

Videoconferencing and Other Distance Education Techniques in Chemoinformatics Teaching and Research at Indiana University

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At a time when the demand for people with expertise in chemoinformatics is increasing, there is still only a very small number of academic institutions that offer chemoinformatics-related classes and degrees. The distance education (DE) approach allows both learning and research to be carried out at multiple geographic locations and institutions, thus leveraging the few educational offerings that are available. In this paper, distance education techniques and technologies (with emphasis on videoconferencing) are reviewed, and examples of how they are used to increase the accessibility of chemoinformatics education and research at the Indiana University School of Informatics are presented.

INTRODUCTION

The use of computers for the processing of chemical information had its origins in the pioneering work done at the University of Sheffield in the late 1960s on the representation and use of chemical structure information, which led to the development of a wide variety of techniques for applying and using the information. For many years, this field, most commonly known as chemical information handling, had a well-defined and important part to play in library and information systems, where the techniques were used for the storage and searching of chemical and patent databases. In addition, computational chemistry methods were applied to aid the understanding of theoretical chemistry and pharmaceutical drug discovery where a variety of techniques such as similarity searching and docking helped scientists find potentially active molecules and model how those molecules bind to protein targets in the body. This latter application, known as computer-aided drug design or molecular modeling, rapidly became an essential part of the process of modern drug discovery, and thus the pharmaceutical industry became a strong supporter of the field.

During the mid to late 1990s, some technological innovations began to impact significantly the processes of early stage drug discovery. High Throughput Screening enabled several hundred thousand compounds to be screened for biological activity in a short period of time, and combinatorial chemistry enabled the automatic synthesis of thousands of new structural analogues at once. Likewise, improvements in X-ray crystallography and NMR spectroscopy meant that the number of proteins with resolved 3D structures increased dramatically, and new experimental pharmacology and toxicity methods led to a dramatic increase in useful information about the effects of a drug in the body. More recently, the advent of genomics and particularly microarray assays has meant that cellular samples (including those treated with chemical compounds) can be tested for genetic up- or down-regulation of thousands of genes at once.

Modern-day early-stage drug discovery therefore involves the generation of vast amounts of pertinent data from a diverse set of sources. Effectively managing, organizing, and analyzing that data, however, can be extremely difficult, particularly since the volumes are much more than can be humanly analyzed. There is therefore much demand for techniques that allow the data to be turned into useful information and knowledge. The field of bioinformatics became established in response to needs to computationally process and analyze biological information (particularly protein, nucleic acid, and genomic information), and the corresponding field of chemoinformatics (also known as cheminformatics) is following suit for chemical information. A more detailed historical overview can be found in Noordik's work¹ and also on the Internet.²

The relationship between chemoinformatics and the disciplines mentioned above is still being established, but it is clear that there is an increasing need for scientists and computational specialists to understand the principles and techniques of managing chemical information on a computer: indeed, the U.S. National Institutes of Health has recently awarded six grants to U.S. academic institutions including Indiana University to establish exploratory centers for cheminformatics research.³ There is also evidence of increasing interest in the creation of cheminformatics programs. The Beilstein Institute has funded an endowed chair for cheminformatics at Johann Wolfgang Goethe-University,⁴ and Unilever has funded the Centre for Molecular Informatics at Cambridge.⁵ The Department of Computer Science at University of Massachusetts (Lowell) has created both an undergraduate and M.S. program in bio/cheminformatics.⁶ There is a 1-year post-graduate distance education diploma program in India at the Institute for Cheminformatics Studies in Noida.⁷ Michigan Technological University now offers a B.S. in Cheminformatics.⁸ Several undergraduate institutions list cheminformatics as possible areas of specialization, for example, Rensselaer has a science IT concentration option in cheminformatics.⁹ Despite these developments, there is still only a very small number of academic institutions that offer teaching and qualifications

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in chemoinformatics or related disciplines and an even smaller number with well-established programs. These institutions generally only offer substantial graduate courses that require relocation to the site of the institution and a time commitment that is incompatible with maintaining a parallel full-time job. The most widely recognized and well-established research and teaching base in the field is Sheffield University's Department of Information Studies, which offers Masters and Ph.D. qualifications in chemoinformatics. Subsequent programs have been developed at the University of Manchester and Indiana University's School of Informatics.^{10,11} In the short history of the M.S. and Ph.D. programs at IU, two major chemoinformatics software companies, Daylight Chemical Information Systems and Elsevier MDL Information Systems, have already provided fellowships for graduate study, thus validating the perceived need for students in this area of specialization.

