PROJECT NARRATIVE

1.0 PRIOR NSF SUPPORT

1.1 Deborah L. Knox

No prior NSF support pertaining to undergraduate education in the past five years.

1.2 Scott B. Grissom

Award Number:	DUE-9551332
Amount:	$26,991
Period of Support:	July 1995 - June 1997
Title:	Undergraduate Networks and Operating System Laboratory
PIs:	Ted Mims and Scott Grissom

Under this ILI grant we established a laboratory for networks and operating systems. Funding was received in Summer 1995. Our first purchase was four Pentium PCs fully loaded with several operating systems, CD ROM, large screens and extra memory. We purchased ten additional PCs during Summer 1996. Students develop and experiment with networks and operating systems in the undergraduate courses. Each semester, they install Linux and create a network serviced by NIS. Students have presented papers at regional conferences describing their experiences [Sidener96, Zhong96, Lancaster97]. Professor Mims has developed teaching modules for networks and operating systems courses. He gave a presentation at the NSF sponsored undergraduate faculty enhancement workshop on networks in the summer 1996 and at SIGCSE in 1997 [Dezhgosha97].

1.3 Edward A. Fox

Award Number:	CDA-9312611
Amount:	$449,088
Period of Support:	August 1993 - December 1997 (if supplemented)
Title:	Interactive Learning with a Digital Library in Computer Science
PIs:	N. D. Barnette, E. A. Fox (director), H. R. Hartson, J. Lee, C. Shaffer

Key concepts of our project 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 initially developed with NSF support of our "Envision" digital library project, "A User-Centered Database from the Computer Science Literature";
- 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;
- 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 (later renamed Introduction to the Internet); and
- significantly change courses like "Computer Professionalism," to make use of interactivity (e.g., asynchronous online debates) and digital library support.

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" [Heatth95]. In 1993, Virginia Tech expanded its work on digital libraries to launch the 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 WWW, leading to over 4.8M accesses from January 1995 through mid-May 1997. There are several gigabytes of ACM publications available. The Virginia Tech server has been upgraded, and an IBM donation has provided a mirror machine with ATM connection in the Computing Center to ensure reliability. Ongoing collaboration with ACM has expanded to include IBM and their digital library systems, which also are helping Virginia Tech coordinate development of the National Digital Library of Theses and Dissertations (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, 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. 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. One of the

courses developed under this effort, and extended through support from SUCCEED, is CS1604, Introduction to the Internet. A self-study version of this course was finalized in 1997, and is expected to be widely used throughout the Southeast and beyond by those interested in a freshman or beginner-level orientation to Internet. This version has numerous audio and movie files to help learners, an automated real-time feedback facility (using our SGML-based QUIZIT tool [Tinoco96]), and a variety of illustrations and demonstrations.

Materials that Have Been Developed: One result of our effort is the prototype Envision system. Its interface, being ported to Java, 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 in increase interactivity of learning: SWAN (algorithm visualization) and QUIZIT. Finally, there are over 10,000 WWW pages of CS courseware.

Dissemination: The following citations are selected from over forty publications and many presentations. Project Overviews: [Fox94a, Fox95c, Fox96d, Fox96b]; Digital Library - General: [Chen96, Fox93e, Fox94b]; Digital Library - Education: [Fox96c, Fox96d, Fox95b, Fox96a, Laughton96]; Digital Library - Interface: [Nowell94, Nowell96, Wake95a]; Interactive Applications: [Wake95b, Wake95c]; Interactive Learning: [Shaffer96a, Shaffer96b, Tinoco96]

Benefits Seen and Expected: In summary, we have developed tools, expanded our digital library systems and content, and built over 10,000 “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.

2.0 PROBLEM STATEMENT

Pedagogy in computer science is maturing, as instructors shift from a lecture based style to one that increases the active learning experiences for students. This transition requires a commitment from the teacher in terms of time and creativity. Effective teaching requires careful preparation and organization to develop a course and to integrate appropriate assignments that reinforce important concepts. Unlike many established disciplines, computer science is evolving at a rapid pace [Tucker96a]. Courses never quite seem “settled”, as the choice of programming language frequently changes, new textbooks are adopted, or new teaching paradigms emerge. It is difficult for faculty to keep up with the changes and still devote enough effort to advising, service, and research. Computer science faculty would benefit from access to high quality teaching materials designed by dedicated and gifted teachers. However, it is important that these materials be easy to find and convenient to integrate into a course.

