eBat: A Technology-enriched Life Sciences Research Community

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We are leveraging Web-based technology to create an online community for Life Science research. Our prototype community for cardiovascular research with live bats, called eBat, consists of local researchers as well as remote collaborators. The eBat project offers scientists and students a remote-controlled microscope for conducting experiments, a message board and a chat system for scheduled as well as spontaneous communication, and an online peer-reviewed manuscript repository. In this paper, we report our observations of the use of the eBat infrastructure by local researchers over a period of six months. Resident researchers quickly adopted the eBat infrastructure. eBat technology has now become an indispensable part of the local research group and is used extensively for co-ordination, communication, and awareness. eBat complements face-to-face interactions well and has resulted in improved communication amongst lab members. We are currently exploring the extension of eBat technology to include distant researchers in live cardiovascular research experiments. We discuss our initial experiences with adapting the eBat infrastructure for research-at-a-distance and the lessons learned from these initial interactions.

INTRODUCTION

In addition to being a globally accessible information repository, the WorldWide Web serves as a communication medium. Web-based communities leverage and augment these two aspects with targeted, community-specific tools to create virtual societies through shared goals, interactions, and experiences. Several Web-based communities have been developed in domains such as education and learning (Marlino et al., 2001; Pimentel et al., 2001), workplace enhancement (Churchill & Bly, 1999), e-commerce (Girgensohn & Lee, 2002), social interaction (Lee et al., 2001), and healthcare (WebMD, 2006; Cheng et al., 2000). Web-based communities are designed either as online-only communities or as online extensions of physical communities. Members of communities that only exist online are typically separated by great distances and rarely, if ever, meet in person. Online extensions of physical communities employ Web-based technologies to supplement face-to-face interactions of educational, social, and professional groups. Such Web-based interactions within user groups blend the physical and online spaces (Churchill et al., 2004).

We are exploring the inclusion of Web-based interactions to support Life Science research as well as research education. In particular, our research has two thrusts: to design mechanisms for facilitating communication between local as well as distant researchers and to investigate the issues involved in including distant populations in research experiments. We are examining these issues in the context of cardiovascular research on live Pallid bats. Research with live animals requires trained staff for handling these animals as well as the use of specialized equipment for conducting experiments. Staff training and equipment costs are usually high. Consequently, the Life Science research model does not scale well and the research is restricted to specific locations that possess the necessary financial resources and technical expertise (Gatson et al., 2005).

In addition to conducting research experiments and reporting the results, academic researchers juggle administrative and educational responsibilities, such as teaching classes, recruiting and training new students, and writing grant proposals for research funding. Time is usually short and researchers are constantly looking for tools to improve the productivity and technical interactions.

Our infrastructure for augmenting the research environment, called eBat (http://ebat.tamu.edu/), has three components: live experiment controls, communication tools, and a document repository. Typically, researchers observe activity in the wings of live bats by placing them under a microscope that is hooked up to a Web-accessible computer. A Web-based application allows distant users to control the microscope to conduct live experiments. A suite of communication and awareness tools that include a chat system, a message board, and a web camera that provides a greater awareness of activities in the lab facilitates online interaction and promotes collaboration between lab members. A peer-reviewed manuscript preparation system aids in training researchers in writing and improving paper drafts. Having observed the benefits of eBat for local researchers, we are expanding our efforts to include distant collaborators as well as non-traditional demographics such as high school students and those in teaching universities.

The rest of the paper is organized as follows: the following section contextualizes our work in terms of other Web-based research and educational communities. We then present the eBat infrastructure and our observations of its use by a local research community over the course of about six months. We then briefly discuss our efforts to extend the eBat experience to geographically distant and culturally diverse audiences, followed by the insights that we have gained through this project. We conclude by providing a glimpse of future directions for continuing this research.

RELATED WORK

Web-based communities facilitate interaction and awareness to help members develop a sense of belonging by including features and interaction mechanisms that promote particular goals. Information repositories serve to augment communal knowledge aggregation. For example, the Answer Garden, a system for growing organizational memory, provides mechanisms for accessing, maintaining, and promoting the intellectual assets of organizations (Ackerman, 1998). While video and audio chat features support personal communication, research has shown that a simple, textual online chat mechanism serves to improve shared understanding between members and helps them achieve a common ground in a community workspace (Birnholtz et al., 2005). Message boards and bulletin boards ease information dissemination to community members.

In addition to these general-purpose community integration tools, different communities use targeted tools to meet their requirements. For example, education-centric communities must include support for specifically structured documents, such as syllabi and exams. The leading online education support tool, WebCT aims to provide a full-featured online classroom experience through course management support for instructors as well as students (WebCT, 2006). It aids instructors in preparing course materials and in managing their daily course-related tasks efficiently. Instructors can organize content by topic, create learning modules, and design, administer and assess tests. WebCT aids students in managing their workload and includes tools for self-assessment of their progress. It also provides shared areas for collaborative project work. In addition to its use in distance education, instructors can also use WebCT to support traditional, classroom-based education. Similarly, the Classroom 2000 project employs Web-based technology to enhance classroom education (Pimentel et al., 2001). Classroom 2000 augments the classroom sessions with external information based on the lecture contents, such as synchronized presentation of automatically generated transcripts of the instructor's audio lecture with the PowerPoint slides used in the lecture and links to relevant materials in a course repository. Searching over these materials allows students to connect topical threads across lectures, and across transcribed text, presented slides, and instructor's annotations.

Unlike the systems described above, the Digital Library for Earth Science Education (DLESE, http://www.dlese.org) project takes a community-centric approach for educational support (Marlino, 2001). DLESE serves a community of teachers and students at all academic levels, through interfaces and tools that support exploration of geospatial materials, access to peer-reviewed teaching and learning materials, services to help users effectively create and use materials, and a community center to facilitate sharing and learning collaboration. DLESE encourages teachers and students to create and contribute educational materials for community use. This model enables teachers to create, reuse, and share quality-learning materials. While the earlier models tightly integrate pedagogical techniques with academic materials, DLESE successfully decouples these while allowing teachers to tailor materials for their own purposes.