DISTANCE EDUCATION (DE)

One way of overcoming the discrepancy between the increasing demand for graduates trained in chemoinformatics and the small number of institutions that offer such training is through the use of distance education techniques. Distance education refers to the form of education where the teacher and learners do not have to be geographically colocated; it thus encompasses the techniques and technologies used to achieve this. Distance education has been formally defined by Moore as "planned learning that normally occurs in a different place from teaching and as a result requires special techniques of course design, special instructional techniques, special methods of communication by electronic and other technology, as well as special organizational and administrative arrangements".¹²

Distance learning has been popularized by universities such as Britain's Open University.¹³ In the United States, the University of Phoenix has existed as a virtual academic institution since 1976.¹⁴ Another example is Walden University, founded in 1970.¹⁵ Now merged with Walden is the National Technological University, an online engineering program that has been in existence for several years.¹⁶ NTU offers programs in software engineering, computer science, and other related technology areas. Recent increases in the speed of broadband communications are likely to facilitate distance education offerings of specialized courses and degrees that could potentially find students worldwide. Already in the U.K., the Universities of Leeds and Manchester cooperate on an online modular degree program leading to the M.Sc. in Bioinformatics.¹⁷ Other schools offer a hybrid of online distance learning with some traditional on-campus instruction. Such is the case with the "iMBA" Master of Business Administration degree at Syracuse University in New York state.¹⁸ (The "i" stands for "independent study".) Students in the program attend three week-long classroom sessions at the campus each year, but everything else is done remotely.

As videoconferencing technology on the Internet has matured, one would expect that this would have emerged as the preferred medium. Indeed, there is a Web site devoted to improving the techniques employed in this medium.¹⁹ However, there is very little activity on the "Teaching via

Videoconference" site, a forum for "research, insights, and ideas" about the use of videoconferencing in education. Martin has recently lamented the fact that videoconferencing remains a forgotten technology in teaching.²⁰ She reports that in the U.K., videoconferencing was not included among the technologies for which teachers were trained under the New Opportunities Fund programs. According to Martin, the most commonly cited negative aspects of videoconferencing are the difficulty of sustaining the interest of remote learners, the lack of specific training and guidance for teachers, and concerns about the robustness and cost of the technology.²¹

There is a large and growing literature of distance education. The literature search for this paper utilized free Web searches as well as several standard commercial services: ERIC, Education Full-Text (the Web version of Education Index), and the Web of Science (including both the Social Science and Science Citation Indexes portions). In addition, contents of recent issues of major distance education journals were scanned. Those included *American Journal of Distance Education*, *British Journal of Educational Technology*, *Distance Education*, *e-learning*, *Educational Technology Research & Development* (ETRD), *International Journal of Distance Education Technologies*, *Journal of Distance Education Administration*, and *Tech Trends*.

A relevant white paper sponsored by Polycom is Greenberg's "Navigating the sea of research on videoconferencing-based distance education".²² Summarizing the research published as of early 2004, the author concludes that "...two-way, interactive videoconferencing technology can be an extremely effective medium for delivering quality education to a broad, geographically dispersed student population".²³ He cites the earlier work of Thomas L. Russell that there is no significant difference in learning outcomes between traditional educational approaches and distance education. That conclusion leads him to urge us to look at ways in which technology provides an edge as a tool for reaching expanded populations of students, with the attendant economic, professional, and personal benefits that implies.