The ACM Strategic Directions in Computing Research Workshop met in June 1996 at MIT. The Education Working Group from this workshop identified a need to improve the coordination and communication across the computer science education community [Tucker96b]. Unfortunately, materials currently available on the Web do not address this need. This section reviews the current state of computer science teaching resources available on the Web.

2.1 Web Education Resources for Computer Science

There is a proliferation of course materials on the Web. However, most material is simply course syllabi and assignments for a local course maintained by the instructor. Although the information is published on the Web the primary intent is to support a local course. The material

is rarely provided in a format suitable for easy reuse. Another problem is that there is too much material of questionable quality and it is dispersed all over the Web. Wandering from one site to another looking for appropriate materials takes a great deal of time and is often not productive.

There are several aspects to consider when evaluating the quality of a Web site. 1) Are the resources peer reviewed? What assurance is there that the materials will be of the highest quality? There are three ways to review content of a Web site: no review, editorial review, and peer review [Knox96a]. A site that has no formal review may have more entries but the quality will be relatively low. A peer reviewed site will accept fewer submissions and the process will take longer but the result is higher quality. 2) Are the resources designed for reuse by other educators? Is there sufficient documentation to allow teachers to quickly adapt the material to their needs? 3) Are the resources in a common format? A common format helps instructors quickly evaluate material. 4) Is there a search capability to quickly identify relevant material? A comprehensive site will likely have hundreds of resources. An intuitive and effective search engine is critical to the usability and therefore the success of a site. 5) Are the resources kept on site or off site? Index sites point the visitor to an external home site maintained by someone else. This can raise quality concerns if the external site is not maintained well.

2.2 Index Sites for computer science education

Many Web pages only provide links to other Web sites. These index sites can be useful but also can be overwhelming. These sites do not provide resources but only redirect visitors to other sites.

The Academic Cooperative Curriculum Program [Microsoft97] is an index site with course descriptions from more than 350 universities and colleges that use Microsoft products in their curriculum. A search facility allows visitors to look for syllabi based on the discipline and the ACM computer science curricula Knowledge Groups [ACM/IEEE91]. Course descriptions are presented in a common format but only contain superficial information such as course description, textbook and Microsoft products used. A link is provided to an external home page maintained by the instructor.

The Computer Science Education Links index site [McCauley97] is maintained by an instructor in her spare time. Although the sixty links are organized by computer science courses, there is no search capability. The references are editor reviewed. University Courses in Computer Science [Ingargiola97] is a similar index site maintained by another individual. The links are editor reviewed and there is no search capability.

The World Lecture Hall [TeamWeb97] is an extensive site of indices to pages created by faculty worldwide who use the Web to deliver classroom materials. Over one hundred subjects from Accounting to Zoology are provided. Materials are not peer reviewed. Instructors provide a brief description with a URL and the information is added to the site. There is no search capability. For example, the fifty entries in computer science are not listed in any order and are not grouped by categories.

The NSF Computer Science Courseware Repository [Owen97] is a collection of over one hundred abstracts for NSF funded education projects. Abstracts are organized into three categories: introductory courses, advanced courses, and general support. Each abstract is presented in a common format but only includes a short summary of the project and contact

information for the PIs. Only five of the abstracts have materials that can be obtained through FTP. There is no search capability.

2.3 Content Sites for computer science education

A few Web sites have been proposed or are currently under development to provide teaching resources designed for reuse. These sites differ from index sites because they provide content that can be retrieved. One of the proposed sites is for a repository of courseware to support computer science courses [Goldwebber96]. Two sites are currently under development for visualization tools [Grissom97] and laboratories [Knox97a]. A third site is a large digital library to support the computer science curriculum at Virginia Tech [Fox97].

