

## 1. Introduction

The NSF Digital Libraries (NSDL) initiatives have acknowledged the importance of collaboration from the beginning. The 1996 NSF workshop on the uses of information technology in higher education identified effective information technology applications as those that: engage students, illustrate complex relationships, and “*encourage interaction with other individuals or teams*” (National Science Foundation, 1998, p. v). Subsequent workshops reiterated the need to support collaboration in digital libraries (National Research Council, 1998; National Science Foundation, 1999). These reports emphasize that a national science digital library should not be just a repository of materials for teaching and learning. Rather, it should provide opportunities for “an unprecedented level of collaboration” in a community of learners, given appropriate support tools (National Science Foundation, 1998, p. 24).

It is interesting to note that the strongest statements about the need to support collaboration come from recent NSDL grantees themselves (Manduca, McMartin, & Mogk, 2001). In March, 2001 the NSDL grantees meeting called for support for communities of scholars. Its requirements for core integration and functionalities included support for communication tools and collaborative tools. The current NSDL solicitation includes in its list of example research topics “research on building and sustaining user communities within the context of the digital library” (National Science Foundation, 2003, p. 8). Past and current NSDL grants have targeted some aspects of collaboration. These include an infrastructure for providing workflow services to help stakeholders of a digital library coordinate their shared activities across different organizations (NSF Award Abstract #0121460, 2001) and facilitation of discussion groups to help middle school students and teachers utilize mathematics material online (NSF Award Abstract #0226284, 2002).

We propose to study formation and collaborations of small groups as they utilize digital resources and to design and evaluate a prototype system to support group work in digital library settings. We also propose to extend the group-work environment to help in the identification and formation of new combined groups, or the identification of people with potentially shared interests, based on common utilization of digital resources.

## 2. Statement of Need

### 2.1. Collaboration and Group Work

In physical libraries, the stereotypical image of the user is as a lone researcher lost in solitary reading and writing, but this is not an accurate characterization (Levy & Marshal, 1995). Observation of physical libraries suggests that collaboration occurs frequently when a group of people have a common goal. A classic example involves student teams in a school media center or university library, who search for resources together and then gather around a table and to read, extract relevant information, evaluate, and organize it. Several researchers have argued that social interaction in general, and collaboration in particular, is an important way in which library users achieve their goals (Crabtree, Twidale, O’Brien & Nichols, 1997; Pottenger, Callahan & Padgett, 2001).

Through ethnographic studies in libraries, Twidale and his colleagues (Crabtree et al., 1997; Twidale, Nichols & Paice, 1997) have shown that browsing and searching are collaborative activities in which users partner with others to find information they need. Some partnering is opportunistic, as when a user asks someone nearby for help. However, collaborative or coordinated searching by users with a common goal is frequent, as is brainstorming about how to find resources by a group of library users working on the same topic (Twidale et al., 1997). Library users have also been shown to work as intermediaries to a larger group of users, retrieving information from the library, broadcasting it to their team members, and archiving it for group use (O’Day & Jeffries, 1994).

Retrieving documents from a library is only the prelude to using the information. Research in human-computer interaction has shown that documents are the focal point for collaborative understanding and knowledge construction (O'Hara, Smith, Newman & Sellen, 1998; Sellen & Harper, 2001). Being able to view documents together and mark them up collaboratively is a fundamental step in creating shared understanding within a group. In a physical library these activities take place face-to-face. However, workplace prototypes have been developed to allow text chats to be anchored to a document (Churchill, Trevor, Bly, Nelson & Cubranic, 2000). Likewise, annotation systems have been designed to allow asynchronous collaboration around work documents (Cadiz, Gupta & Grudin, 2000; Nichols, Pemberton, Salhoumi, Larouk, Belisle & Twidale, 2000; Wilensky, 2000), and interfaces are being developed to allow 3-D social navigation of documents (Borner, Feng & McMahon, 2002). The traces that an original group leaves could be preserved to provide information to subsequent users with similar goals, e.g., making document annotations and chats visible (Cadiz et al., 2000; Churchill et al., 2000) allowing the library to serve as a matchmaker that introduces users with common interest to each other (Nichols & Twidale, 1997), and making bibliographies and "best references" on a subject visible. Recommender systems have been suggested for digital libraries modeled after existing collaborative filtering systems (Huang, Chung, Ong, and Chen, 2002; Resnick, Iacovou, Suchak, Bergstrom & Riedl, 1994).

Thus, digital libraries should support group work and collaboration both within and between groups. In this proposal, our focus is on collaboration among users of a digital library. Here, we can distinguish "indirect" from "direct" collaboration. By indirect, we mean collaboration in which the work of one user may somehow benefit anonymously from other users in the future. For instance, if browsing trails, query formulations, annotations or rankings created by current users are captured and stored in the library's metadata in order to guide future users with recommendations, that would be a form of anonymous, asynchronous, indirect collaboration within the user community. By "direct collaboration" we mean instances where several users agree to work together as a team exploring and making use of digital library resources. These might be friends learning about a shared hobby, a workgroup in industry conducting library research, or a team of students learning collaboratively for a class group project. Direct collaboration is of particular concern for us and we will be conducting detailed studies and experiments with student teams using digital libraries in class projects. In direct small group collaboration, group members know that they are working together toward a common goal (Dillenbourg, 1999). They may divide up some of the tasks and then share their findings; they may communicate face-to-face, through synchronous chat or by means of asynchronous email and threaded discussion.