The advantages of Internet2 for videoconferencing are reviewed by Özkam.²⁴ He notes that Internet2 is 15 000 times faster than traditional Internet connections and is more reliable, utilizing the next generation of Internet protocol, IPv6. Over 200 universities are already connected to Internet2.²⁵ Extrapolating from their experience at Brunel University, Clarke et al. maintain that a distance learning program must be based on an existing full-time M.Sc. program and where possible use common examinations and assessments of student progress.²⁶ (At IU the chemoinformatics courses taught by DE are identical to those taken by M.S. and Ph.D. students in the School of Informatics; DE students do the same assignments as other students.). Smyth describes the use of broadband teleconferencing that originated at the University of New England in Australia and serves 10 university centers.²⁷

In chemistry, an early experiment in videoconferencing was sponsored by ChemWeb using VSi's technology.²⁸ As early as 1997, ChemWeb provided online lectures, panel discussions, and videoconferencing of live meetings such as the Sheffield Chemoinformatics meeting and the Noordwijkerhout conference. Simultaneous delivery of combinations of text, slides, and live video streams were tried with

Table 1. Comparison of Features in Current Versions of Macromedia Breeze (Version 5),⁴⁰ Microsoft Live Meeting,⁴⁶ WebEx,⁵³ and Raindance Meeting Edition⁴⁷

	Breeze 5	Live Meeting	WebEx	Meeting Edition
software	flash application in browser	Windows or Web-based meeting console	application launched from browser	full (installed on Windows) or Lite (Java Application)
compatibility	MS Windows to present. Mac/Unix for viewing only.	MS Windows or Mac/Unix for Web-based version	MS Windows to present. Mac/Unix for viewing only.	MS Windows (Full), All platforms (Lite). Must have full version to present.
audio	Partners with teleconference providers. Some integration with software. VoIP also available.	Partners with teleconference providers. Some integration with software. VoIP also available.	telephone conferencing included	telephone conference integrated with software
video	WebCam	Webcam	Webcam	WebCam
slide sharing	yes	yes	yes	yes
application sharing	yes	yes	yes	yes
annotation tools	yes	yes	yes	yes
recording and playback	yes	yes	yes	yes
chat	yes	yes	yes	yes
live technical support	limited, depending on plan	unlimited	unlimited	unlimited

varying degrees of success. More recently, Douglas Connect's eCheminfo attempts to make similar services available for the chemoinformatics and molecular modeling community.²⁹ For chemistry, the literature reveals relatively little use of DE techniques in teaching, particularly when videoconferencing is the mode of delivery. One example is Holland et al. who applied videoconferencing to undergraduate research between two campuses of Kent State University.³⁰ Another earlier example in Australia investigated the feasibility of developing a virtual faculty for undergraduate, honors, and postgraduate chemistry specializations at regional and remote universities.³¹ This allowed senior chemistry students in small science departments at regional universities to access classes offered by experts at different centers.

Proponents of distance education tend to stress the benefits of students working in a collaborative environment, i.e., of forming a community. Collaboration is said by Palloff and Pratt to assist with deeper levels of knowledge generation, to promote intuitive creativity and critical thinking, and to allow students to create a shared goal for learning. They suggest that the role of the instructor in such an environment is to set the stage, create the environment, model the process of learning, guide the participants, and evaluate the process. The feeling is that such a collaborative environment reduces the sense of isolation, thus laying the foundation for a learning community.^{32–36} Whatever the approach, there is no denying that presenters need to work harder to make the impersonal, "distant" medium more friendly and intimate.

CURRENT DISTANCE EDUCATION TECHNOLOGIES

The primary purpose of software and hardware technologies for Distance Education is to facilitate the communication of information between teachers and students, and they can be classified as either synchronous technologies, which facilitate live, real-time communication, or asynchronous technologies, which permit the sharing of information at a time of convenience to student and lecturer (such as document sharing). A secondary, but important, purpose of these technologies is to foster community within a learning

group. Gaide notes that some degree of synchronous delivery benefits online students and leads to greater student satisfaction in online distance education programs.³⁷

Synchronous technologies have the basic requirements that the lecturer and students be able to interact audibly and that they be able to share visual materials such as slides and documents (usually broadcast by the lecturer). The ability to share video feeds of lecturers and students can also be used to enhance the experience. Several current Internet collaboration systems primarily designed for business-style remote meetings exist that satisfy one or more of these requirements. The features of some of the most popular of these are listed in Table 1. A guide to many more real-time conferencing options can be found on the Web.³⁸ Other technologies focus only on the audiovisual aspects—in particular, Polycom offers a range of hardware devices that allow sharing of high-resolution video and audio feeds over ISDN or broadband Internet connections.

