

Part II – Summary of Completed Project

Learning about computer science has been enhanced through digital library technology at the two universities supported by this grant, as well as at hundreds around the nation; newly developed WWW resources at <http://ei.cs.vt.edu> have been accessed over 11 million times during the grant period. The Departments of Computer Science at Virginia Tech and Norfolk State University have developed extensive online courseware, laboratories, and self-study materials (e.g., on Introduction to the Internet at the first-year level, on Computer Professionalism and the History of Computing at the junior level, and about Digital Libraries for upper-classmen). Tools for automating quiz delivery and for algorithm visualization (accompanied by two new books) have helped add interactivity to the learning experience. The way professors teach, the way students learn, and the influence of digital library technology at Virginia Tech and Norfolk State University have been dramatically enhanced. Furthermore, a 1997 summer workshop facilitated nationwide dissemination; one attendee, from the College of New Jersey, now leads an NSF DUE grant with University of Illinois, Springfield and Virginia Tech to develop a Computer Science Teaching Center that is extending this grant's work with digital libraries, labs, and visualization. The overall CISE education infrastructure/ innovation program has been supported by a set of WWW pages at <http://ei.cs.vt.edu/~csei/> pointing to all its projects for which information has been supplied.

Part III – Technical Information

NSF award number, amount and period of support:

CDA-9312611, \$513K, 8/15/1993 - 7/31/1998

Project title:

Interactive Learning with a Digital Library in Computer Science

Principal Investigators:

Virginia Tech: N. Dwight Barnette, Edward A. Fox (director), H. Rex Hartson, JAN Lee, Clifford Shaffer;

Norfolk State University: Sandra DeLoatch (director), John Urquhart

Overview of Goals and Objectives:

Key concepts of our project [1] were to improve CS education by increasing interactivity and use of a digital library (DL). The main objectives/accomplishments were to:

- expand the capabilities [2], content, and software (especially user interfaces [3-10]) initially developed with NSF support of our “Envision” DL project, “A User-Centered Database from the Computer Science Literature” [11];
- 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 [12-16];
- incorporate use of specialized DL systems like Netlib into related courses;
- add new courses related to human-computer interaction, multimedia, and a freshman level Introduction to Networked Information (later renamed Introduction to the Internet);

PI/PD Edward A. Fox, NSF CISE Research Infrastructure Award Number 9312611

- significantly change courses like “Computer Professionalism” [17], to make use of interactivity (e.g., asynchronous on-line debates [18]) and DL support (e.g., adding to a large computer history collection);
- apply the key concepts to improve other courses.

History, 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” [11]. In 1993, Virginia Tech expanded its work on DLs to launch this NSF EI (Education Infrastructure / Innovation) project, partnering with Norfolk State University, which has developed extensive sets of laboratory manuals. Over 40 courses are available through our WWW server, with the number of accesses exceeding 11 million. The original courseware server was upgraded in 1997, and an IBM donation has provided a mirror machine in the Computing Center to ensure reliability. Ongoing collaboration with IBM and their DL systems [19] has helped Virginia Tech coordinate development of the Networked Digital Library of Theses and Dissertations ([20-25] <http://www.theses.org/>).

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 (CS4624, Multimedia, Hypertext and Information Access), there was a dramatic increase in megabytes transferred because of more images, digital audio, and digital video: from 847 in 1995 to 1052 in 1996 to 2373 in 1997. Due to the development by Prof. John A. N. Lee (then Editor-in-Chief of *IEEE 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. Starting in 1996—with the help of NSF-funded digital video capture and editing facilities especially in the Information Access Laboratory [26]—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 (an NSF-supported engineering consortium), is CS1604, Introduction to the Internet. A self-study version of this course was finalized in 1997, designed to be widely used throughout the Southeast and beyond by those interested in a freshman or beginner-level orientation to Internet, DLs, 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 [27, 28]), and a variety of illustrations and demonstrations.

In several old and new courses, we have adapted Keller’s Personalized System of Instruction [29] to our networked environment. Students proceed at their own pace, study on their own, receive 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. Students requested that we add interim deadlines, since they tend to procrastinate and require help with time management — doing so seems to have solved the major problem faced earlier. Pilot tests with courses like CS1604 are demonstrating how these subjects can be mastered through independent study.

