe that their work is inherently interdisciplinary and/or collaborative in nature, although the definition of interdisciplinary research often varies. A geology student asked the important question: "Where do you draw disciplinary lines?"

- Students in the health sciences, particularly public health and veterinary health, noted that the nature of the work is one that "cuts across disciplines," but often within the same school or department, i.e. epidemiology and biostatistics. One public health student comments: "The

work is absolutely interdisciplinary. There are perceived barriers of what kind of work you can do, but you have to know a lot of things to do the work. You also have to have community involvement."
- A veterinary medicine student says: "For what I do you have to know anatomy, physiology, animal and human health, physics, biochemistry, math, statistics, molecular biology, basic sciences, surgery, histology. How do you learn enough to come up with a creative idea?… There is not a wide-enough database for all this, and the devices are changing faster than the records, so it's hard to know what's been done."
- A geology student who worked with colleagues in ecology, geography, civil engineering, computer science and physics stated that: "The intangible contributions people make through casual conversations sometimes really propel science."
- A student in Soil, Water, and Climate says: "It's harder when you are looking at journals outside your own area. You can find them, but you don't know which ones are the best or what you are missing."
- The pressure to specialize often runs counter to the benefits of interdisciplinary research. A conservation biology student says: "There is some inertia when you are starting in a new area. There is so much to learn, and I rarely have enough time to learn what I need to know in my own field. But I really have to learn about theory and how it applies to conservation…so that it counts."

There are also significant challenges to working on interdisciplinary and collaborative teams.
- A chemistry student noted that often it is difficult to find people in other departments who are working on similar things.
- A geology student comments that she has trouble finding the right resources in fields related to hers: "I don't know any key journals in ecology."
- An environmental health student indicated that it is often difficult to identify an appropriate journal in which to publish when work is truly interdisciplinary.
- Several students pointed out the difficulties in communication, including differing vocabularies and ways of thinking that inherently come into play when working across disciplines.

Information is primarily shared with collaborators via e-mail. Students share information by the following methods:
- Weekly group meetings
- Publishing
- Casual conversations
- Posters and presentations at conferences
- Journal club meetings.

Many students agreed that there is a need for a better virtual environment that facilitates collaborative research.

Organization and Preservation

A majority of students admit to being poorly organized, and even a public health student who stated that she was fairly organized noted that: "There is always room for improvement. It is difficult to keep track of hundreds of references." The main systems of organization for most graduate students interviewed include:

- Saving copies of pdfs in folders on hard drives or portable USB drives
- Printing copies of pdfs and filing in three-ring binders or file folders by author or subject

Most students interviewed did not use RefWorks or a similar system of managing references, because the systems "are not user-friendly." Some students are unaware of classes offered to assist with using bibliographic management tools like RefWorks: "It's hard to keep track of hundreds of references. I wish there was a class on organization that would make me more efficient" (Public Health graduate student).

Laboratory notebooks and data entry software are often used by those engaged in field or laboratory research. Lab books are stored on shelves or on computer hard-drives.

Research Assistance

Many students use library resources when beginning to work on a new topic and during the information-gathering phase of any project. Often students become frustrated when searching for information on a new topic, but rarely do students turn to librarians unless they are desperate.

- A chemistry student stated that: "I would only ask a librarian for help if I couldn't find something" specific.
- "I ask my advisor or colleagues, or I send e-mails to researchers who are of interest worldwide" (Geology graduate student).
- "I ask my colleagues first, and then if the question isn't stupid, I will ask my advisor" (Geology graduate student).

Other comments on the topic of information and assistance included:

- The fact that search terms are too strict. A chemistry student said: "You don't think of one word and you miss a whole bunch of things you need."

Role of Mentors and Advisors

Graduate students in the sciences rely heavily upon advice and input from their advisors. Graduate students enjoy a well-established culture of mentoring by advisors, who often play key roles in the following activities:

- Information gathering
- Project development
- Making contact with potential collaborators
- Suggesting resources
- Financial support
- Creating supportive environments
- Suggesting journals for publication.