As with synchronous technologies, a number of asynchronous systems are available that have been developed primarily for communication of business project information. For example, the Groove Virtual Office allows sharing of documents and e-mail within a group or project. For academic use, several U.S. universities are participating in the open-source Sakai project,³⁹ which offers a code-base of facilities for Classroom Management Software (CMS), including document sharing, course roster management, grading, course announcements, and so on. Oncourse is Indiana University's Sakai-based CMS. Like commercial CMS endeavors such as Blackboard and WebCT, Oncourse has options for syllabus and schedule creation, announcements, a resources section that links to various library databases, a discussion forum, pages for assignments, a test and gradebook facility, drop boxes for student assignments, a chat room, and other features. The Web-based system allows easy dissemination of information (slides, assignments, e-mail, announcements, etc.) as well as collation of grades and projects. Thus, it provides a fairly comprehensive environment in which to manage interactions with students outside the classroom.

EVOLUTION OF A LOCATION-INDEPENDENT
CHEMOINFORMATICS TEACHING CENTER AT THE
SCHOOL OF INFORMATICS

Currently, Indiana University (IU) offers an M.S. in Chemical Informatics and a Ph.D. in Informatics with a Chemical Informatics track at both its Bloomington and Indianapolis (IUPUI) campuses. We have seven permanent or adjunct faculty members engaging in chemoinformatics activities. The research areas include chemical informatics and the lab of the future, organizing large chemical data sets, cluster and grid computing for chemical informatics, crystallographic informatics, and quantum mechanical chemical informatics databases. Complementary bioinformatics programs also exist in the School of Informatics on both the Bloomington and Indianapolis campuses, and there is a laboratory informatics program at Indianapolis.

Initial DE Efforts. In the academic year of 2001/2002, the introductory chemoinformatics course Chemical Information Technology was offered for the first time using Polycom videoconferencing equipment technologies at both the Bloomington and Indianapolis campuses of IU. The primary purpose of using these technologies was to enable students to enroll at both campuses. Polycom, Inc. has long been a leader in audio conferencing and now has developed widely deployed videoconferencing machines.⁴¹ Indiana University has Polycom machines installed in many classrooms and conference rooms around its eight campuses. We used point-to-point connections between units in Indianapolis and Bloomington classrooms, along with NetMeeting for sharing of slides and applications. Occasional remote guest lecturers were accommodated by using a central IU Polycom conference bridge to allow the connection of more than two videoconferencing units. The combination of Polycom and NetMeeting worked well for this simple configuration. With local supervision at each location, the students reported a good experience with the course and were able to interact well with other students at their locations. We employed lecturers from both sites, meaning that no set of students had only remote instruction.

In 2004/2005, we needed to add an extra location to incorporate regular delivery of lectures by one of the authors from Ann Arbor, MI. At this time, we were also interested in expanding our use of the technologies to allow students to participate from outside the classrooms. We began to refer to this arrangement as location-independent teaching, i.e., it was teaching not constrained by the geographic location of students or lecturers. This expansion exposed several technical limitations. In particular, adding a third Polycom site required the use of a conference bridge, requiring scheduling and intervention by central IU IT staff, thus increasing the support burden for our operation. At the Ann Arbor site, we initially installed a Polycom ViaVideo II camera which connects through the USB port of a computer in a similar way to a Webcam, along with a standard broadband Internet connection (2 Mbps download, 256 Kbps upload). This proved to be unsatisfactory. First, the ViaVideo regularly had problems connecting with the Polycom bridge or other units, either because of software/computer issues or because we had to run the videoconference at a slower 128 Kbps to accommodate the limitations of the broadband connection (and still leave bandwidth for Breeze). Further, the audio signal from Ann Arbor would readily become choppy and

difficult to comprehend. We later upgraded to a stand-alone Polycom V500 unit for the Ann Arbor site, at the same time as upgrading the broadband connection to 5 Mbps download, 768 Kbps upload. This proved much more satisfactory, with little difference in quality or reliability between the Ann Arbor location and the on-campus locations. However, connection problems through the bridge still frequently arose (such as one site being unable to receive video from another) which were never satisfactorily resolved.