Norfolk State Report:

The principal goal of this part of the project was to improve the computer science undergraduate learning experience for Norfolk State University (NSU) students. Results include 1,000 Web pages of courseware, new and enhanced courses, and electronic collaborations with other universities. Specifically, all required and selected elective courses were enhanced through the development of laboratories and the interactive use of algorithm animations, video, images and text. A new course - Introduction to the Internet - was developed and the existing Computer Science Seminar course made extensive use of computerized materials comprising a comprehensive Digital Library as an information resource. The Seminar course also included joint electronic debates on computer ethics with students at Virginia Tech and Heritage College. Instructional materials and other innovations were extensively tested and evaluated. Rising passing rates and student surveys suggested that these activities were successful.

Supplements:

Three small supplement requests led to an increase in the budget and extension of the activities and grant period into 1998. These dealt with additional WWW services and dissemination.

1) As a result of discussion at an NSF EI workshop in 1996 [30], it was decided that support should be provided for a single WWW site to highlight results of all CISE EI efforts. A WWW site was developed and populated with all information and pointers provided by recipients of EI funding, at <http://ei.cs.vt.edu/~csei/>.

2) As a result of the growing interest in digital libraries, and as a side benefit of two DL courses (one undergraduate and one graduate) taught at Virginia Tech in Fall 1997, a self-study course, with a complete set of online quizzes, was developed and made available. This can be accessed from <http://ei.cs.vt.edu/~dlib/>.

3) In June 1997, a workshop to disseminate project results was conducted in Blacksburg, VA with attendees from all over the nation. Norfolk State project personnel conducted a session on laboratories that emphasized development, logistics, and evaluation. In addition, participants were provided with access (<http://www.cs.nsu.edu>) to the hundreds of laboratories and other course innovations that have been developed to support NSU computer science courses. Additional important benefits accrued. For example, Deborah Knox, from the College of New Jersey, attended, and is now collaborating with co-PI Fox, on the Computer Science Teaching Center, CSTC, <http://ei.cs.vt.edu/~cstc/>, funded early in 1998 by NSF [22-24]. A related effort builds on activities with multimedia curriculum and resources [31, 32], <http://ei.cs.vt.edu/~crim/>.

Materials that Have Been Developed:

One result of our effort is the prototype Envision system. Its user interface was designed for access to bibliographic collections, as well as richer DLs, and has been mostly ported to Java in 1998. Its search engine, MARIAN, is likely to be ported to Java by 1999, thanks to a grant from NLM. A second result is the content converted from ACM, made available to ACM to help with their DL efforts. A third result is the software created to increase interactivity of learning: SWAN (algorithm visualization software, along with 2 related books [12-16]), an on-line debate system for managed dialog [17]; and QUIZIT, a system for automating quiz handling [27-28]. A fourth result is the set of pages about EI projects, at <http://ei.cs.vt.edu/~csei/>. Fifth is the self-

study courseware on digital libraries at <http://ei.cs.vt.edu/~dlib/>. Finally, there are well over 10,000 WWW pages of CS courseware accessible from <http://ei.cs.vt.edu> and <http://www.cs.nyu.edu>.

Publications Summary:

<i>Areas of Accomplishment</i>	<i>References</i>
Project Overviews	[1, 30, 33-39]
Digital Library - General	[40-54]
Digital Library - Architecture	[1, 37, 55-62]
Digital Library - Capture	[23, 63]
Digital Library - CS Tech. Reports	[64-68]
Digital Library - Education	[1, 18, 21, 23, 30, 36-38, 69-90]
Digital Library - User Interface	[1, 4-11, 91-97]
Digital Library - System	[11, 36, 98]
Interactive Learning (Applications, Tools)	[12-18, 27, 97, 99, 100]
Multimedia/Networking	[80, 101-123]

Presentations by Project Investigators:

Many presentations have been given over the course of the project, including:

- 11 keynote/ distinguished/ plenary lecture talks: Puebla Mexico (6/10/98 [22]), Rice Univ. (3/97 [84]), Univ. Utah (3/7/96 [79]), UNC Chapel Hill (2/1/96 [124]), NORD-INFO (Helsinki, 11/94 [125]), Multimedia Systems (Ottawa, 10/94 [70]), ISMIS'94 (Charlotte, 10/94 [98]), EG-MM'94 (Graz, Austria, 6/94 [126]), CAIA'94 (San Antonio, 3/94 [127]), IR'93 (Regensburg, Germany, 9/93 [128]), Boca Raton (FL, 3/93 [110]).
- 15 tutorials [82, 129-141], and
- 4 demonstrations [7, 9, 75, 142].

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PI/PD Edward A. Fox, NSF CISE Research Infrastructure Award Number 9312611

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