The interest in small groups is motivated by the desire to build active user communities around digital libraries to increase the impact of these libraries (Renninger & Shumar, 2002). Small groups can function as micro-communities that mediate between the individual users and the whole, abstract user community of a digital library. They can provide social structure to the amorphous larger community as well as providing vehicles for trajectories through community roles (Wenger, 1998). For communities to function effectively, they must reproduce their constituencies, continually socializing new generations into the largely tacit practices that make up a community's life (Lave & Wenger, 1991). Geographic communities have hierarchies of levels such as nation, state, county, township, city, neighborhood, block, extended family, nuclear family and couple to integrate individuals into the larger world. People learn to interact within different levels, and gradually move from peripheral roles into more central leadership positions within particular levels. Virtual communities of practice need to develop similar structures if they are to thrive (Shumar & Renninger, 2002). Small groups within classes within departments within universities within academic fields can start to provide such structure. In addition, small groups can be assigned class projects that are explicitly intended to contribute indirectly to the community, for instance building public FAQs or annotated bibliographies to aid anonymous future users.

## 2.2. Knowledge Communities

Collaboration and social processes have been discussed in many studies dealing with designing systems that support information sharing between people. Erickson and Kellogg (2000) suggest that a vision of “knowledge communities” will be able to support the creation, management, and reuse of knowledge in a social context. The system they suggest enables users to draw upon their social experience and expertise to structure their interactions with one another. By making it possible for users to find one another, they believe that “digital systems can become environments in which new social forms can be invented, adopted, adapted, and propagated – eventually supporting the same sort of social innovation and diversity that can be observed in physically based cultures” (p. 80).

Ackerman and McDonald (2000) explain the importance of collaborative support for informal information in collective memory systems by describing the systems they have been developing to support informal information exchange. They suggest the utility of three types of support for informal information in a collective memory: including human resources in a collective memory, incorporating communication flows, and reducing the information in a collective memory to manageable proportions. Ackerman (1994) describes the use of social interaction in information environments in four ways:

- Getting help to understand what information is worth pursuing.
- Providing mechanisms for seeking informal information.
- Getting ad-hoc, collaborative, and highly contextual information.
- Helping people with common interests to meet one another.

The use of knowledge-capturing systems and organizational memories within corporate situations has led to the realization that communities of interest, or communities of practice, are extremely important to organizational learning and productivity (Davenport & Pruzak, 1998). Communities of interest form naturally when people have opportunities to see what others are doing (Wenger, 1998). They are typically informal groupings of individuals with common goals who are attempting to solve common problems.

While communities of interest have been studied most carefully within organizations, libraries offer an opportunity to form communities of interest among individuals who are not otherwise within the same social or work contexts. Many studies of behavior in physical libraries have shown that library users spend considerable amounts of time interacting with one another and with staff members (Bishop & Star, 1996; Ehrlich & Cask, 1994; Levy & Marshal, 1995; Nardi & O’Day, 1996; Rao, Pedersen, Hearst, Mackinlay, Card, Masinter, Halvorsen, & Robertson, 1995; Twidale, Nichols, & Paice, 1997; Wilensky, 2000). Libraries serve as informal meeting places for people with common interests, and they can be instrumental in the formation of communities of interest (Constant, Sproul, & Keisler, 1996; Covi & Kling, 1996; Hinds & Keisler, 1995).

What is needed is for the library to offer a service by which individuals with common goals, as evidenced by their search, browsing, or questioning activities, can find each other.

## 2.3. Electronic Collaboration

Collaborative tools are software environments that support various forms of interaction among people (Johansen, 1988). They might support simple, non task-oriented interactions such as dialogue, or they might support complex, group work interactions such as design, writing, or manufacture. Collaborations can be synchronous or asynchronous, and they may involve people who are in the same location or in multiple locations.

Common electronic communication tools, such as file transfer and e-mail software, can be used to collaborate. However, more comprehensive and complex collaborative environments have been

developed to support a variety of forms of collaboration. Many collaboration tools combine various technologies such as chat (synchronous dialogue), bulletin boards (asynchronous dialogue), shared drawing spaces, shared document repositories, and other tools in an integrated environment. There are now commercial systems like Blackboard®, WebCT® and Lotus LearningSpace®--as well as research systems like CSILE/KnowledgeForum (Scardamalia & Bereiter, 1996), WISE/KEY (Slotta & Linn, 2000), BSCW/Synergeia (Stahl, 2002)--that are in widespread usage for supporting collaborative work and collaborative learning. The Knowledge Depot (Zimmerman, Atwood, Webb, & Kantor, 2000) supported knowledge sharing and the formation of communities of interest within a corporate setting by allowing participants to share online documents and be alerted about interesting contributions of new documents. The Knowledge Depot system was integrated into the workflow of users, and did not require extra steps for sending documents into the repository, creating groups, or doing other knowledge-sharing activities. Answer Garden (Ackerman & McDonald, 1996) helped to build communities of interest from individuals asking questions. In the library context, Robertson and his colleagues (Robertson & Reese, 1999; Robertson, Jitan, & Reese, 1997) developed a system for identifying communities of interest from the content of online interactions between research librarians and their clients.

The single most important finding of CSCW and CSCL has been the importance of social factors in the successful adoption of such systems (Kling, 1999; Orlikowski, 1992). This is why we believe it is important to take a strong user-centered research approach to developing computer support for small groups in digital libraries, rather than jumping into software development without adequately understanding the social context.