This separation of resources from methodology is essential for enabling online research support systems. While research revolves around a set of artifacts, whether physical or digital, the methods for examining these artifacts change with research questions, the personal take on a specific research problem or evolution of new research methods. Yao (2003) presents a framework for research support systems. This framework aids scientists in conducting some general-purpose research tasks, such as support for exploration of existing literature, retrieval of information related to a specific idea, and support for critically reading found materials. The framework also includes support for managing resources, data, and knowledge, and for analyzing this data and for presenting the results of experiments. In addition to these general features, the framework also espouses a strong personalization support in order to cater successfully to discipline-specific practices and processes. Based upon this framework, the CUPTRSS system provides a bi-level support for research management: institute-level support for management staff and individual-level support for researchers (Tang, 2003). The CUPTRSS system takes a top-down approach to support management, expertise, collaborative and information-centric research tasks. However, the top-down approach erodes the much-deserved focus on core research tasks and treats them as a part of the research management environment.

In contrast, we propose a bottom-up approach for supporting research activities in the Life Sciences in academic settings. Our approach emphasizes support for active remote participation in live experiments and explores mechanisms for supporting research activities and processes. Research in the Life Sciences deals with animal experimentation. This research requires expensive equipment and often involves working with live animals. Typically, faculty members guide several projects and trains students in addition to their teaching and administrative responsibilities and thus, are strapped for time. Our research addresses the issues of awareness mechanisms, remote participation, sharing expertise and time, and balancing the concern of animal rights activists in the context of cardiovascular research with live bats.

eBat

The Cardiovascular Systems Dynamics Lab conducts research with live bats. Affectionately called the “bat lab”, our lab has the only colony of Pallid bats devoted solely to cardiovascular research. The lab houses extensive equipment for cardiovascular studies and has developed an expertise in non-invasive methods for studying the cardiovascular system (Desai et al., 2004). Traditional research methods are invasive and require euthanizing the animals after removing their vital tissue or blood for studies and analysis. Furthermore, even when the animals are not euthanized the researchers can analyze these extracted samples only for a short period of time and the conclusions regarding blood flow mechanisms are retrospective, rather than active (Roberts et al., 2004). The bat lab has developed non-invasive, *in-vivo* procedures for examining blood and the cardiovascular network in live Pallid bats. The Pallid bat's wing is thin and transparent and a visual inspection of blood cells, vessel walls, and much of the cardiovascular network is possible by looking at the wing through a microscope (Widmer et al., 2006). While bats do not, by nature, stick their wings underneath microscope objective lenses, we have trained them to sleep in a special container designed for this purpose with one wing extended. Researchers in the bat lab observe the bat wings while the bats are napping. This method enables the study of development and behavior of an individual animal throughout its natural life span.

This technique, being unique as well as humane, is worthy of a broad dissemination and provides exceptional opportunities for training young researchers and establishing local as well as remote collaborations (Young et al., 2004). To fulfill this agenda, the bat lab maintains a live colony of Pallid bats. It also houses two high-resolution microscopes, one of which is connected to a computer that is instrumented with special-purpose equipment.

The bat lab is headed by the director, who serves as the academic advisor for the graduate students, sets the research agenda, and acts as the administrative head of the lab. A full-time staff assistant trains and rears the bats and is responsible for maintaining the bat colony. Several graduate and undergraduate students conduct research in the bat lab. Each semester, the bat lab recruits and trains about 40 undergraduate students, many of whom continue their research in subsequent semesters.

Students work in project-specific groups. Experienced graduate or undergraduate students lead each group and define the research agenda for their group in consultation with the lab director. The microscopes are a critical resource. Many groups need access to a microscope on a weekly basis. Graduate students also need these microscopes to achieve the research objectives in pursuit of their degrees. Students also juggle hectic work and study schedules. Furthermore, to insure the well-being of the bats that these groups study, an individual animal can be used for observations only so often. Consequently, coordinating research and microscope time while managing individual, group, and bat schedules is a challenging task.

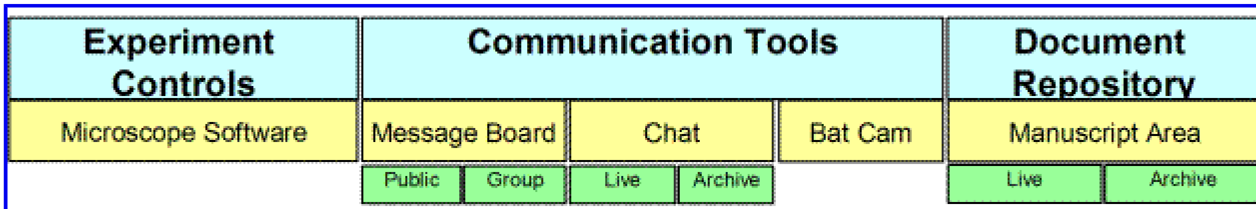

Figure 1. eBat Technological Enhancements

Figure 1

While students regularly interact with their group leaders, there is little contact across the groups. To ensure coordination between research projects and to avoid repetition of research across project groups, each group must be peripherally aware of the activities of other groups. The physical layout of the lab further exacerbates the challenge of coordinating lab events and enabling awareness of others' activities. The bat lab operates in four distinct physical areas, each with different levels of access restrictions. Microscopes and equipment that is required for conducting experiments is located in the microscope room. Graduate student desks and offices are located in a nearby area. In a separate building, a room with ten computers serves as a meeting area and is often used by students who do not have designated desks. Finally, the lab director's office, located adjacent to the computer lab, contains two computers for student use.

The eBat project seeks to develop and employ technology in order to foster a greater awareness and develop a sense of community within the lab personnel. The technology developments made by the eBat project in support of these objectives, illustrated in figure 1, can be broadly classified into three categories: experiment controls, communication tools, and a document repository.

Experiment Controls

We have developed a LabVIEW-based software program to control the microscope's movement from a computer. The instrumented microscope and computer setup for conducting experiments is shown in figure 2. In addition to providing precision control of microscope movement, this setup enables researchers to observe bat wings from outside the microscope room. They can connect remotely to this computer and perform experiments using remote desktop clients such as NetOps or Windows Remote Desktop. Of course, a lab technician must be present locally to prepare the bat for the experiment and place it under the microscope. However, as a trained technician handles bats even when the researchers are working locally, this requirement is not an additional burden. The LabVIEW program also supports specialized features such as recording and tagging the position of the microscope on the bat wing for later return to these coordinates, temporal tracking of blood vessel diameter (Meisner et al., 2005), measuring the velocity of the blood flow, and calculating the blood flow. It allows researchers to take snapshots of interesting or unusual features and phenomena and enables them to record the complete experiment by saving it as a video file.