The fact that the Ann Arbor site was located behind a router firewall created issues for both the Polycom unit and NetMeeting. The router had to be set up to forward a large number of ports to the Polycom V500 (which had an IP address on the local network), which did work but required significant effort. Since NetMeeting requires dynamic allocation of ports, it is unable to work through any kind of firewall. This issue, together with the fact that NetMeeting only works on Windows machines and is no longer a supported Microsoft product, led us to switch to Macromedia Breeze, an IU-supported product.

Breeze is a browser-based product which does not require any significant client setup or have any problems connecting across firewalls. It utilizes Macromedia Flash to publish from the authoring environment of Microsoft PowerPoint and offers capabilities such as live and recorded video and audio, screen sharing, and application sharing. The Macromedia Breeze Education Edition package includes a perpetual server license of Breeze Presentation Platform and Breeze Training with support for as many as 2000 concurrent learners.⁴⁰ Either AICC^a or SCORM^b Learning Management System (LMS) adapters are available to facilitate integration with course management systems. If the Macromedia Breeze Live perpetual server license is added to the Education Edition, interactive presentation and discussions are possible, including live and recorded video and audio, screen and file sharing, text chat, etc. Voice over IP (VoIP) is also available with Breeze. It is not possible to publish from a Macintosh or Unix environment at present, but students coming in from Mac or Unix machines can see the material.

Evaluation of the Combination of Polycom, Breeze, and Oncourse. For the 2004/2005 academic year, we used the combination of Polycom videoconferencing and Macromedia Breeze for live lectures and Oncourse for asynchronous needs, quite successfully. Two courses were offered among the three sites: Chemical Information Technology and a new Programming for Chemical Informatics course. Guest lecturers from other locations were incorporated either by including their Polycom videoconferencing units in the conference or by having them telephone the conference bridge for audio-only conferencing if no videoconferencing units were available. This proved generally successful, with the audio quality even from a telephone being sufficient. Students appreciated the ability to learn from experts from around the world whose insights they would otherwise have been unable to hear. After the 2004 Chemical Information Technology class was complete, a survey of the students ($N = 8$) was conducted to see how the location-independence had impacted them and the quality of the class overall. Despite the fact that this was the class that experienced the most technical difficulties, the results are very encouraging. Six of the seven students who responded to this question (86%) rated the class excellent or above average, with one rating it average. Seven