III. FOCUS FOR THE FUTURE

The University Libraries have a significant opportunity to respond to the research needs and challenges of scholars in the sciences. At the same time, many of the research practices engaged in by scientists are common to researchers at the University of Minnesota and beyond: the overwhelming preference for electronic resources and the need for increased and improved access; the difficulties and benefits of interdisciplinary research including the challenges of staying current in multiple fields, finding appropriate partners, communication, sharing of resources, and the need for increased logistical and financial support; the need for clear standards and support for data and resource curation and preservation; and many more. Core research behaviors like “discovery,” “gathering,” “organizing,” and “sharing” are applicable both to researchers in the sciences and in the humanities and social sciences.

That said, disciplinary culture is well established in the sciences, and can be glimpsed in the importance of publication in key journals in the evaluations of hiring, promotion and tenure; in the dependence on scholarly societies for networking purposes, as well as to stay abreast of the newest research; and in the proliferation of sub-specialties within a discipline that allow scholars to pursue new dimensions of a research area while interacting with familiar funding agencies, publishing venues, and administrative policy. Different kinds of proficiencies are required in each discipline and even sub-discipline, as the knowledge required of a geophysicist will differ from that of a geochemist, for example. Disciplinary cultures, though, cannot completely account for the idiosyncrasies of personal habits and practices. Attitudes about privacy and sharing, for example, depend more on the individual than the field.

A number of key findings raise questions about how best to support research at the University of Minnesota, especially in the realms of interdisciplinary research and data and resource organization and preservation.

Researchers are seeking new ways to make connections between and among disciplines, especially as they expand the purview of their fields. With the ubiquitous dependence on electronic resources and tools, and the disappearance of browsing as a source of serendipitous discovery, technology takes the place of the physical library for discovery. The place-less library found online, then, is required to provide more and more ways for researchers to answer questions, find what they are looking for, and be surprised. While some researchers in the sciences are suspicious of aids that return search results based on what other researchers have done (e.g. Amazon.com), other researchers are happy to take any help they can get when faced with a large field and a burgeoning amount of information. New tools that break search results into classic categories (author, date, keywords, etc.) are under development already at the Libraries, and could enhance the interdisciplinary discovery process.

In response to the increasing importance of interdisciplinary research in the sciences, the University Libraries have hired three science librarians who work together as a cohort on special projects, including this assessment of scientists' research practices, despite residing in different libraries across the University of Minnesota – Twin Cities campuses. The three librarians, working in the Science and Engineering Library, the Bio-Medical Library, and Magrath Library on the St. Paul campus, work collaboratively to forge relationships across the disciplines and to work on projects that are expressly interdisciplinary. The "Sciences Cohort" is meant to supercede the traditionally disciplinary organization and structure of academic libraries by providing an alternative model of assistance, expertise, and infrastructure.

The work on the myU Portal by the University Libraries, in partnership with the University-wide Office of Information Technology, also represents a continuing effort to present researchers with specialized resources that correspond to a person's position (graduate student, post doc, faculty member, etc.) and their department. Focused attention to the needs of interdisciplinary scholarship is a key motivator of this effort.

EthicShare, an interdisciplinary repository for bioethics scholars, is currently in the planning phase, and represents a model of how licensed content and publicly accessible online resources can be brought together in a single gateway for researchers to use, organize, and share in an online environment.

New efforts by the University Libraries to improve discipline-specific and interdisciplinary library research resources available to graduate students (workshops, online tools, tutorials, and other research guides) are being explored. The Information Literacy Collaborative, launched in summer 2007, will work to design, develop, and implement sound instruction practices to support competent research.

The "seamless" research process spoken of by a scholar from UMD is desired by scientists across the university, and has as much to do with "literary" support systems (online access to library resources, for example) as with "non-literary" support: the tools and infrastructure that facilitate research activities: chat technology, remote conferencing by video and phone, web assistance, resources for grant writing, collaborative writing tools, ways to identify potential colleagues, and more. For researchers, knowing what is available an*d* knowing how to employ the available resources is necessary and important.

Scientists are also looking for better ways to “see” their data and literature. Reading from a computer screen is very unpopular, although double screens ease this for some. Several faculty wished for data display methods that would allow them to connect pieces of experimental data, make connections between literature and data and between separate pieces of published work. Scientists not only want to retrieve data and literature in an organized fashion, but also to relate data and publications systematically.