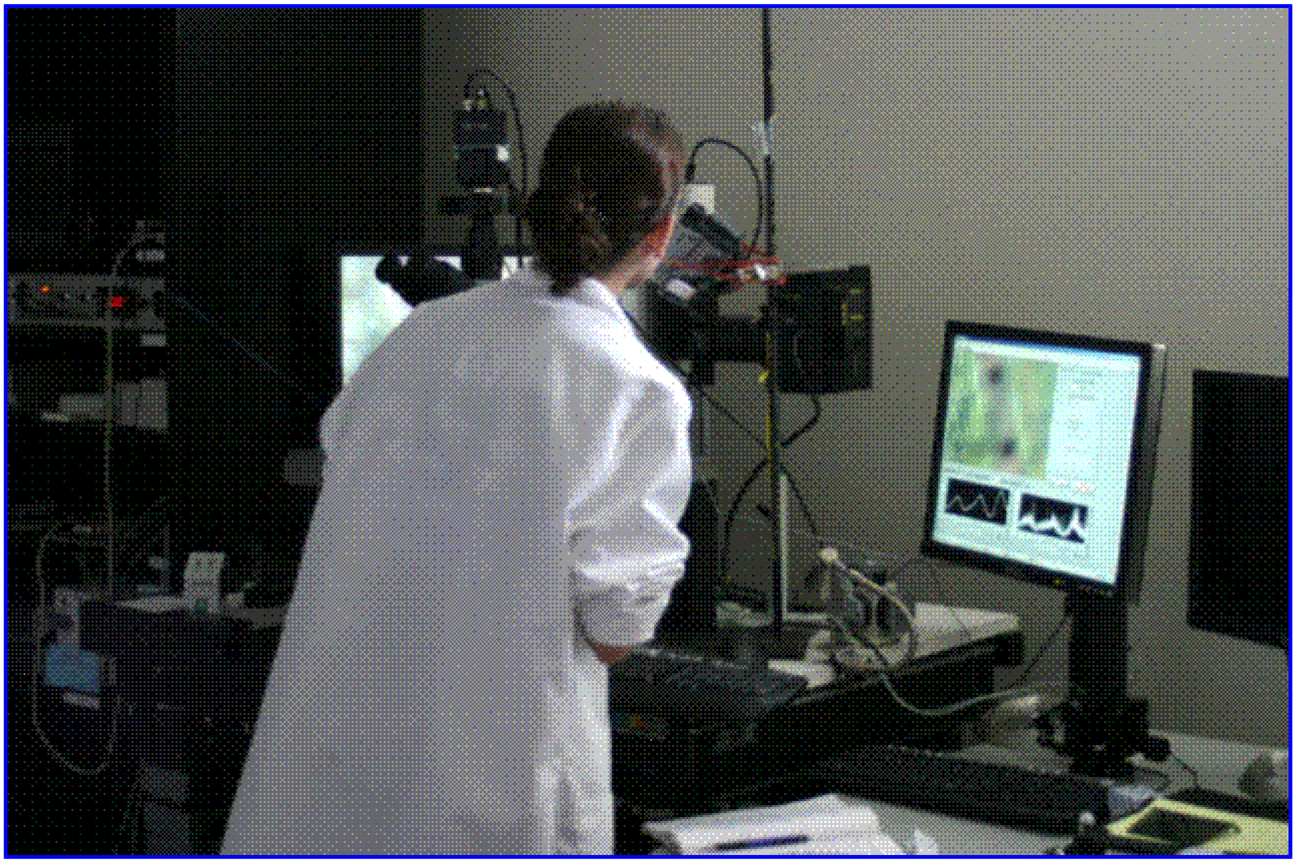

Figure 2. Experimental Setup

Communication Tools

Figure 3. eBat Message Board

Our suite of communication tools includes a public message board, shown in figure 3, for advertising lab events and general as well as topical discussions. Both registered and unregistered users can post and read messages. We have customized the open source Drupal software (Drupal, 2006) to organize messages by programs and projects in our lab.