2.3.1 Visualization Resource Center

Visualization tools are used to clarify complex concepts in computer science [Grissom95b, Grissom96c, Naps96b]. A recent working group identified several reasons for developing and using visualization tools in the classroom. Among other reasons, these tools are used to increase students' understanding, allow instructors to cover more material in less time, and encourage new modes of learning [Naps96a]. Creation of visualization tools is a difficult and time-consuming task. However, the recent proliferation of graphical interface development environments is making it easier. Given the usefulness of visualization tools, an effective means of sharing them is called for. A web repository is an effective way to share tools and has several benefits [Naps96b]. It provides a single location for tool users as well as tool makers. It provides

tested tools for anyone to use and provides the necessary information of how to use the tools in the classroom. Repositories also facilitate new development that builds upon previous work.

In 1995, a list of resources was published on the Web that contained approximately fifteen visualization tools [Grissom95b]. Some tools are designed for specific courses such as computer graphics [Schweitzer92, Wolfe96], automata [McFall94, Bilska97], computer architecture and artificial intelligence [Ingargiola94]. Other tools are general purpose algorithm animation packages used to show the flow of control for almost any algorithm [Naps90, Brown91, Stasko90 & Stasko97]. In 1996, this information was provided as an editor reviewed content site with links to download the software [Grissom96c]. There were no search capabilities and the content was limited to only a dozen entries. Appendix A contains several screen captures from the editor reviewed site [Grissom96c].

In February 1997, Grissom organized an advisory group to establish review criteria and submission guidelines for a peer reviewed site [Grissom97]. The Visualization Resource Center will contain a variety of resources to help faculty integrate into their curriculum. *Visualization tools* are applications whose primary purpose is to allow one to create pedagogical visualizations, for example, algorithm animation software. Tools are subject to at least three reviews. *Visualizations* are prepackaged demonstrations for a specific concept or algorithm, for example, an algorithm animation to demonstrate binary tree insertion or an applett to demonstrate ray tracing. Visualizations are generally a product that must be downloaded and are subject to at least one external review. *Demonstration gems* are brief descriptions of original visualization techniques used in the classroom. These low tech visualizations generally do not need a computer and can be used by someone immediately. Gems are merely good ideas for others to use and do

not include a product to be downloaded, for example, using tinker toys to show 3D coordinate systems in computer graphics or large cardboard numbers to walk through sorting algorithms.

2.3.2 Laboratory Repository

Over the past two years, SIGCSE (ACM Special Interest Group on Computer Science Education) has sponsored two working groups focusing on developing and using the laboratory approach in support of teaching and the hands-on learning of computing. A common theme that emerged was the need to disseminate information about lab materials. The need for a lab repository was first discussed by the SIGCSE Working Group on Closed Labs [SIGCSE95]. Members of this group believed that availability of sample labs would be helpful to others wanting to integrate the lab experience into their courses.

At the 1996 SIGCSE Technical Symposium, a large audience at a panel discussion on laboratories called for a central location for information on labs [Wolz96]. After that session, Dr. Knox volunteered to develop a prototype web-based laboratory repository. The first prototype received approval from SIGCSE for continued development.

In June 1996, the Working Group on Computing Laboratories generated a report detailing the integration of labs into the curriculum and advocating a web based laboratory repository [Knox96a]. At that meeting, the prototype project was demonstrated to members of the Working Group. They discussed future directions of the repository project and included an outline of options in developing a Web based repository. The Computing Laboratory Repository prototype features: editor reviewed abstracts; on-line submission, retrieval and searching for labs; materials available from the author's home site; and feedback to through

collected comments. Appendix B contains several screen shots from the SIGCSE Computing Laboratory web site [Knox97a].

Since the availability announcement, the site has received a number of requests for more information. It has become obvious that we need to proactively recruit submissions, especially in the early stages of the project. In early May 1997, members of the SIGCSE email list received a call for participation, which resulted in three labs submitted in a period of one week. During the two week period immediately following the call for participation, the site had over 100 visits.

The immediate future of the SIGCSE Computing Laboratory Repository will be much brighter due to the recommendations of the Working Group on Developing Laboratory Materials for Computing Courses, to be held in June 1997 [Knox97c]. Members of this working group will prepare a number of exemplary laboratories, following the recommendations of the previous working group.