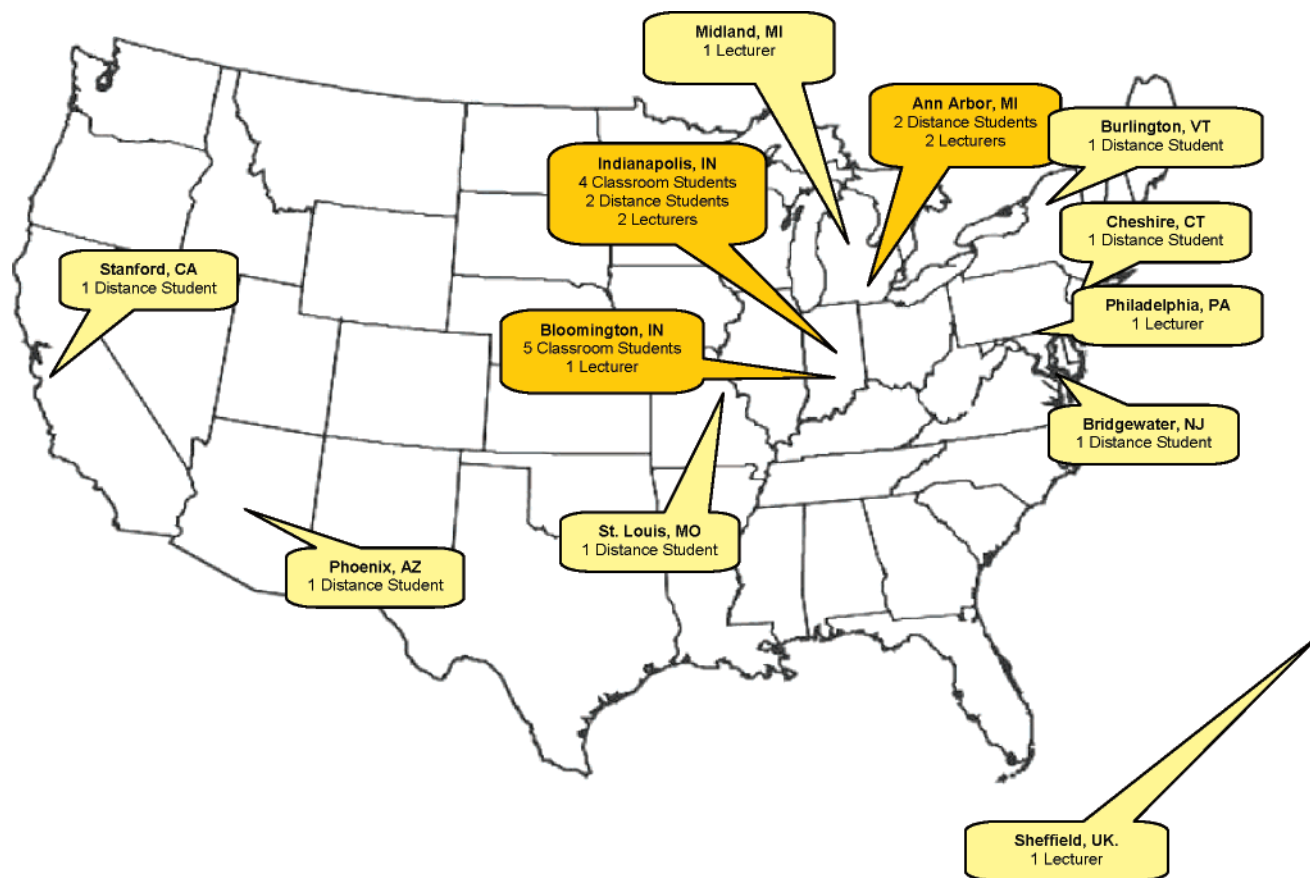


Figure 1. A depiction of our main (orange) and other (yellow) locations for classroom and distance students and lecturers.

rated the class much or slightly better than expected. Four (57%) thought the quality and value of the class were about the same as a nonvideoconferenced class—one rated it better than a regular class, and two rated it worse. One hundred percent of the respondents thought it was important to be able to see the lecturer on the videoconference. Seven students said that the technical difficulties had little or no impact on their learning from and enjoyment of the class, and one said that it had a major negative impact. Six rated Breeze average or better as an effective slide presentation tool—two rated it below average, and none rated it unacceptable. In particular, it was interesting that students considered it important to see a video feed of the lecturer. One of the technical issues we had with the Polycom unit was that the video took so much bandwidth that audio quality was compromised. In subsequent conversations with students, it was apparent that audio quality was the most important factor and that the quality or refresh rate of video was less important, yet it was still important to be able to see the lecturer.

We believe that we got such a favorable student response only because of the effort that we put into resolving ongoing problems with the teleconferencing. Further, it was clear that this arrangement would not be very extendable. Adding more Polycom units would create extra support burden, would be expensive, and would require participants to bypass firewalls and have Internet connections better than the standard broadband cable bandwidth. Macromedia Breeze proved satisfactory, but the resolution of slides was diminished, and the capabilities for interacting with students was very limited. We were unhappy with the amount of interactivity between

students and lecturers (and among students) that this arrangement engendered. At the end of the 2004/2005 academic year we therefore decided to do a wider evaluation of synchronous tools. In particular, we were interested in systems that would allow us to include easily students and lecturers who were not located in Bloomington or Indianapolis and would thus enable us to transform our initial efforts into a true DE program.

During this period we used the university's Oncourse CMS system for all asynchronous operations. We found this tool to be very effective for the sharing of documents (slides and supplemental material) and URLs and for the setting and marking of coursework. We did not use some of its more advanced features such as threaded discussion lists.