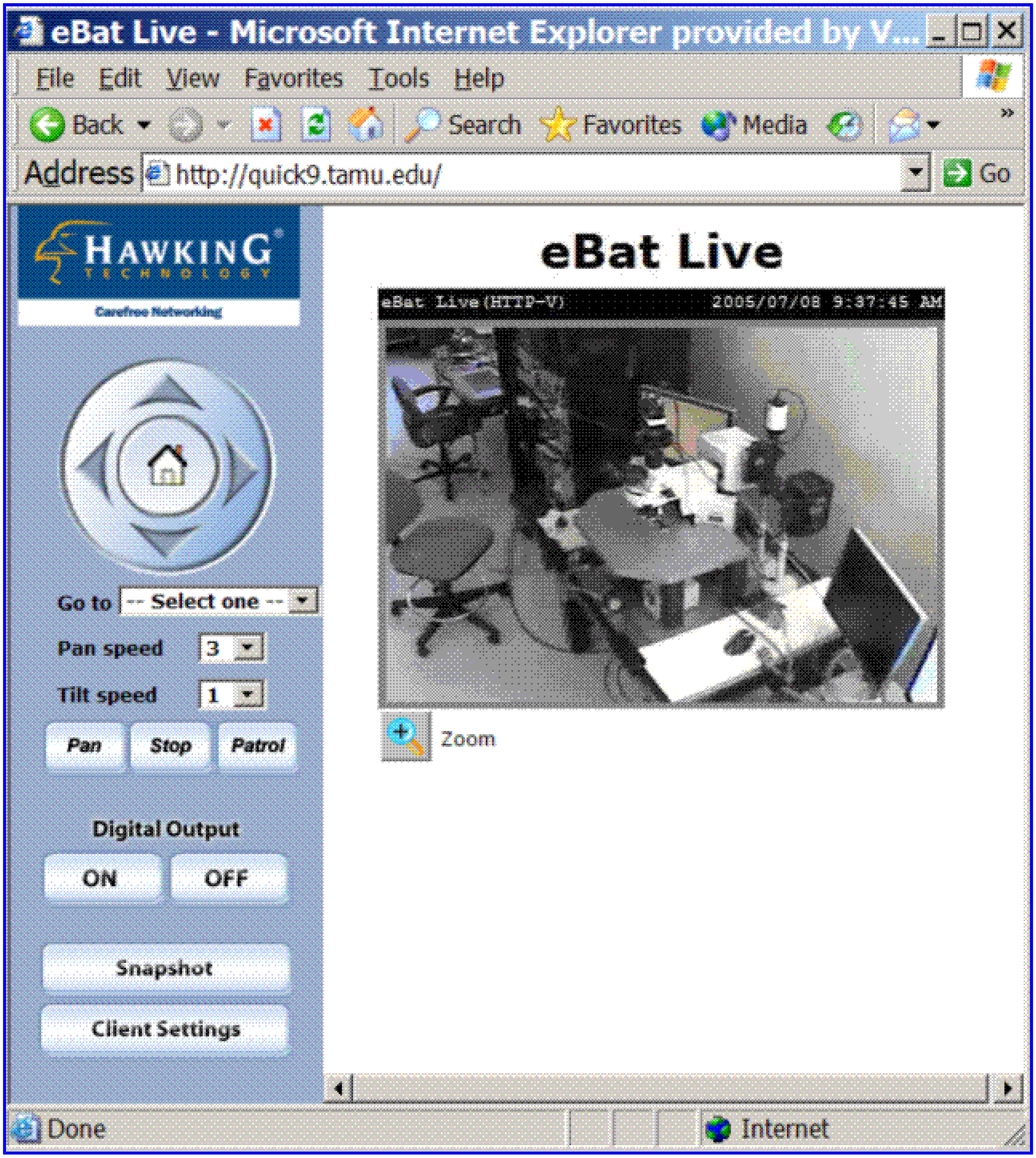

Figure 4. Bat cam View

This classification helps users distinguish between messages that are critical to their academic or research objectives and those that are of marginal importance. The message board supports two forms of posting: free form messages for general communication and a more structured format for summarizing experimental results that researchers are encouraged to complete after each experiment. The summary forms provide a structured format for researchers to briefly describe the experiment, list the problems encountered, state whether the experimental goals were met, seek input from the online community regarding their observations, and record other aspects of interest. In addition to the public message board, user groups may create private or semi-private message boards as needed. The person who creates the group decides which members can view the messages posted in the group space.

The eBat infrastructure also includes a chat system in order to support spontaneous, synchronous online interaction between users. Users may sign in to identify themselves to others or join a chat session as guests. Conversations in the chat space are archived for future reference.

Furthermore, a ceiling-mounted Web camera, called the “bat cam”, communicates the microscope’s status to remote users. The bat cam view, shown in figure 4, is available through the eBat online space. The bat cam enables lab members to monitor the status of the microscope room, and depending upon availability, perform unscheduled experiments even if they are traveling or otherwise unable to get to the microscope room right away. Lab users as well as guests can control the bat cam’s direction and zoom to observe different parts of the experiment room. The bat cam is equipped with an internal microphone allows visitors to listen in on the experimenters. As far as we know, our bat cam is the only case where a publicly accessible camera is focused on researchers during live animal experiments.

Document Repository

The manuscript area is designed to promote document-centric communication between lab members. This area serves as a sandbox of ideas in progress, publication drafts, posters, and other materials for presenting research to internal audiences or intended for public dissemination. Authors receive comments from lab members on various aspects of these drafts, such as clarity of presentation, validity of scientific text, appropriateness for specific audiences, level of detail presented, research methodology, and significance of the results. This critical review process serves two purposes: firstly, it ensures that the publications from lab members are significant, complete, consistent, and presentable; secondly, the group review mechanism helps novice researchers improve their scientific presentation and technical writing skills.

Authors can guide reviewers in providing relevant and targeted feedback by tagging their drafts with stage-specific keywords. For example, authors may solicit comments regarding the story line and the flow of ideas in the paper or request a feedback on the grammatical correctness of their document. After receiving feedback, the author may upload an updated draft for further review at its current stage or at a different one. The system architecture allows authors to associate multiple drafts for each manuscript entry simultaneously. Each manuscript entry is also tagged as “active”, indicating that the paper is being worked upon currently, or “archived”, indicating that the paper is not being actively pursued. The interface of the manuscript manager, illustrated in figure 5, clearly separates the active drafts from the archived ones.