Several researchers have explored collaboration among people engaged in information seeking behaviors (Hoppe & Zhao, 1994). Twidale & Nichols (1998) described users of a library as they collaborated in several different ways, including coordinated searching, asking for help, monitoring others, and noticing things by chance. Some researchers have described systems for supporting collaborative information searching within libraries (Davenport, Procter, & Goldenberg, 1997; Kasowitz, 2001; Procter, Goldenberg, Davenport, & McKinlay, 1998; Procter, Goldenberg, McKinlay, & Davenport, 1997; Lankes, 1993a, 1993b; Twidale, Nichols, Smith, & Trevor, 1995), although in general tools to support collaboration and community building within digital libraries are in their infancy (Ackerman, 1994; Ackerman & McDonald, 1996). DSpace (Bass & Branschofsky, 2001) is an open source, shared, digital work space now being deployed in many libraries, including Drexel in 2003. DSpace is a promising new platform that supports the creation of community areas for storing, organizing, and finding electronic materials. Because DSpace is being widely deployed for the first time, there are not yet empirical studies of its use.

## **2.4. Knowledge Centers and Information Sharing**

Willingness to share knowledge is one of the most basic changes in culture and technology that can lead to effective use of an organization's information resources (Davenport, 1997; Davenport & Prusak, 1998). Knowledge sharing involves breaking organizational boundaries and undermining traditional lines of control. One resource for this purpose that is appearing in some organizations is the corporate "knowledge center," a clearing house for diverse sources of information staffed by professionals who keep track of cross-organizational goals and needs (Chase, 1998; Davenport & Prusak, 1998; Marshall, 1997; Williams & Bukowitz, 1997). Knowledge centers are natural outgrowths of forward-looking libraries.

While communities of interest make sense within organizations that have a common purpose, how can they form from situations such as disparate digital libraries where people are not otherwise connected by a common goal? Information relevant to the ongoing activities of a community or organization will tend to flow into a heavily used library. For example, if a school district begins a program on environmental education, the library serving the district will begin to receive many questions about environmental issues

from students. Staff members will notice relevant library materials being checked out. Similarly, if a corporation begins planning a new product launch or a strategic acquisition, the corporate library will begin to receive requests for specific market information or for corporate financial information, from a variety of sources involved with the corporate action. Indeed, it is something of a sport of research librarians to figure out what is going on in the community they serve.

Librarians use the information about community activities to help them determine what is most relevant to their clients. For example, a corporate research librarian might provide different information in a company profile if he or she thinks the profile will be used to negotiate a merger instead of to enter a competitor's market. Because one of the research librarian's roles is to filter and focus information, inferences about community activities, as reflected through the goals of the librarian's clients, are very important in guiding the research librarian's work. Unfortunately, the concentration of information about community activities is often a lost resource. Librarians use it locally for their own purposes, but it seldom leaves the library and is unavailable to rest of the community. While confidentiality is sometimes required between research librarians and their clients (and is, in fact, part of the code of ethics for library professionals), there is nonetheless a potential value in sharing a library's unique perspective with others in an organization. One possibility for supporting information sharing is for clients to make some of their work available for others to see. Additionally, a software system might be created which examines the digital resources being used by individuals and groups and attempts to match them up. In the latter scenario, it is not necessary for information to be public, so long as the match-making system preserves anonymity when connecting people and groups to each other.

#### **2.4. Identity, Privacy, and Trust**

Anonymity is a hallmark of cyberspace. However, anonymity blocks community building and knowledge sharing. It precludes the creation of a social atmosphere based on observed behaviors. If a virtual library is to support community building and knowledge sharing, then the users must be visible to each other. For a community over time to develop, it is important to learn who people are and how to find them. There are many groups that meet in particular places at particular times in which the participants only know each other's names, relevant interests and purposes, and histories that are relevant to the group. This slice of identity and behavior is enough to support many special-interest communities. "Identity" in these cases is revealed gradually and does not have to encompass a broad range of details. Consider the case of a person taking books from a shelf in a library: It is enough to initiate a meaningful conversation if their presence and behavior is visible, and if the content of the materials they are choosing is visible. It is not necessary to know much more about them.

In the context of digital libraries it will be important to explore these various levels of identification and connection. Users of a library trust the research staff with their identities, and any match making that librarians carry out is carefully negotiated. It is an empirical question how these aspects of identity and confidentiality will carry into digital library settings. Trust is likely to play a major role in digital library users' comfort in collaborating. Several researchers have framed trust in terms of vulnerabilities (Corritore, Kracher, & Wiedenbeck, 2001; Mayer, Davis, & Schoorman, 1995). Trust is the willingness to be vulnerable to the actions of another on the expectation that the other will perform an action important to the trustor, even through the trustor may be unable to monitor or control the other party (Mayer et al., 1995). Development of trust is encouraged by shared experiences and norms (Lewis & Weigert, 1985; Mayer et al., 1995). Research on computer-mediated communication has shown that trust and cooperation are low when people communicate electronically without face-to-face or video interaction (Bos, Gergle, Olson, & Olson, 2001; Rocco, 1998). Collaboration in the context of digital libraries will need to find mechanisms to engender trust by highlighting shared experiences and norms, without revealing too much about participants too soon.