Evaluation of Synchronous Tools. Four conferencing tools were evaluated: WebEx, Raindance Meeting Edition, the previously discussed Macromedia Breeze, and Microsoft Live Meeting. The features of the current versions of these tools is shown in Table 1. Note that some of the evaluations were done on previous versions (most notably, we evaluated Macromedia Breeze version 4 before 5 was released). Each of these products permits the sharing of slides, applications, and computer desktops, with the main variance among the products being the extent to which audio and video are integrated, the pricing structure, and the flexibility of the software used for conducting conferences (including the extent to which participants can interact with each other). We determined that the critical factors for our evaluation were (in order of importance, most important first) as follows: reliability, good quality audio, sharing of slides and applications with fast refresh; easy installation and use by

participants, and some kind of video support. The ability to record lectures in their entirety was also desirable, and pricing was a factor in the decision making. Each of the four packages met the critical criteria, but we found that Raindance Meeting Edition consistently performed better for our needs. In particular, the reliability was excellent, the sharing refresh rate was better than the other packages, and we liked the clean, straightforward design of the software. Ultimately, we chose Meeting Edition as our core synchronous tool for the 2005/2006 academic year, based on these factors plus the following:

- The excellent integration of audio, video, and slide/application sharing and the fact that audio conferencing is provided and supported by Raindance, as opposed to a third party provider (as is the case with the other packages).
- The ability to record all aspects of a meeting into a small playback file (around 10 MB for a 90 min meeting, if Webcam feeds are excluded or around 60 MB with Webcam feeds) which can be uploaded into Oncourse.
- The fact that students and lecturers could participate from any location that has a broadband Internet-connected computer and a phone, with easy setup of software, 24 h technical support, and toll-free phone connection for U.S. participants.

Expansion of the DE Program for the 2005/2006 Academic Year. The switch to using Raindance Meeting Edition for the current academic year opened up the possibility of expanding our efforts from a constrained multilocation program to a full Distance Education program, with students and lecturers theoretically able to join from anywhere in the world. IU's graduate continuing nondegree option enabled us to offer our autumn Chemical Information Technology class to any graduate in the United States (i.e., without the requirement that they be previously registered as a student at Indiana), and with the Raindance technology we were able to remove any requirement that they relocate to one of our teaching centers. The availability of the course was announced via email distribution lists just a couple of weeks before the start of semester. Despite the short notice we had an excellent response and now have 10 true DE students signed up. As well as these DE students, we have an additional nine classroom students (four in Indianapolis and five in Bloomington).

Our experience so far with this arrangement has been excellent. There is a greater degree of interactivity between lecturers and students than in previous classes. Particular features of Raindance have facilitated this. For example, lecturers can quickly solicit acknowledgment of understanding of a topic from students by asking them to "raise a hand" (clicking a button which shows a raised hand by their name in a participant list). Students can ask questions in a nonintrusive manner by using the "question and answer" feature (we usually find it best to respond to questions verbally at a convenient point in the lecture). Sharing of Webcams at different locations allows students to see each other at their discretion (or even send private messages to each other—the equivalent of passing notes in class). The ability to record and play back classes has proved invaluable, especially for DE students in industry who frequently find that they have to miss all or part of a lecture due to work commitments. We have found several ways of engendering a sense of community within the class, including featuring photos of individual class members at the start of each class

(and asking them to say a bit about themselves and where the photo was taken) and featuring maps with current weather or events shown, with the location of participants marked, so students get a sense of their geographic location relative to the other students.