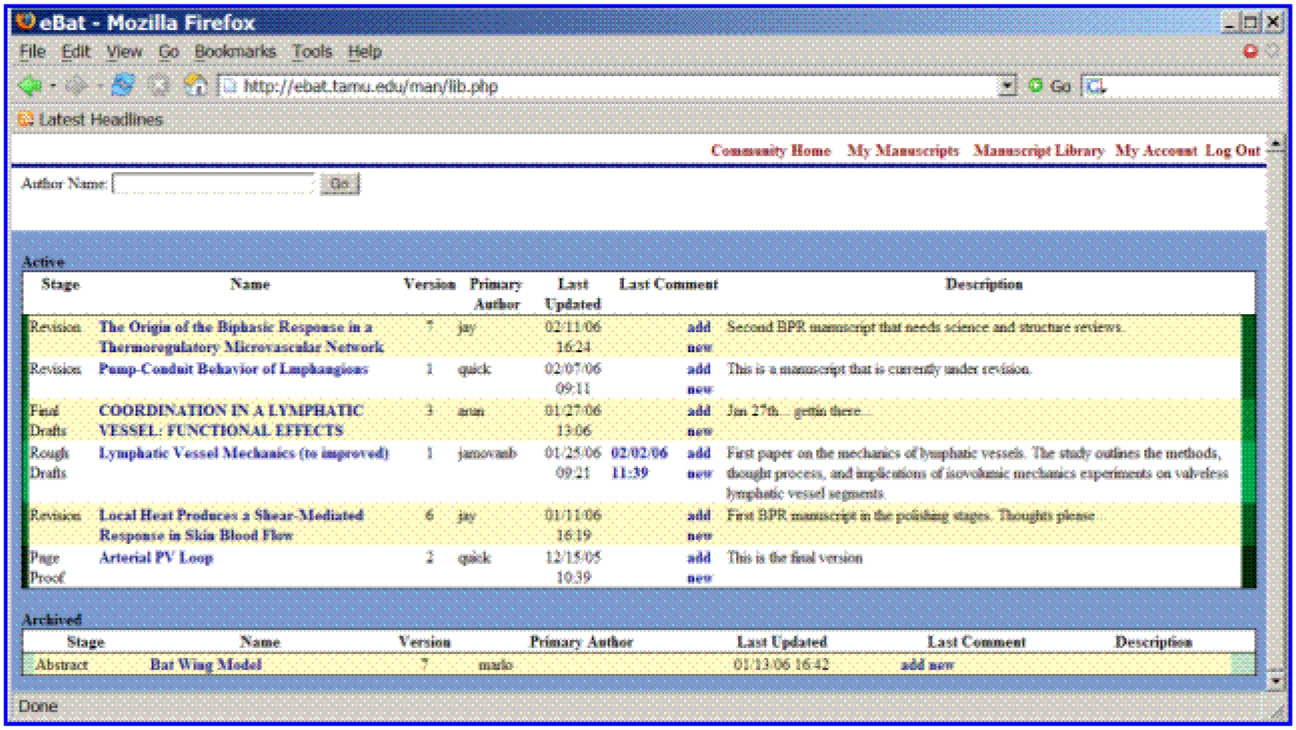

Figure 5. Manuscript Manager

OBSERVATIONS

We have observed the usage of eBat since its deployment in the summer of 2005. In this section, we present a qualitative analysis of our observations of individual as well as group behavior.

eBat Community

The eBat community consists of students and staff associated with the bat lab. A majority of these online participants reside locally, although we have recently added collaborators from other universities. The eBat community consists of about 150 registered members from diverse academic disciplines such as biomedical engineering, education, physiology, computer science, sociology, and veterinary medicine. Students who engage in research with the lab are required to register as eBat members and report their observations for each experiment using the experiment summarization forms. Our observations indicate that while students are required to participate in eBat to a certain degree, many students go well beyond the required interactions.

In addition to being an online community, eBat also serves as a recruiting tool. We have noticed that recruiting pitches that include a demonstration of live bat wing views through our remote-controlled microscope interfaces result in considerably higher response rates from students.

Coordination and Communication

The message board and the chat system are the most popular components of the eBat infrastructure. The message board is used for publicizing upcoming events, such as meetings, conferences, local talks, presentations, and course-related deadlines. Students' experiment summaries are also available for viewing on the public message board.

The chat system is used predominantly for short, topical discussions, scheduling face-to-face meetings, and for sharing research ideas. The lab director uses the chat system for increased personal interaction with students. While his other commitments limit the amount of time he can be present in his office, he often logs into the community chat room outside of the office hours to provide additional "face-time" for the students. The chat interface serves as an ideal mid-point between email, which does not guarantee a response within a particular time frame and phone calls, which are considered appropriate for extremely short-term deadlines or for emergencies. Much of the chat interaction revolves around the lab director. Of the approximately 9,000 chat messages we analyzed, about a third can be attributed to the director. Students feel comfortable discussing research, administrative, and personal issues. (In the following conversation excerpts, LD indicates Lab Director)

> [14:02]
>
> ..., is this a good time/place to ask for career advice? [14:02] you can ask it now if you like. Career is always a good thing to think about

The following excerpt illustrates the use of chat for scheduling a meeting. This small excerpt reveals two interesting traits:

> [11:11] we could set a time limit for the meeting b/c I know you are busy with the

> grant [11:12] Maybe after 5 today–we could chat by phone? This way I can use buis hours to work on grant.

Firstly, the student (Guest706), through her reference to a grant deadline, exhibits a degree of awareness about other demands upon the lab director's time. The student thus leverages external knowledge and ambient awareness to negotiate time for a meeting, successfully bridging the gap between the physical and digital worlds. Secondly, the student involved in the conversation has not logged in as herself, a frequent occurrence in our chat system. While users would have to login with a username and password to be identified as themselves, users can chat via a guest account with a single click. The chat software then assigns a random number to this guest user-706 in this case. When users anticipate a short interaction in the chat box, they prefer to chat via a guest account and identify themselves with their real name as a part of their greeting message. Here again, the user has discarded her online identity in favor of her real identity.

During the period of the study, we noticed that significant events in the physical world directly affect online interaction. For example, chat activity as well as message board posting peaks just prior to the draft submission deadlines for conferences, before the beginning of the semester, and just before Christmas, when students were finishing up their work before leaving for vacation. The message board area has also been used to publicize the lab director's schedule, especially when it affects other events.

> "Since [LD] is in Kingsville, the 6 pm meeting has been cancelled."

This post is significant as it was posted by a graduate student to alert others of possible openings in their schedules.

Exchange of Research Ideas

Team Sanguine

time:
Wed, 2005-11-16 03:00

brief summary of experiment:

We tried a new experiment today in which we took baseline measurements of the diameter and velocity. We then heated a heat plate to 34 degrees Celsius - increasing the temperature every 2 minutes by 2 degrees Celsius. We took baseline measurements at this point of diameter and velocity - observing the dilation in vessel size. LNAME was applied to the wing and allowed to sit for 10 min. before being wiped off. Baseline measurements of diameter and velocity were taken again to observe any effects of LNAME on the vessel.

expected goal achieved:
yes

problems encountered:

It is difficult for the bat to remain calm after applying the LNAME to the wing. Due to this complication - it sometimes takes longer than we would like to take baseline readings.

questions:

Does the LNAME have any effect on the constriction/dilation of the vessel that we are applying it to?

Are we using the correct concentration to have a great enough effect?

Is the concentration too great for the bat to stand - could this be why the bat is never calm after application?

Is the light from the microscope breaking down the LNAME - causing it to have the opposite effect than what we expect?

new observations:

Without analyzing the data as of yet, from looking at LabView - it seemed as though instead of the vessel constricting with the application of LNAME - it looked like it was actually dialiting. After talking to other people on staff, this may be because the LNAME may be breaking down with the light intensity from the microscope.

» add new comment

Figure 6. Experiment Summary Form

The public message board was frequently used to post ideas and thoughts and to invite comments from other students. For example, an undergraduate student post entitled “i actually have an idea” stated:

> well, since we are studying the stress-strain of the tissue in the bat wing, i was thinking about human skin and its elasticity. so much of that depends on water content that varies with age, gender, and body-type. there is so much that we could characterize in the bats. simply looking at water content, or level or hydration, i'm sure that the vasculature would change and effect the stress-strain relationship... just a thought, there's a lot more of it to be thought through, but just wanted to throw that out there...