In a corporate setting there is much to be gained and nothing lost in re-using work that has already been done. In other settings, such as academic or public libraries, the problem is more complicated. For example, if several students in a course are asked to do papers on a particular topic, can the work done by a research librarian for one student be shared by all students? What issues of academic honesty arise when students view an archived collaboration on the same topic with a research librarian? Academic librarians are familiar with scenarios like this in their regular practice, however it is an empirical question how such matters would carry over into electronic collaboration environments.

Faculty also use the academic library in support of their own research and teaching. In the case of faculty research, it seems that an open collaboration environment would be useful for knowledge sharing among faculty members both within and across institutions. On the other hand, faculty researchers might feel competitive about their work or not wish others to see what questions they had in formative stages of thinking about a problem.

What is the desirability of sharing collaborations on faculty research with students? There could be some desirable advantage to allowing students to see how a teacher went about developing the material for a course. In a manner akin to design rationale systems in software engineering, insight into the reasoning and problem solving processes of a teacher might be useful to a student. On the other hand, it might not be desirable for a student to have access to research being conducted in preparation for an upcoming examination.

In public settings, these issues are even more difficult. While individuals seeking similar health information might benefit from knowing each other, to what degree are they willing to be identified to each other and to what degree are librarians willing to serve as intermediaries in such situations? Seeking information in a new and unknown field is difficult because users do not know what exists or what is most valuable to pursue. They need direction and guidance to make good information choices. This direction and guidance may come from a professional intermediary, such as a librarian, but it may also come from other people with similar interests and needs. A collaborative environment in a digital library could allow users to be supported by both professional intermediaries and other users. A problem that arises in collaboration among users is that a user with an information need often does not know about other people who are pursuing information on the same topic. There has to be a way to put a user in contact with the right person and to do it in such a way that it is to the mutual benefit of both.

### **3. Target Audience**

The initial setting of our project is formal education at the college level. The types of people impacted by this project are students, educators, and academic librarians. The system is being designed primarily to facilitate collaboration within and among these three user communities. In the long run, however, we envision scenarios in which small groups form in many contexts. Examples might include clients and medical professionals in a health center who need to collaborate on medication and diet plans; employees and managers who need to collaborate on strategic business research; voters, government officials, candidates, and other interested parties who wish to collaborate on election issues; etc. While our project takes place in an academic setting, in envisioning and design workshops described below we will be including representatives from a wide variety of backgrounds.

### **4. Project Goals**

This project has three primary goals:

- To understand how small groups can form and collaborate in the context of digital libraries.
- To design a prototype software environment to support small group formation and collaboration in the context of digital libraries.

- To evaluate the prototype empirically and to offer suggestions for further development.

It is important for the design of systems that support collaboration to understand how groups collaborate with each other using library materials and how they interact with library staff. It will be important to understand what members of working groups are willing to share with other members and with other groups, and how this willingness changes over the course of a group project. We also seek to understand how small groups collect resources together, negotiate about their use, divide tasks, create artifacts, and otherwise structure their activities. In addition to understanding work within groups, we seek to understand how groups might find out about each other and benefit from sharing information or work. Such sharing could occur synchronously while multiple groups are working on related projects or asynchronously when one group uses the archived resources of another that worked on a related project at an earlier time. We will seek to understand what groups would like to know about other groups and what resources they would like to use. To these ends, we propose a series of initial user studies, described in Section 5.1.

A collaboration environment that is integrated with digital library resources such as electronic archives, search tools, reference services, and databases would be useful to small groups. We propose to build a prototype with the help of users including students, librarians, teachers, and researchers. We will build upon existing platforms such as DSpace. We will use iterative and participatory design practices as described in Section 5.2.

Evaluation of the use of the prototype will be an important part of the project. We hope to support activities that were observed in small groups who were not using the prototype. However, we also hope to foster and observe new activities in those groups who are using the prototype. The evaluation phase, described in more detail in Section 5.3, will serve both to measure the success of the project and point in new directions for development of a full-fledged service.

The research questions will guide our initial study of current practice and our later study of the working system that we develop. The first set of questions concerns what kinds of information are valuable to people in an intellectual discovery task.

1. What kinds of information do users seek in orienting themselves to a topic? Ideally, what would they like to find?
2. Where do they first look for orienting information: on the Web, in digital library collections, in print collections?
3. Do they prefer to obtain information by searching on their own, by asking peers, by asking a professional intermediary?
4. If they fail to find what they need in an initial search, what is their next step? Under what circumstances do they approach another person for help or collaboration?

The second set of questions concerns collaboration of users in intellectual discovery tasks.

1. What would a user be interested in seeing of another person's work on a topic, e.g. questions and answers, materials retrieved, materials used, products produced using the material, chat?
2. At what points would users want collaboration with others?
3. What is the value of seeing and following up on what another person has looked at? What is the value of direct contact with the other person?
4. What would a person who has collected information be willing to share? What are their concerns about sharing?
5. What would be the value of contact to the person who shares his/her workspace with another person? What would be the motivation for sharing or establishing direct contact?

6. What levels of access to their work would people be willing to give?

The third set of questions concerns facilitation of collaboration in a digital library setting.

1. How could a professional intermediary facilitate collaboration between users? Is a human intermediary needed or could this role be played by an electronic intermediary?
2. What support for evaluation of materials can be provided in a collaborative setting in a digital library?
3. How can trust be engendered in order to facilitate collaboration in digital libraries?
4. How can collaboration and reuse be achieved in a digital library, respecting concerns for anonymity and privacy? How can a user share information but control the level of revelation?
5. How could past user-intermediary and user-user interactions be reused via archiving, search and retrieval?

