

## Nov. 1996 NSF EI PI Meeting Report

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October, 1996

**1. Institution:** Virginia Tech

**2. Title of Project:** Interactive Learning with a Digital Library in Computer Science

**3. List of PIs:** N. Dwight Barnette, Edward A. Fox (director), H. Rex Hartson, JAN Lee, Clifford Shaffer

**4. Overview of Goals and Objectives:** Key concepts of our project [FOX95c] are to improve CS education by increasing interactivity and use of a digital library. The main objectives/accomplishments were to:

- expand the content and software (especially interfaces [NOWE84, NOWE96, WAKE95a]) initially developed with NSF support of our "Envision" digital library project, "A User-Centered Database from the Computer Science Literature" [HEAT95];
- develop/apply algorithm visualization tools that are easy for instructors to use in supplementing courses, and feasible for students to work with as an aid to program development and debugging [YANG95, SHAF96a, SHAF96b];
- incorporate use of specialized digital library systems like Netlib into related courses;
- add new courses related to human-computer interaction, multimedia, and a freshman level introduction to Networked Information;
- significantly change courses like "Computer Professionalism," to make use of interactivity (e.g., asynchronous online debates) and digital library support (e.g., adding to a large History collection); and
- apply the key concepts to improve other courses

**5. Current Status and Accomplishments:** In 1991 Virginia Tech began working with ACM through support from NSF on a "User-Centered Database from the Computer Science Literature" [HEAT95]. In 1993, Virginia Tech expanded its work on digital libraries to launch the NSF EI project, partnering with Norfolk State University, which has developed extensive sets of laboratory manuals. Over 25 courses are available through WWW, leading to over 1.8M accesses since 1995. There are several gigabytes of ACM publications available. A server to handle authentication and other tasks has been installed at ACM Headquarters in NYC. Ongoing collaboration between ACM and Virginia Tech is being expanded to include IBM Research and their digital library systems.

Several courses have all the on-line materials required for self-study available, and new programs are under development for distance learning and continuing education. In the new multimedia course, there was a dramatic increase in bandwidth required for the 1996 offerings as compared to the 1995 ones, because of more images, digital audio, and digital video. Due to the development by Prof. Lee (editor of *Annals of the History of Computing*) of one of the largest repositories on computer history, with a unique image collection of the founders and early systems in our field, there is extensive additional traffic from throughout the nation. In 1996, with the help of NSF-funded digital video capture and editing facilities, audio annotations, digital video movies, and animations to show interactive applications have been added. One of the courses developed under this effort, and extended through support from SUCCEED, is CS1604, an introduction to networked information. A self-study version of this course will be finalized later in 1996, and is expected to be widely used throughout the Southeast and beyond by those interested in a freshman or beginner-level orientation to Internet, digital libraries, collaboration technologies, etc. This version has numerous audio and movie files to help learners, an automated real-time feedback facility (using our SGML-based QUIZIT tool [TINO96]), and a variety of illustrations and demonstrations.

In one old and two new courses, we have adapted Keller's Personalized System of Instruction to our networked environment. Students proceed at their own pace, study on their own, get help through asynchronous communication with peers and instructors, and in general have much greater flexibility in learning. Many students prefer this type of course, and in the case of CS1604 we simply could not accommodate the demand any other way, in this time of scarce resources. However, students have requested that we add interim deadlines, since they tend to procrastinate and require help with time management - this seems to solve the major problem faced earlier.

**6. Plans for Remainder of Project:** As our project winds down, we are getting new hardware to support the increased server load, disseminating results further, and seeking local and other support to extend our efforts further.

**7. Materials that Have Been Developed:** One result of our effort is the prototype Envision system. Its interface, if ported to Java, and connected to Z39.50, could be a very convenient means for accessing a variety of bibliographic collections, as well as richer digital libraries. A second result is the content converted from ACM. The most convenient portion is several hundred articles from *CACM* available now for those with permission using the Dienst system. A third result is the software created to increase interactivity of learning: SWAN and QUIZIT. Finally, there are about 5000 WWW pages of CS courseware.