2.3.3 CISE Education Innovation Clearinghouse

Since 1991, ACM and NSF have supported digital library research at Virginia Tech for the computer science area. Adopting a user-centered approach [Heath95], a good deal of the early emphasis was on developing a prototype search system and an innovative and usable interface [Nowell96]. Leveraging other experience at Virginia Tech with Elsevier's TULIP project [Dougherty95], a large number of page images were captured and delivered to ACM.

NSF support through its CISE Education Innovation (EI) Program has supported the application of digital library research to computer science education. The Virginia Tech site has one of the richest collections of CS courseware in the world [Fox94a, Fox96b, Fox97]. A number

of the courses include labs as well as multimedia tutorials, and several also have online quizzes [Tinoco97]. There are over 100K hits per week to this site, from all over the world.

This site is being extended in three ways through a supplement to the original award. First, a June 1997 workshop is disseminating results of the project. Second, courseware on digital libraries, including demonstrations of the technology developed through the NSF/DARPA/NASA Digital Library Initiative, is being added. Third, Web pages for the entire EI Program are being added, to serve as a foundation and template for all projects supported through that program, so their results can be disseminated better. Finally, it should be noted that one of the courses at the site, on Multimedia, Hypertext and Information Access, serves as a model for ongoing discussions about curricular and resource development in the broad multimedia area, supported by ACM SIG Multimedia [Fox95b].

At the November 1996 PI meeting for currently and previously funded EI projects, an important topic of discussion was dissemination. Since many innovative research and educational efforts in computing are funded through the EI initiative, it is of particular importance that results of those efforts be widely applied. Accordingly, Edward Fox was asked by the EI program officer to submit a supplement proposal to develop Web pages and templates for all EI efforts. Thus, Fox is serving as Editor for the CISE Education Innovation Clearinghouse through the end of 1997. In addition to having pages about the EI program, and pointers to sites of EI projects, the Clearinghouse will include indexes based on topic, level, course, lab, and other criteria.

3.0 PROPOSED PROJECT

A clearinghouse of teaching resources for computer science educators will provide a trusted avenue for dissemination, and will foster collaborative efforts as people are brought together by their common interests. We propose to develop a framework for making high quality, reusable teaching resources available for Computer Science educators. We envision a digital Computer Science Teaching Center (**CSTC**) that encompasses several related but distinct resource centers.

This project is similar to a vision proposed by the ACM Strategic Directions in Computing Research Workshop [Tucker96b]. They propose a Computer Science and Engineering Education Center that provides several services. 1) A resource center for course and curriculum development; 2) a repository of successful programming assignments and laboratory exercises; 3) a centralized test bank; 4) a library of tools and demonstration software; 5) a clearinghouse for student opportunities; 6) A virtual university to support distance education and 7) a storehouse of educational models for other disciplines. They acknowledge that this is a grand challenge that will require a great deal of exploratory research and significant support from public and commercial sources.

ACM, "The First Society in Computing", identifies itself as an international scientific and educational organization for advancing information technology [ACM95]. The ACM Education Board upholds the educational goals of the organization. ACM's Special Interest Groups (SIGs) provide support for members to keep current in specific areas within the field of information technology [ACM97b]. SIGCSE is the professional group on computer science education and provides a forum for educators to discuss all aspects of computing science programs and courses [ACM97c]. SIGGRAPH promotes the acquisition and exchange of information on computer-

generated graphics [ACM97d]. The ACM electronic publishing plan directs the societies of the ACM to offer the "facilities and mechanisms whereby authors can post collections of their works and obtain public comment..." [Denning95].

Implementing a comprehensive and complete CSTC is beyond the scope of our proposal. Instead, we propose a gradual development. We will build upon three prototype Resource Centers and draw upon an institution with extensive digital library experience. At the end of this project we will have:

- a framework for developing and distributing peer reviewed reusable teaching resources,
- a fully functional Visualization Resource Center (Section 2.3.1),
- a fully functional Computing Laboratories Resource Center (Section 2.3.2), and
- a fully functional CISE Education Innovation Clearinghouse (Section 2.3.3).

Our proposal has support from leading organizations interested in computer science education. The ACM Education Board is enthusiastic about this project and has pledged its support (Appendix C). SIGCSE endorsed development of the prototype computing laboratory repository. The SIGGRAPH Education Committee provided a modest amount of funding for the prototype Visualization Resource Center. NSF has funded the prototype CISE Education Innovation Clearinghouse.