A few days later another undergraduate member, who was participating in a graduate student lead research project, created a post entitled “I also have an idea” and received comments on his idea as well. One of the comments later suggested that:

> “Since there are now three people interested in similar thing, I was wondering if we could form our own group. As far as breaking away from the graduate student umbrella…”

This discussion resulted in the formation of an all-undergraduate project team for the Spring 2006 semester.

Posting online summaries for public record enables research teams to identify problems that have already been addressed by another team, thus avoiding duplication of effort. We have observed instances where the research summaries receive responses that offer suggestions on improving the experimental methodology and troubleshooting problems. The following response answered questions in the experiment summary illustrated in figure 6.

> “L-NAME (10 nanoM - 100 microM), supprisingly, has been shown to inhibit UV light-induced vasodilation in the rat aorta (Kim et al., 2000), which makes it the only in its class to inhibit photorelaxation.”

Responses such as these foster collaboration and cross-group seeding of research ideas. This behavior also helps improve productivity and promotes the research objectives as well. The “prevention measure” in avoiding research duplication is difficult to quantify as it can be observed only when someone explicitly posts a response to a question or an observation. However, viewing another person’s posting may, in itself, help a researcher avoid a mistake or prevent duplication of effort.

While the message board and the chat area encourage users to share ideas, the manuscript area provides a place for developing and nurturing ideas into publications via a write-review-revise maturation process. In the initial design, manuscripts in progress were included within postings on the message board and users commented on these like any other post. However, users’ desire for a more structured format for developing the manuscripts resulted in the current design of the manuscript area. While it is still under development, the manuscript area hosts five papers from four authors. Three of these papers have passed through multiple review cycles, indicating the authors' seriousness in using this feature.

eBat Culture

In the short time that it has been in operation, the online eBat community has developed a culture of its own. This culture has borrowed some traits from the physical bat lab community. For example, the informal communication style of the chat conversation and the message postings has descended from the bat lab. Yet, there are differences. The online interaction is clearly work-centric. eBat has not adopted the bat lab's social behavior patterns. Members take their scientific postings seriously. More than 95% of the messages posted are work-related. To foster interaction and cross-pollination of ideas, we designed a point system for rating user contribution and awarded two points for each comment to a posting and one point for each new posting. However, our strategy of inviting members' favorite quotations, which we floated as another initiative, backfired when members were awarded points for these postings. Several members voiced their displeasure over awarding points for non-technical and, hence, counter-productive content.

This seriousness of purpose is also reflected in other communication. While members desire and seek opportunities to chat with their advisor online, some students were uncomfortable with the idea of posting their research-related thoughts on a public forum. They did not wish to be perceived as "stupid", just in case their ideas were not received well. We accommodated these requests by allowing students to create private or group message boards, the access to which was controlled by the group creator.

As a mixed offline-online community, the boundaries between the two worlds are somewhat fuzzy. Often users login to the chat box as guests and then identify themselves by their real names. Although the login names are usually distinct from their real names, members often refer to others by their real name in a chat session. For example, a member wrote,

> "I responded to josh's comment this morning about how ebat is different than bugscope".

The other member translated this comment and quickly retrieved the earlier post using Josh's screen name.

Security and Privacy Issues

The incorporation of technology in traditionally “closed” spaces, such as laboratories, has raised several issues. Lab members are sometimes concerned that their conversations while conducting experiments may no longer be private. Taking heed of these concerns, we have temporarily disabled the microphone connected to the bat cam. While the bat cam provides awareness information regarding experiment status and availability of the microscope, the lab technician who has a desk in the microscope room must deal with being potentially visible on the bat cam throughout the day. She fixed this problem by taping several letter-sized paper sheets to the ceiling to shield her workspace from the camera.

In a stark contrast to these privacy concerns, we have observed that several eBat community members provide their cell phone numbers and email addresses during a chat session. While they know that the chat sessions archives are posted publicly on the Web, this has not deterred them from handing out their information to friends and colleagues. Occasionally, they also refer others to find the information via the archives, if they cannot recall someone’s contact information right away.

Some of our distant collaborators have also exhibited similar behavior. The following conversation occurred between a local and a distant member of the community while they were waiting to conduct a distance experiment:

> [09:39][Guest284] … We are here. We see that the bats arrived and are ready to get started. Our phone number in the lab here is xxx.xxx.7779 …. [09:53][B] your cell phone keeps ringing but no one is answering..is it still xxxxxx8645? [09:54][LD] I have a cell phone siganl. [09:54][LD] xxx-xxx-1914

These phone numbers are permanently archived and placed on public record for all to see. Ironically, the institution that our distant member belongs to is highly security conscious and has stalled the plans to operate distant collaboration due to lack of a secure microscope-view connection for the experiments.

One of the few times we have noticed participants observing restraint in sharing personal information online is when one of our distance collaborators needed a password to access part of our technology system. The local member responded that he would call the collaborator to share the password because he did not “want to put password on the world wide web for all to see". We are looking into addressing these issues and designing a minimally constraining, yet secure environment for our local and distant users.

DISCUSSION

While public access to chat archives provides some value, there is also a privacy concern. We are exploring alternative solutions for addressing this concern. One option is to restrict access to the chat archive only to registered members. This approach would, however, shut out causal viewers completely. As an intermediate solution, we are looking into the possibility of providing automatic summaries of chat sessions to non-registered users, while providing the complete archives for registered users. Text from discussion groups can be successfully summarized (Farrell et al., 2001) but to serve our purpose, the summaries must eliminate all personally identifiable data.

We have also noticed that while students use the chat facility extensively to interact with the advisor, there is little peer-to-peer communication. When students join a chat session, they announce themselves and wait to be pinged by the lab director. This behavior seems appropriate when the discussion between the advisor and another student is personal. However, when the discussion is technical, active participation from everyone present in the chat session is likely to benefit all parties. Such lurking in virtual communities has been widely documented and has been shown to influence interactions outside the online community (Takahashi et al., 2003).