The fourth set of concerns design and testing of a prototype to facilitate collaboration in digital libraries.

1. How should a prototype be designed to facilitate collaboration while respecting constraints of privacy and confidentiality?
2. How well does the prototype perform in promoting useful collaboration in field trials in digital library settings?

## 5. Project Design

The project blends user studies, prototype development, and evaluation. We do not envision these as stages, but rather hope that the three activities will inform each other.

### 5.1. User Studies

We propose to study both the attitudes and beliefs that are important for collaboration and also the behaviors of collaborating groups. Almost all course work at Drexel involves small groups working together on projects. The four investigators will coordinate the group work in their courses in order to facilitate this study. We will ask students to use several electronic resources—including NSDL, Drexel's Hagerty Library (which contains several thousand electronic journals, databases, and books), the HCI Bibliography ([www.hcibib.org](http://www.hcibib.org)), the ACM Digital Library, and others—to develop projects related to HCI. Each investigator typically teaches at least one course per quarter involving 5-7 groups of 4-5 students each. Thus in any given quarter, the investigators will be able to look at 20-28 groups working at the same time.

In the initial user studies, we will ask students to first begin individual research on selected topics in HCI. We will directly observe the work of some students, electronically record the work of all students, and ask all students to keep careful records of:

- The search terms they use.
- The materials they look at.
- Their thoughts about the materials (relevance, interest, etc.).
- Their intended use of the materials.

After a short period of individual research, we will provide students with each other's records. We will ask students to use the records to find potential collaborators for group projects. We will observe how students inspect and reason about each others' digital library records. Ultimately we will form groups, some will be formed by students and others will be formed by the investigators using criteria that they feel

will make good project teams. The groups will continue to use digital resources to complete their research projects. Their group behaviors will be observed and recorded in planned group meetings, and they will be asked to keep structured records of their activities in impromptu group situations. We intend to describe the processes involved in examining other researchers and forming groups. We intend to compare the performance of different groups formed with varying criteria.

For our observational studies, we plan to use contextual inquiry (Beyer & Holtzblatt, 1998; Holtzblatt & Jones, 1997), a modern ethnographic technique that has been successfully applied to analysis of interactive systems (Beyer & Holtzblatt, 1998; Cleary, 1999). In this technique, researchers carry out active observations in the work setting. Researchers gather rich data by observing in context, forming a partnership with the persons being observed, asking the partner to help in interpreting the activities and events, and empowering the partner to take the lead in focusing the researcher on key aspects of the situation. A precedent for use of contextual inquiry in a library setting is Normone's (1998) research on information-seeking behavior.

There will be several focuses of our studies, described next:

### ***Focus 1: Small group formation***

An initial task is to understand how groups organize themselves and begin their work. When a group is first formed, there is a need for members to get to know each other's capabilities and interests. The group must also form a shared identity and purpose. We propose to observe and interview groups in the early stages of their activities to understand how these first steps are achieved. We expect to find:

- Questions about and statements of relevant interests aimed at finding mutual interests.
- Questions about and statements of skills, knowledge and background.
- Establishment of provisional goals and directions.
- Development of a group "identity."

A questionnaire will be designed to assess willingness to share information, and interest in knowing information about other groups, during this early stage of group formation. Will group members be interested in sharing or knowing about skills and knowledge of individual members or the group as a whole? What aspects of groups' early goals will members be interested in sharing or knowing about? What constitutes group "identity" and what parts will be private and public?

Information collected from this focus will be used to design prototype components which facilitate interaction and knowledge sharing among group members and between groups.

### ***Focus 2: Working in groups***

After a group has formed, members develop tasks and begin work. They collect materials and create information and ultimately bring it to the group for consideration. We propose to observe small groups working in the physical library and other settings using the library's electronic resources as they collect, organize and discuss materials. How do individuals decide what to bring to the group and what to leave unshared? What do group members share about their searching and browsing strategies and experiences? How do group members decide what to use and how to use it? We expect to find:

- Negotiation about the importance and usefulness of various materials.
- Summarization and sharing of contents among group members.
- Discussion of how material integrates.
- Agreement on tasks.
- Iterative review of material contents and tasks.

- Periodic updating on progress.
- Creation of common artifacts such as documents.

A questionnaire will be designed to assess willingness to share, and interest in knowing about, the materials being used by groups, their ratings and ideas about the materials, drafts of documents being created, and progress.

Information collected from this focus will be used to design prototype components which facilitate sharing of in-progress information and resources being used during group work.

### ***Focus 3. Interacting with others***

While work is progressing, members of workgroups interact not only with each other, but also with people outside of their groups. Examples include other group members, their professors, and library personnel. We propose to monitor interactions of groups with others in order to understand who they communicate with and what information they gather and share. We expect to find:

- Selected sharing of information with others.
- Asynchronous and synchronous communication patterns.

A questionnaire will be designed to assess willingness to share, and interest in knowing about, the interactions of groups with others.

Information collected from this focus will be used to design prototype components which support communication and collaboration across groups and between groups and other stakeholders in the groups' projects.