DEVELOPMENT OF A LOCATION-INDEPENDENT RESEARCH CENTER

Chemoinformatics research groups at IU are investigating a number of "hot topic" research areas.⁴² The Huffman group in the Molecular Structure Center is already well-known for its innovative uses of remote video collaboration tools.⁴³ We recently obtained significant funding to develop a Chemical Informatics and Cyberinfrastructure Collaboratory as part of the NIH Road map program for exploratory cheminformatics research centers.³ The work is currently being carried out at three locations (Bloomington, Indianapolis, and Ann Arbor). To facilitate group collaboration, the Wild group has employed a Research Wiki to enable group members to discuss particular research topics and to collate and classify rapidly changing information. The Wiki uses the MediaWiki framework (wikipedia.sourceforge.net), which is also used by the popular online Wikipedia.org encyclopedia. We are also investigating some alternative group collaboration frameworks including Groove⁴⁴ and IO Informatics Sentient.⁴⁵ The Wiki has been found to be a highly effective tool, although users must make the effort to learn the text markup tags required by the system. As well as using the Wiki for communication, there are biweekly group meetings using Raindance Meeting Edition. Research group members either attend one of the group meeting rooms or connect remotely if unable to attend physically. During meetings, Meeting Edition is used to share slides, demonstrate applications, and to serve as a "virtual whiteboard". For these research meetings, there is a higher degree of interactivity than in a lecture environment, and it tends to work best for all participants to have "presenting" privileges. This framework is a good one, although for complex technical discussions, Meeting Edition is limited as a whiteboarding tool, and most drawings end up looking like they were done by a child. We have yet to find an effective whiteboarding tool—all rely on the use of the mouse which is not accurate enough for nontrivial diagrams. We hope that whiteboarding technology improves to make it more usable in this environment. The intent is to expand our research groups and possibly collaborate with other, geographically dispersed institutions in the future.

FUTURE PLANS

For the future, location-independent teaching offers exciting possibilities. We are investigating the sharing of courses with other universities, both within the United States and abroad, and we aim to expand our incorporation of nonaffiliated Distance Education students. In particular, there are excellent possibilities to offer chemoinformatics education to industry professionals and academics in other fields who desire some training in this emerging area but do not have the time or interest to pursue an M.S. or Ph.D. To this end, a *Certificate in Chemical Informatics* has been developed which will formally recognize DE students who complete four chemoinformatics-related classes.

Indiana University is a member of the Big Ten Athletic Conference (which actually has 11 members!). Along with the University of Chicago, the Big Ten universities are also members of a cooperative organization known as the Committee on Institutional Cooperation (CIC).⁴⁸ The CIC gives the legal authority for the separate academic institutions to engage in all manner of cooperative activities, including the licensing of databases and electronic journals. In addition, an administrative framework was established a few years ago to allow the sharing of online and other distance education courses, under the CIC CourseShare program.⁴⁹ Since David Wild is already the instructor of a chemoinformatics course at the University of Michigan, one of the CIC participants, we have arranged to offer one of the chemical informatics courses there as a pilot project for the next 2 years via this avenue.

SUMMARY

Distance education offers a viable means of tying together geographically dispersed teachers and learners. Videoconferencing is particularly well suited to an area such as chemical informatics, which has its potential critical mass of students in many different locations, and where there is a desire for education which does not involve relocation or primary time commitments. Furthermore, the techniques and tools of DE can be brought to bear on research problems where the researchers are not all at the same location. We believe that distance education can effectively bridge the gap between the demand for chemoinformatics training and the small number of institutions offering such courses by using currently available asynchronous and synchronous technologies.

NOTES

(a) AICC (Aviation Industry CBT Committee)—The AICC publishes guidelines and recommendations for computer-based training.⁵⁰ A software or hardware package is said to be “AICC Compliant” if it adheres to one or more of the 9 AICC Guidelines and Recommendations (although officially the AICC prefers “Designed to AICC Guidelines” or “AICC Certified”).

(b) SCORM (Sharable Content Object Reference Model)—In 1997, the U.S. Department of Defense established their Advanced Distributive Learning (ADL) initiative to promote e-learning standardization and cooperation among government, academia, and the business world.⁵¹ SCORM consists of technical standards that enable Web-based learning systems to find, import, share, reuse, and export learning content in a standardized way. Through a Learning Management System (LMS), the SCORM services launch the content, keep track of learner progress, figure out the proper order for the learning objects, and generate reports on mastery of the material by the learners. A Sharable Content Object (SCO) is digital content that can be delivered via the Web, tagged with metadata, and zipped up in a content package that has an XML representation of the course structure. The content package is then played in course delivery software. For example, Dreamweaver creates SCORM compliant objects. The current version of SCORM is v. 1.3 (SCORM 2004). It provides for branching of the content based on the user's mastery of the material. A free digital library of objects

can be accessed at the Wisc-Online (Wisconsin Online Resource Center).⁵²

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