Online communities have successfully solicited participation from lurkers via the use of techniques in social psychology (Beenen, 2004). The MovieLens design team sent targeted email reminders to participants that focused on the uniqueness as well as benefits of their rating contributions. These reminders resulted in a significant increase the response rate from previously dormant users. We are exploring social as well as technological means to solicit wider input from lurkers during a chat session. Members of virtual communities are more likely to participate actively when they feel that they are recognized (Chan et al., 2004). In this framework, recognition consists of identity, expertise, and tangible rewards (such as a reputation system). Many eBat users know each other personally and are intuitively aware of each other's expertise. The point system that we initiated for message board participation succeeded in promoting active involvement in technical and professional interaction.

While our attempt at encouraging social interaction was not received very well by our users, we attribute this behavior to the fact that many eBat members already know each other in person and interact socially in the physical world. Research has shown that mixed offline-online learning communities can benefit from casual offline interaction coupled with online sharing of user-contributed technical resources (Bellamy, 1998; Houde, 1998). StudioBRIDGE promotes offline social interaction by providing location awareness of students in close physical areas (Yee and Park, 2005). In contrast, members of online-only communities, such as Slashdot (Slashdot, 2006), tend to mix business and pleasure. Many Slashdot discussions start out seriously before turning into a social free-for-all.

While the online community predominately consists of local members who interact face-to-face, the disinclination to extend social interaction online is understandable and even acceptable. However, as the community becomes more dispersed and face-to-face social interaction is no longer practical for all involved, a reconsideration of the social aspects is necessary to exploit the full potential of the life science research community.

Distance Collaboration

Long-distance research collaborations are still in their infancy. Kraut et al., (1988) highlight the barriers to forming productive long-distance research collaborations. While communication media and technological advancements have lowered some barriers, long-distance collaboration is not a norm. We are in the process of starting collaboration using live experiments with two remote groups. However, technological and administrative barriers have resulted in significant delays. In one case, the remote collaborators at our partner institution are unable to view the video output from the microscope online due to the poor Internet connection. The connection slows the video down to the extent that it is impossible to observe the blood flow. In another case, the remote institution requires secure network for connecting to all external computers. This has been an issue as the administrative structure at our institution does not require such connections and, hence, cannot accommodate our requests for such connections.

While the progress with the live remote experimentation is slow, our remote collaborators often use the eBat message board and the chat box. The cultural differences across the institutions are startling. While interaction in the bat lab is informal and the hierarchical structure, almost non-existent, this is not the case with the remote institution. Initially, the remote researchers were surprised to find that the questions that they had posted were not answered immediately. When eBat members did answer these questions, the collaborators perceived the informality of our responses as a lack of interest. This caused some tension until we communicated that the eBat members answered questions on their own initiative and had different communication patterns than did the remote collaborators. Local members share the expectations, which arise in part from sharing the same physical space, having face-to-face interactions, and the same calendar of external events. We will have to put additional efforts into reconciling cultural differences while the two communities establish a common ground and develop a set of shared expectations.

The member profiles in the current eBat space are not integrated closely with other system components and cannot be reached easily from the Web site. Furthermore, many of these profiles are rudimentary and provide very little information about the individuals. As our members know each other personally these profiles are not viewed as a critical resource and hence, are largely ignored. However, as remote collaborators become serious participants, this is unlikely to be true for long. We are augmenting the eBat infrastructure in order to provide easy access to member profiles in order to help the distant communities integrate smoothly. Picture profiles serve as an important tool in the formation of online communities (Girgensohn and Lee, 2002). We have observed that remote collaborators often schedule their eBat interactions a priori and login to the chat box only for the duration of this activity. Furthermore, they chat with people that they have met in person and are hesitant to initiate communication with others who may be in the chat session. We believe that the incorporation of user information and expertise through their profiles will serve as icebreakers to facilitate the formation of cross-location groups. The profiles will also allow remote researchers to make connections between a person's real and eBat identities. This will enable remote researchers to decipher our chat archives that refer to people by their real names by associating these names with the user profiles.

The formation of trust relationships in online communities has been studied in detail. Shneiderman (2000) points out that assurances, references, and third-party certifications, along with guarantees of privacy and security help establish trust relationships in online spaces. Zhang and Zhang (2005) present a theory-supported, integrated model of online trust formation. In the case of eBat, the local community, as well as the distant community has external means of establishing this trust. The trust in our system is based upon the researchers' reputation in the physical world and their connection networks. In that sense, the collaboration is based upon trust between a subset of the people. This trust can be leveraged through personal references and mechanisms such as the point system for messages to provide a sense of individual reputation within a semi-closed community.

Current awareness mechanisms included in the eBat infrastructure are designed only for the local community. Local members share the physical-world constraints and experiences. For example, last semester, snowfall caused the University to shutdown for a day. While a University-wide email notified our local members of this cancellation, the distant members did not know about this event until a local member thought of posting this information in the chat archive:

"The university is shut down–roads are all iced up"

Clearly, different information constitutes awareness for different user groups.

FUTURE WORK

The bat lab is unique within the life sciences in many regards-from the high end microscopic equipment, to the bats themselves, to those who care for and train the bats-and cannot easily be duplicated because of the expense of the equipment and animal care and the time required to establish and train a bat colony. We therefore are exploring the possibility of opening our lab to as many researchers as possible using the technology enhancements already developed for the local participants. While some of our technological solutions scale gracefully, other components need to be redesigned for serving a hybrid community of local and distance users. We have a unique opportunity to observe a physical local community expand into the digital world and subsequently reach out to distance communities. Technological enhancements to experimental equipment in our life science laboratory enables greater awareness among lab members, improves coordination and communication, and results in greater productivity through sharing of ideas and faster response time.

In the near future we expect to resolve the administrative and technological problems involved in conducting experiments from remote locations. The real challenge in ensuring the success of our collaborations, however will be our ability to build upon existing trust, establish a common ground, and develop a culture that is conducive to long-distance research.