The rise of distributed computing technologies and access to electronic tools and content has changed how scientists store and save data, but leaves unanswered key questions about the longevity and usefulness of their data. How long “should” they keep the raw data used in publications? Some will maintain orphaned, unpublished data sets, especially if the work can be built upon and published later. The decision to retain data sometimes is answered by simple space constraints, particularly when the data are physical specimens. Faculty are left to create their own guidelines, except where funding agencies may provide definitions (which are often woefully unclear). The University Libraries can develop ways to address aspects of these problems by continuing to research the importance of data and resource preservation to faculty and students, and by investigating the different curation needs of disciplines. Additional questions include:

- Can disciplines, perhaps through their professional societies and core journals, develop “standards” for the storage and/or preservation of data, both in “legacy-paper” and electronic formats?

- Should/can the U of MN create and support clear and explicit policies concerning data storage/security, archiving and preservation? Some faculty allude to the Libraries’ potential role in this. What is the role of the University Libraries, and of the University Libraries Digital Conservancy, in the future of data preservation?

In response to the question of data preservation and scientists’ research workflows, the Libraries are investigating the many policies, including the University’s, that determine standards for data curation and storage, as well as methods of making such policies more accessible. The myLibrary tab at the myU Portal may be one such vehicle for enhanced access to information and assistance. The University Libraries’ upcoming Digital Conservancy, a repository dedicated to preserving the digital assets of the university, is poised to take on the complex questions of long-term data access and preservation.

IV. CONCLUSION

The question of how libraries can better integrate discovery/management/creation/sharing tools into the workflow of scientists is still an open question, as is that of what tools will have the most significant impact. With the rise of e-science and the growing influence of popular social networking sites (which are slowing making their way into scholars' purviews), will social tools facilitate scholarly research and collaborations?

Engagement with the needs of interdisciplinary and collaborative scholarship, as well as the continued importance of core resources, is a constant motivation behind the current and future work of the Libraries. We also are actively considering how institutions and individuals drive collaborative relationships and scholarship; how libraries and institutions can better support multi-institutional research; and how to assess the sustainability of new models of research support.

Through focused dialogue with scholars, the University Libraries is able to target its internal discussion to reflect the actual experiences of researcher. Through an iterative process of assessment, engagement, analysis, and experimentation, the Libraries are attempting to integrate the full range of research needs by scientists into its commitment to providing "a great library for a great university."

APPENDIX

Interview and Focus Script, and "Tips"
University Libraries Sciences Assessment (Fall/Spring 2006-7)

Introduction

- **Who we are**
- Thank you for coming
- Why here? The University Libraries are exploring ways to better facilitate research in the sciences
- Want to go beyond what we think we know to get to what scientists actually do and need, and beyond what you do in the libraries
- Interested in the **full range of research activities in all stages of research**
- Questions will be asked about your experience as researchers and scholars
- Input valuable so that the Libraries can improve ways to support science research

- A few requests
    - Discussion will be tape recorded

- Participation is confidential, no names will be used in the study
- Consent form provided—please read and keep for your records
- Anyone uncomfortable with being recorded is free to go at any time
- Please speak openly and frankly

- Trajectory of conversation:
  - We will ask about your own work—interests, sources, methods, how to keep current
  - Role of Library in your research
  - Financial, technical, and other kinds of support or assistance needed
  - Finally, ideas about the best possible environment to support your work

  If there are not any questions…

1. Please introduce yourself and briefly describe your current research. Can you describe the various stages of your research and where you physically work in each stage?

2. When you are beginning a new project or working in a new area, how do you go about educating yourself about the research and information that you need to know? How do you keep up to date, generally?

3. How do you organize the data from your research? Secondary research that you gather? Data that you collect? How do you preserve and share data?

4. What, to you, makes research interdisciplinary? What does interdisciplinary research involve? What challenges, if any, does it present for you?

5. What challenges do you confront when working collaboratively (with colleagues at Minnesota or at other institutions?

6. How do you share ideas or information?

7. How adequate do you consider your methods for finding, organizing, and sharing information to be? Is there anything that would make your methods better or easier?

8. In your experience, what kinds of research spaces (physical or virtual) are needed for successful collaborative research?