## **5.2. Prototype Development**

Development of a prototype for supporting and archiving electronic research interactions will begin after data has been collected from users about their current and possible information-sharing behavior. The characteristics of the prototype will largely be determined by the results of these user studies. Here we suggest some high-level characteristics that may be part of the prototype, based on past research and experience in collaboration in libraries and knowledge management. We expect that the prototype will include:

- Information spaces in which groups may keep retrieved and created documents, queries, annotations, conversations, and other resources.
- Mechanisms to allow degrees of sharing of the contents of group information spaces.
- Capabilities to find other groups based on shared interests as indicated by overlapping content in the information spaces.
- Support for communication among groups, possibly including chat, collaborative information retrieval, collaborative evaluation, and collaborative document creation spaces.
- Archiving and search of information spaces that are no longer active.
- "Recommender" capability that compares the content and activities of various groups and suggests new materials and new interactions.

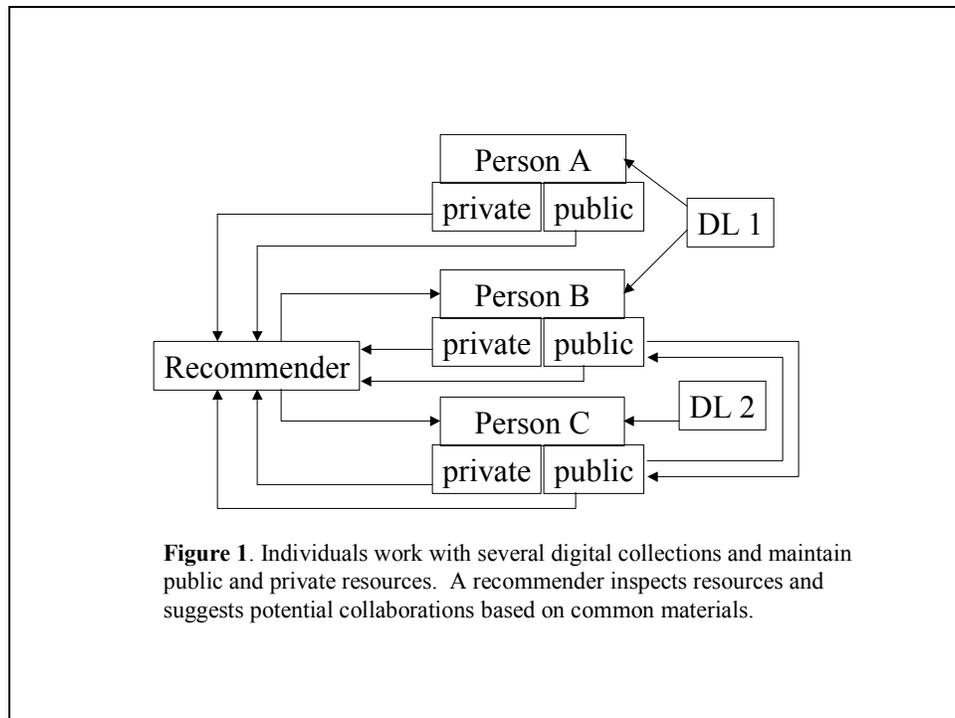
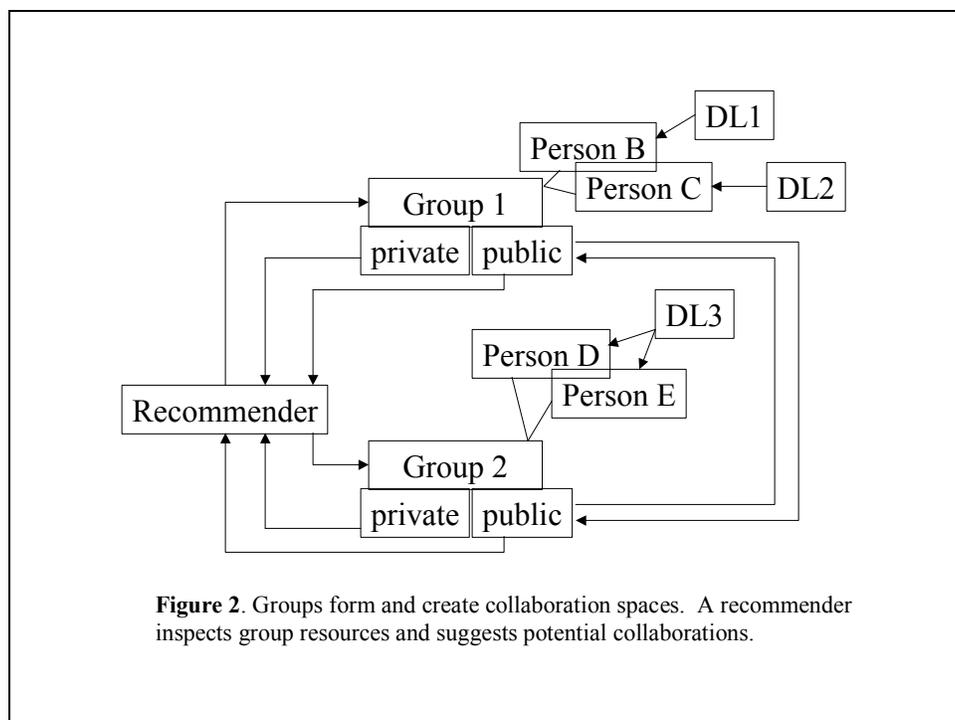


Figure 1 suggests that individual users of digital library systems may begin to collect materials together in a digital workspace in preparation for a project. They may make some of the materials “public” so that other individuals can see what they are doing. This is much like piling books or journals up on a table in a physical library where others can notice what is being worked on. A recommender system has access to the content of the materials, both public and non-public, and can compare them between users. The recommender system can, in turn, notify individuals that others are working with similar materials. In Figure 1, Person B and Person C are notified that they are working with similar materials. Note that this can happen even though Persons B and C are working with different digital collections.