References

Ackerman, M. (1998) Augmenting Organizational Memory: A Field Study of Answer Garden *ACM Transactions on Information Systems* 16(3), ACM Press, 203-224

Beenen, G., Ling, K., Wang, X., Chang, K., Frankowski, D., Resnick, P., & Kraut, R. (2004) Using Social Psychology to Motivate Contributions to Online Communities *Proceedings of CSCW 2004* ACM Press, 212-221

Bellamy, R., Genevro, E., Houde, S., Leahy, L., & Young, G. (1998) Developing a Community Intranet: Social Practices and Technology Interventions *Proceedings of CHI 1998* ACM Press, 193-194

Birnholtz, J., Finholt, T., Horn, D., & Bae, S. (2005) Grounding Needs: Achieving Common Ground via Lightweight Chat in Large, Distributed, Ad-hoc Groups *Proceedings of CHI 2005* ACM Press, 21-30

Chan, C., Bhandar, M., Oh, L., & Chan, H. (2004) Recognition and Participation in a Virtual Community *Proceedings of the 37th Hawaii International Conference on System Sciences* IEEE Press, 194-203

Cheng, L., Stone, L., Farnham, S., Clark, A., & Zaner, M. (2000) HutchWorld: Lessons Learned *Proceedings of the Second International Conference on Virtual Worlds* Springer-Verlag, LNCS 1834, 12-23

Churchill, E., & Bly, S. (1999) Virtual Environments at Work: Ongoing Use of MUDs in the Workplace *Proceedings of the International Joint Conference on Work Activities Coordination and Collaboration* ACM Press, 99-108

Churchill, E., Girgensohn, A., Nelson, L., & Lee, A. (2004) Blending Digital and Physical Spaces *Communications of the ACM* 47(2), ACM Press, 39-44

Desai, K. V., M. F. Young, R. H. Stewart, & C. M. Quick. (2004) Noninvasive characterization of vascular network structure and function in the bat wing *Proceedings of 21st Annual Houston Conference on Biomedical Engineering Research* Retrieved June 21, 2006 from http://ebat.tamu.edu/library/files/Ketaki_HSEMB_2004.pdf

Drupal. (2006) Drupal.org Retrieved June 21, 2006 from http://drupal.org/

Farrell, R., Fait-weather, P., & Snyder, K. (2001) Summarization of Discussion Groups *Proceedings of CIKM 2001* ACM Press, 532-534

Gatson, S. N., J. K. Meisner, M. F. Young, R. Dongaonkar, & C. M. Quick. (2005) The eBat Project: A Novel Model for Live-Animal Distance Learning Labs *FASEB Journal* A1352: 771.6

Girgensohn, A., & Lee, A. (2002) Making Web Sites be Places for Social Interaction *Proceedings of Computer Supported Cooperative Work* ACM Press, 136-145

Houde, S., Bellamy, R., & Leahy, L. (1998) In Search of Design Principles for Tools and Practices to Support Communication within a Learning Community *ACM SIGCHI Bulletin* 30(2), ACM Press, 113-118

Kraut, R., Egido, C., & Galegher, J. (1988) Patterns of Contact and Communication in Scientific Research Collaboration *Proceedings of Computer Supported Cooperative Work* ACM Press, 1-12

Lee, A., Danis, C., Miller, T., & Jung, Y. (2001) Fostering Social Interaction in Online Spaces *Proceedings of INTERACT '01-Proceedings of the Eighth IFIP Conference on Human-Computer Interaction* Hirose, M. (Ed.), IOS Press, 59-66

Marlino, M., Sumner, T., Fulker, D., Manduca, C., and Mogk, D. (2001) The Digital Library for Earth System Education: Building Community, Building the Library *Communications of the ACM* 44(5), ACM Press, 80-81

Meisner, J., Yazdani-Beioky, S., Weaver, A., & Quick, C. (2005) Real-Time In-Vivo Microvascular Diameter Tracking System *22nd Annual Houston Conference in Biomedical Research* Retrieved June 21, 2006 from http://ebat.tamu.edu/library/files/JKM_HSEMB_2005.pdf

Pimentel, M., Ishiguro, Y., Kerimbaev, B., Abowd, G., & Guzdial, M. (2001) Supporting Long-term Educational Activities Through Dynamic Web Interfaces *Interacting with Computers, Special Issue on Interacting with the Active Web* 13(3), 353-374

Roberts, L., C. M. Quick, M. F. Young, & S. N. Gatson. (2004) Reduce, Reuse, Recycle: The eBat project. Poster *North American Symposium on Bat Research, Salt Lake City, Utah* Retrieved June 21, 2006 from http://ebat.tamu.edu/library/RRR-abstract-LJRoberts.doc

Shneiderman, B. (2000) Designing Trust into Online Experiences *Communications of the ACM* 43(12), ACM Press, 57-59

Slashdot. (2006) News for nerds, stuff that matters Retrieved June 21, 2006 from http://www.slashdot.org/

Takahashi, M., Fujimoto, M., & Yamasaki, N. (2003) The Active Lurker: Influence of an In-house Online Community on its Outside Environment *Proceedings of GROUP 2003* ACM Press, 1-10

Tang, H., Wu, Y., Yao, J., Wang, G., & Yao, Y. (2003) CUPTRSS: A Web-based Research Support System *Proceedings of the Workshop on Applications, Products and Services of Web-based Support Systems,WSS03* 21-28

WebCT. (2006) Learning without Limits Retrieved June 21, 2006 from http://www.WebCT.com/

WebMD. (2006) WebMD Retrieved June 21, 2006 from http://www.webmd.com/

Widmer R.J., Laurinec J.E., Young M.F., Laine G.A., & Quick C.M. (2006) Local Heat Produces a Shear-Mediated Biphasic Response in the Thermoregulatory Microcirculation of the Pallid Bat Wing *American Journal of Physiology - Regulatory, Integrative and*

Compartive Physiology 290(5) (2006), doi:10.1152/ajpregu.00929.2005

Yao, Y. (2003) A Framework for Web-based Research Support Systems *Proceedings of the 27th IEEE Annual International Computer Software and Applications Conference* 601-606

Yee, S., & Park, K. (2005) StudioBRIDGE: Using Group, Location, and event Information to Bridge Online and Offline Encounters for Co-Located Learning Groups *In Proceedings of CHI 2005* ACM Press, 551-560

Young, M. F., Quick, C.M., Roberts, L., & Gatson, S. N. (2004) Leveraging informal networks: research/conservation partnerships. Poster *North American Symposium on Bat Research, Salt Lake City, Utah* Retrieved June 21, 2006 from http://ebat.tamu.edu/library/files/NARBS_Missy_Final_Really.ppt

Zhang, X., & Zhang, Q. (2005) Online Trust Forming Mechanism: Approaches and An Integrated Model *Proceedings of ICEC 2005* ACM Press, 201-209