9. What role does the library play in your research? At what stages of your research are you most likely to use library resources? What resources do you generally use? When do you come to the library? When do you go online? (**DON'T NEED TO ASK ALL)**

10. If you seek assistance from the library, what kinds of help are you looking for? What kind of assistance is needed (For grants? Publishing? Data curation and preservation?)

11. **(FOR GRAD STUDENT GROUPS ONLY)** What role do your advisors or mentors play in your research?

12. What factors do you consider when selecting a journal for publication? Are there any other ways to share research that are important to you?

13. If there were some magic wand that would make your work easier, what would it allow you to do?

Conclusion

- Thank you
- Participation is very valuable
- We will keep you up to date as the study progresses
- If you have any questions, or would like to add anything to the discussion, please let us know
- Thank you

> Thank you for your thoughtful and provocative comments. Your participation is extremely helpful. We will keep you up to date about the progress of the study, and its results. Please let us know at any time if you have any questions, or if there is anything else you would like to add to this ongoing discussion. Again, thank you for talking with us about your work.

Basic Tips for Focus Group Moderators

Important traits in an effective moderator:

· Knowledgeable: become thoroughly familiar with the topics of the focus group.

- Enthusiastic: value your work but remain impartial.
- Structuring: explain the purpose for the focus group; ask whether participants have questions.
- Clear: ask simple, easy, short questions without using jargon.
- Approachable: blend in; make sure the group can relate to you.
- Gentle: allow people to finish; give them time to think; tolerate pauses.
- Sensitive: listen attentively to what is said and how it is said; be empathic.
- Open and flexible: respond to what is important to the participants.
- Steering: know what you want to find out; keep the group focused; keep one or two members from dominating.
- Critical: prepare to politely challenge what is said. For example, you might question inconsistencies in participants' replies.
- Remembering and integrating: relate what is said to what has previously been said.
- Interpreting: clarify and extend meanings of participants' statements without changing the meaning.
- Inclusive: encourage reserved members to contribute by using eye contact, body language, and directly asking for their input.

The focus group discussion begins with an introduction that explains the purpose, ground rules, and duration and conveys the expectation that everyone will contribute, all contributions will be valued and notes will be taken during the session. Volunteer moderators will be given a paper that explains the purpose of the study and suggestions for introducing the purpose and focus of the group discussion. Let participants know their contributions are valuable (both through what you say and also your body language).

Following the introduction the moderator should ask the participants to introduce themselves and/or wear name tags. The moderator should encourage free-flowing discussion around the relevant issue(s).

The group discussion can now begin. Moderators should use the questions provided to guide the discussion.

Moderators should use reinforcers and probes. Reinforcers communicate interest in what members share but don't suggest what is expected or acceptable. Use reinforcers like, "I see," or "Let me write that down," but avoid comments like, "Excellent response," or nodding your head after some responses but not others. Try to smile and appear open and friendly.

Be prepared to use probes such as, "Could you tell me some more about that?" "What do you mean by that?" or "Anything else?" Allow participants time to respond, using silence in moderation to encourage someone to expand on an answer. Nonverbal behaviors will help you judge whether a participant is uncomfortable or just thinking about an answer. When a participant rambles or does not state a clear point of view, ask an interpretive question, such as, "Do you mean that your priorities have shifted from developing programs to building support for programs?"

Focus groups should end with the moderator winding-up the session by stressing all that has been achieved and casting it in a positive light.

It's important that the moderator realizes that:

- It may be necessary for them to step in and keep the session on-track
- Disagreements and debates are useful when they lead to new and interesting ideas, but have to be managed carefully
- Issues of power and privacy need to be managed sensitively

Dealing with issues that may arise:

- If one participant tries to dominate the session, the moderator should invite each person to speak in turn
- Avoid personal confrontation - allow the group to police itself (e.g. "do others in the group agree?")
- Respect someone's right to be quiet, but do give them a chance to share their ideas 1-to-1 (e.g. during a break)
- Use differences of opinion as a topic of discussion - the moderator should avoid taking sides

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Moderating: University of Texas at Austin, Division of Instructional Innovation and Assessment http://www.utexas.edu/academic/diia/assessment/iar/how_to/methods/focus_groups.php

Running focus groups: Web Credible http://www.webcredible.co.uk/user-friendly-resources/web-usability/focus-groups.shtml

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