This section outlines our plan and qualifications for successfully completing this project. The two most important requirements of a successful CSTC are the quality of the resources and the usability of the Web site.

3.1 Content Quality

Our primary objective is to establish an infrastructure to insure resources are worthwhile and easy to reuse. We will use the traditional approach of establishing an editorial board for the CSTC and maintaining a pool of referees for each Center. We will implement an open solicitation and review process to collect, critique, refine, and rate submissions. This will add value to those materials, encourage research and educational innovation to continue, reward those who contribute, and provide an atmosphere of sharing to sustain the enterprise. The peer review process will contribute to the professional prestige of the site. We assert that accepted materials should be valued with the same standards as printed refereed papers, which is in accordance with the ACM Policy on The Quality of Refereed Electronic Publications [ACM97g].

Each Center of the CSTC will be administered by an Editor, who will recruit and manage reviewers. Scott Grissom will serve as Editor of the Visualization Resource Center, and Deborah Knox will continue her role as Editor of the Computing Laboratory Resource Center. Edward Fox will continue to serve as Editor for the NSF CISE Education Innovation (EI) Clearinghouse.

Review criteria for visualization resources includes ease of installation, usability, documentation, and pedagogical benefits. Review criteria for laboratory assignments include similar aspects as well as specific required information including a summary, a specification of the type of interaction (individual versus group activity), goals, objectives, time required, and resources and materials required. During the review process each resource will be tested by the reviewers. The EI projects are peer reviewed according to NSF criteria. All reviews will be submitted with Web forms and e-mail to allow a quicker turnaround time than paper publications.

We will develop a set of guidelines for review, appropriate for each Center. The reviewers will provide feedback on the guidelines, which will be modified as necessary. The Working Group at ITiCSE 97 has as one of its objectives to draft guidelines for reviewers of materials for the SIGCSE Computing Laboratory Repository [Knox97c]. These will serve as a guiding reference in our development of the CSTC.

The Editorial Board will provide feedback during the development phase, review submissions, and help in the ongoing maintenance of the CSTC. A number of people have agreed to serve in advisory positions. Qualifications of these individuals span educational research, textbook authorship, courseware tool development, laboratory development, visualization tools, representation on ACM Boards, and active SIGCSE membership. They include: Nell Dale, University of Texas; Elliot Koffman, Temple University; Maria Larrondo-Petrie, Florida Atlantic University; Tom Naps, Lawrence University; Jane Prey, University of Virginia; Viera K. Proulx, Northeastern University; Richard Rasala, Northeastern University; Susan Rodger, Duke University; Rocky Ross, Montana State University; John Stasko, Georgia Tech; and Rosalee Wolfe, DePaul University.

Accepted materials will be stored and distributed from the CSTC. This is preferable to having the material maintained by authors at their home institution because it is easier to control the quality and appearance of the material. If an author makes changes to previously accepted material, the submission and review process must be repeated. With ACM sponsorship, copyrights will be assigned according to ACM publication guidelines [Denning95].

3.2 Usability of the CSTC

We will develop a common user interface for all Resource Centers. A visitor's ability to navigate in one Center will transfer to other Centers. We will apply usability engineering principles to develop a compelling and easy to use interface. The interface will be tested and refined using the equipment and facilities of Virginia Tech's Usability Methods Research Laboratory, funded through a 1993-95 NSF Research Infrastructure grant. Although usability design is well established for traditional software, it appears the principles are often ignored on the Web. This is because almost anyone can publish information on the Web but few people have the expertise to design and implement usable systems. Some usability principles have recently been adapted to hypermedia and the Web [Neiderst96, DiNucci97, Shneiderman97].

An easy to use but robust search facility is important to the success of this project. Visitors will be able to search for resources based on several criteria such as author, date, hardware platform, operating system, and content category. We will build a common support structure for storing materials, drawing upon existing software when possible. For example, the prototype for the Computing Laboratory Repository currently uses the public domain software Swish [Hughes97] for generating an indexed list for searching. Glimpse [Manber97] is an alternative software package that is used as the backbone for Harvest (a web searching tool), and is used by ACM in their digital library of publications to search in the ACM Journal Abstracts [ACM97f]. Discussions among the PIs will lead to a requirements specification of the desired digital library.