In Figure 2, Persons B and C have formed a group to collaborate. The Figure shows that groups may also create working spaces in which to maintain digital resources that they have collected from multiple sources. As the figure suggests, individuals within a group can form both private and shared areas. These group workspaces support organizing, chatting, annotating, document creation, and other activities. Groups may make any of their resources public, which would in turn allow other groups to see them. Groups may also make resources available to a recommender system, which finds similarities between groups based on the material in their workspaces and informs groups about the existence of other, similar groups. With permission of the group, the recommender may inspect otherwise private material for the purpose of comparing groups. In Figure 2, the recommender has suggested that Groups 1 and 2 have similar interests. Members of the groups can then inspect each other’s materials and decide whether to and how to collaborate.



Prototype development will progress using a variety of participatory design techniques (Greenbaum & Kyung, 1991; Schuler & Namioka, 1993). The design process will be iterative and user-centered in order to successively approximate a design that is useful and usable (Gould, Boies, & Ukelson, 1997). We will pay attention to problems known to arise in the design of groupware systems (Grudin, 1994). Stakeholder groups will be identified, although initially we expect them to include students, professors, and library personnel. We propose to organize workshops of potential stakeholders to do an initial envisioning exercise and a later prototype development session. We are seeking sufficient funds to bring additional workshop participants from outside of the Drexel community.

In participatory design sessions, stakeholders will help to create scenarios, identify tasks, and develop task-flow models for group workspaces that integrate interaction with digital resources, librarians, professors, and other groups. Toward the end of the prototyping period, the development effort will shift to implementing a system that can be deployed as a working prototype.

### 5.3. Evaluation of the Working Prototype

Once a working prototype has been developed, it will be deployed in limited test settings within Drexel's College of IST. With their consent and knowledge, users' behavior will be monitored with computer logging technologies, on-site observations, questionnaires, and interviews. We are interested in usefulness, usability, and user attitudes. Logging and direct observation will be used to determine the overall amount of use, use of different prototype features, requests for collaboration by users, amount and level of sharing by owners, direct communication between owners and users, and collaborative activities undertaken in the information space as a result of contact between users. User attitudes will be measured by questionnaire. We plan to use validated instruments to measure satisfaction, for example, the Questionnaire on User Interface Satisfaction (QUIS) (Chin, Diehl, & Norman, 1988) or Perceived Ease of Use and Perceived Usefulness (Davis, 1989; Davis, 1993). Other questionnaire instruments will be developed as needed, for example, an instrument to measure trust in collaboration in the digital library setting. Interviews will be used to probe users' use and attitudes toward the prototype more deeply. The

interviews will be done in conjunction with or after the other evaluations to following up on and interpret interesting behaviors and trends in the data.

<b>Year 1</b>			
<b>Month</b>	<b>User Studies</b>	<b>Prototype</b>	<b>Evaluation</b>
<b>1</b>	Instrument development		
<b>2</b>		Workshop 1 planning	
<b>3</b>	Focus 1 studies begin	Workshop 1 invitations	
<b>4</b>		Design sessions begin	
<b>5</b>	Focus 2 studies begin		
<b>6</b>	Analysis of Focus 1 studies	Workshop 1	
<b>7</b>	Focus 3 studies begin	Workshop 2 planning	
<b>8</b>	Analysis of Focus 2 studies	Workshop 2 invitations	
<b>9</b>		Design requirements 1	
<b>10</b>	Analysis of Focus 3 studies	Paper/screen prototype 1	
<b>11</b>		Workshop 2	
<b>12</b>	<b>User studies report</b>	Design requirements 2	
<b>Year 2</b>			
<b>Month</b>	<b>User Studies</b>	<b>Prototype</b>	<b>Evaluation</b>
<b>13</b>		Prototype building	Instrument development
<b>14</b>		<b>Workshops reports</b>	
<b>15</b>		Prototype deployment	
<b>16</b>			Observational studies
begin			
<b>17</b>			
<b>18</b>			
<b>19</b>			Analysis of observations
<b>20</b>			Interviews
<b>21</b>			
<b>22</b>			Analysis of interviews
<b>23</b>			
<b>24</b>		<b>Redesign report</b>	<b>Evaluation report</b>

**Table 1. Project Milestones and Timeline**

#### 5.4. Timeline

User studies, prototype development, and prototype evaluation will overlap. Each phase is intended to influence the others. However, there are some obvious dependencies among the phases. Table 1 presents a timeline which sequences and integrates our activities. The timeline indicates that there will be at least four significant reports (in addition to publications and presentations). The first is a report on the outcome of user studies. Preparation of this report will play an important role in the conduct of the design workshops, especially the second workshop. The second report involves the outcomes of the workshops. This report includes scenarios developed, issues raised for concern, and prototype requirements and design. The third report describes the results of observations of and interviews with users of the prototype. The fourth report discussed redesign issues which arise from experience with the prototype in use.