## 8. Dissemination Activities:

### 8.1 Publications Summary

Project Overviews: FOXE94e, FOXE95c, FOXE96d, FOXE96f

Digital Library - General: CHEN96, DOUG95, FOXE93b, FOXE93d, FOXE93e, FOXE94d, FOXE95a, FOXE96b

Digital Library - Architecture: FOXE94b, FOXE95f, FOXE96c, GLAD94a, GLAD94b

Digital Library - Capture, Conversion: DALA93

Digital Library - CS Technical Reports: FOXE95b, FREN95, MALY94a, MALY94b

Digital Library - Education: FOXE96a, FOXE96d, FOXE95e, FOXE96e, LAUG96

Digital Library - Interface: NOWE94, NOWE96, WAKE95a

Digital Library - System: FOXE93c, FOXE94c, HEAT95

Interactive Applications: WAKE95b, WAKE95c

Interactive Learning: SHAF96a, SHAF96b, TINO96, YANG95

Networking: ABRA95a, ABRA95b, FOXE94a, WILL96

### 8.2 Presentations by Project Director

Many presentations have been given over the course of the project, including 8 keynote/ distinguished lecture talks: Univ. Utah (3/7/96), UNC Chapel Hill (2/1/96), NORD-INFO (Helsinki, 11/94), Multimedia Systems (Ottawa, 10/94), ISMIS'94 (Charlotte, 10/94), EG-MM'94 (Graz, Austria, 6/94), CAIA'94 (San Antonio, 3/94), IR'93 (Regensburg, Germany, 9/93). Eight tutorials, 3 demonstrations, and > 20 other presentations also were given.

### 8.3 Outreach

Ongoing collaboration with Norfolk State University (NSU) has led to an increase in the use of laboratories to aid learning of CS students at Virginia Tech, and adaptation of many of the Virginia Tech materials and tools for use at NSU. Another systematic extension has been facilitated by additional funding from NSF through Southeastern University and College Coalition for Engineering Education (SUCCEED). The SUCCEED Coalition Grant "Using Computers and Networked Information: Distance Learning with Networked Multimedia" is expanding through the use of digital video/audio tutorials, an alternative VRML (Virtual Reality Markup Language) interface, multiple graphic pathways, an interactive collaboration medium for synchronous communication, and an online interactive real time testing component. Outreach work with a number of universities in the region is underway to help them apply this course to help them deal with increased interest in this field, and to more closely approach full "Information Literacy."

**9. Evaluation Activities:** Our evaluation involves typical traditional methods, e.g., pre- and post-tests, surveys, and focus groups. We performed usability studies of tools we developed or applied, and used formative evaluation methods to refine both our tools and courseware. Yet, our project still requires additional approaches to evaluation.

The investigators in our project are instructors who changed their allocation of time, behavior, pedagogy, course materials, and tools. To understand the effects of these changes, ethnographic practices are of great value - especially regarding use of asynchronous communication (i.e., online debates) [LAUG96].

Another shift in our evaluation has been to rely on network monitoring, logging, and analysis. Here we draw upon special tools for this purpose [ABRA95a]. Part of this work has helped improve our quality of service through caching [ABRA95b]. The rest has helped us understand what students really do, what course materials are accessed, how use of multimedia effects network traffic, and how both remote and local accesses increase over time. There has been a gradual increase in both remote and total access counts, if we ignore the valleys occurring during mid-semester, summer, and end-of-year breaks.

**10. Benefits Seen and Expected:** In summary, we have developed tools, expanded our digital library systems and content, and built almost 5000 "pages" of WWW-accessible courseware, increasing the interactivity and quality of learning about computer science. Evaluation has shown that learning practices have changed, most students are happy with the emerging infrastructure and pedagogy, and there is steady growth in access to our server. Remote users now account for about one-third of the page requests, adding to the hundreds of students served locally.

Our work has helped train hundreds of students, has aided the work of instructors interested in teaching courses for which we have developed useful materials, has developed tools (e.g., SWAN, QUIZIT) that can increase the interactivity of learning about computer science, and has helped with the construction of digital library systems and a content collection in CS (with ACM publications as well as technical reports).

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