## 6. Key Staff

The interdisciplinary research team brings a variety of relevant knowledge and skills to this project. Atwood (MA) and Robertson (SR) have extensive experience with user-centered systems design in industry, including the design of collaborative systems. Atwood participated in research leading to the development of the Knowledge Depot (Zimmerman, Atwood, Webb, & Kantor, 2000), a groupware system that supported knowledge sharing and the formation of communities of interest within a corporate setting. SR was the lead designer of the research collaboration system in a corporate digital library (Robertson, 2000; Robertson et al., 1997; Robertson & Reese, 1999) and the lead strategist and designer for a knowledge management application within a large corporation (Robertson, 2002). SR and Wiedenbeck (SW) have both worked in library settings. SW was formerly a professional librarian in an academic library setting and has done research on information seeking (Jenkin, Corritore, & Wiedenbeck, 2002) and on trust in electronic environments (Corritore et al., 2001). SR was the information technologist in a corporate library for several years. Stahl (GS) has conducted research and developed theory within the field of Computer Supported Collaborative Work (CSCW) and Learning (CSCL) (Stahl, 2002, 2003), and worked to understand and build collaborative information environments in many contexts including education and design (Stahl, 2000; Stahl, Sumner, & Repenning, 1995).

All of the researchers are currently involved in projects regarding information dissemination or collaboration. GS is currently working with the MathForum to study group work in that context. SW, MA, and SR are involved with a project to study information dissemination and computer-mediated support groups in the context of inner-city health care.

## 7. Dissemination

The research team is committed to broad dissemination of findings through presentations at conferences and publication in appropriate journals. There are many areas in which this research has relevance including CSCW and CSCL, HCI, DL, and design. In addition to traditional outlets, we intend that the workshops described in section 5.2. will serve to disseminate our ideas and preliminary findings while, at the same time, providing us with ideas. Once a prototype is developed, we will seek to deploy it in library settings beyond Drexel. We will report on our progress at NSDL grantee meetings and at appropriate working group meetings.

## 8. Evaluation

The success of the user studies can be evaluated by their ability to produce acceptable journal articles and conference papers, and by their ability to contribute to prototype design. An evolving design document will record design implications of the user studies as results are collected.

Success of the design process itself will be measured by evaluative questionnaires administered to design participants, particularly by those in the workshops. One goal of the workshops is to interest many different types of users in the problem of group work and collaboration in digital library contexts, so we will ask directly about the success of the workshops in fostering this interest.

The product of the design process, the prototype itself, will be explicitly evaluated in the last phase of the study as described in section 5.3. We will be concerned with the usability of the prototype and its functionality with regard to supporting group work.

## 9. Sustainability

While this is not a project in the Collections or Services tracks, it is clearly directed toward a service for users of digital libraries. Development of the prototype will always be guided by the intention to deploy a system for small group collaboration in real digital library settings. One goal of the workshops will be to involve and interest libraries in trying out the prototype and ultimately deploying a service. Toward the end of the project we intend to seek further support for creating a service.

## **10. Intellectual Merit**

This research will contribute to the understanding and practice of collaboration and of the role of small groups in building global communities. It will apply principles of CSCW, CSCL and HCI to the domain of collaboration in DLs and advance knowledge of small group needs in information-rich digital environments. It will develop innovative ways to support group needs in information-intensive tasks. A challenge for digital libraries is to make them more than mere repositories; providing group tools tailored to the needs of real users is an important way to make digital libraries “come alive.”

Digital libraries, like physical libraries, must eventually support collaborations of all types. Increasingly, in both workplace and academic settings, tasks are accomplished by groups in collective learning situations. Librarians play the role of expert facilitators and advisors. Our project proposes systematic design of a system to support these activities in a manner that is informed by data on users’ current practices, information on their attitudes and reactions to new possibilities and technologies, and reactions to design and use of a prototype.

The data gathered should influence the design of other collaboration technologies under consideration for digital library settings. Our data will provide information on attitudes towards privacy and information sharing that will influence acceptance of any proposed system. Our data will contribute to the development of standards and policies about information sharing in digital library environments. Our findings will also guide in the development of strategies for introducing digital collaboration environments into various social contexts.

Our goal would be to help digital libraries become knowledge centers and hubs for the formation of communities of interest. Libraries’ tendencies for handling information about their clients are, appropriately, conservative. Confidentiality and privacy are legitimate concerns of libraries, and the usefulness of libraries rests on the trust that their clients have in them. Our data should help libraries balance the need for maintaining confidentiality with the opportunity for helping in the formation of communities based on the common goals of their clients. It should also help in the understanding of how to maintain the trust of library clients as digital libraries become more common. As e-commerce concerns have discovered, it is easy for an organization to lose the trust of clients by making mistakes with the information that the clients have entrusted to that organization. While moving toward support for digital collaboration and knowledge sharing within library communities, we do not want libraries to lose the trust of their clients.

## **11. Broader Impacts**

The prototype is a proof-of-concept for much broader application of the design principles to schools, offices and homes. Focused on integrating DL resources into current collaborative trends in education, the project will provide a model for information-seeking groups in the workplace to adapt. Finally, small group support for information-seeking activities can benefit the larger society, including those most disadvantaged: several of the co-PIs are currently working on using digital information sources and technologies to help groups in a disadvantaged area of Philadelphia manage their chronic health problems. Potential target audiences are described in Section 3.