We will use common classification strategies to facilitate indexing and searching for resources. There are two established systems. The ACM Computing Classification System

(formerly the Computing Reviews categorization) identifies eleven categories that represent the spectrum of the discipline [ACM97a]. They are: general literature, hardware, computer systems organization, software, data, theory of computation, mathematics of computing, information systems, computing methodologies, computer applications, and computing milieux.

An alternative classification to consider is the ACM Knowledge Units [ACM/IEEE91]. They appear to fit in well with efforts toward multimedia curricula [Fox95b]. Knowledge units represent fundamental topics covered in computer science courses. There are nine units defined: algorithms and data structures, architecture, artificial intelligence, database, human-computer communication, numerical and symbolic computation, operating systems, programming languages and software engineering.

Based on experience and resources at Virginia Tech, including the IBM Digital Library System, an effective implementation strategy will be developed and followed. Technical issues such as the security and access speed of the web site will be considered during development.

3.3 Outcomes

The benefits of this project will enhance the teaching of computer science. Our focus is on building a recognized center of information for computer science educators to use during course development. Within the time frame of this grant, we plan on the following outcomes:

- **Resource Centers**. Visualization Resource Center, Computing Laboratory Resource Center and the CISE Education Innovation Clearinghouse.
- **Professional Recognition for Contributors**. Peer review will promote recognition for scholarly contribution towards the development of teaching materials..

- **A Framework**. The underlying support structures for new Centers that will also apply to other disciplines.
- **New Resources**. After a suitable start-up time, it will be easy to identify the gaps in materials contained in the Resource Centers. For example, we may identify that there are no laboratories provided for operating systems. This will lead to directed "Calls for participation" for an area in need of resources. This allows a pro-active approach to finding and addressing needs in the field.
- **Resource Reuse**. The proliferation of web sites with educational materials suggests that educators want to share their ideas. However, the proliferation is preventing many from easily finding desired materials. With the CSTC, developers will have one place to submit and find materials, a site with sponsorship by ACM and SIGCSE, the leading professional organizations. This will encourage more of the tools, demonstrations, projects, laboratories, etc. to be reused rather than developed from scratch.
- **Collaborative Environment.** The prototype Computing Laboratory Repository supports an annotation capability that allows for comments to be collected on each entry in the database. This promotes feedback to the developer and provides information about the success of adopting a lab to future adopters. With this feature, people can find others who are working with similar approaches to courses and may be able to set up their own informal networks of colleagues.

3.4 Insuring Successful Continuation

Success of the CSTC depends upon continued efforts of management, editorship, submission, review, and adoption. We will investigate possibilities for support of the CSTC beyond the timeframe of this project. Editor positions will probably remain volunteer in nature, as are editors of ACM SIG publications. Host institutions will be encouraged to provide support by providing course release time for Editors. Dr. Knox has received a commitment from her institution for the year following this grant (Appendix D).

Management of the Resource Centers and the day-to-day maintenance and hardware support need a funding source. The following ideas do not represent a final plan, but are given as proposed solutions we will pursue.

1. **Publishers**. Deborah Knox has been in contact with Addison-Wesley in regards to sponsorship of the SIGCSE Computing Laboratory Repository, and is preparing a proposal for support. Edward Fox serves as editor for Multimedia Information and Systems at Morgan Kaufman Publishers, Inc., which might serve as sponsor. Other publishers can be contacted. We will need to illustrate benefits to the publishers for this type of support. One idea is to develop a Textbook Review Resource Center, including reviews of texts and curriculum development based on texts from supporting publishers.
2. **ACM.** Just as the SIG publications receive funds for printing and publication, the CSTC project could request funding from ACM for management and maintenance. If computing equipment was required (if, for example, the CSTC could not remain at Virginia Tech), we would pursue becoming part of ACM's digital publication plan.

3 . **Subscriptions.** Consideration of a subscription-based use policy could generate funds for management, maintenance, and equipment. Rather than soliciting individuals to subscribe we would approach academic departments. The CSTC could provide non-subscription based access to abstracts of materials, and provide full access to members only. ACM has such a policy in place for the ACM Digital Library [ACM97e].

3.5 Experience of PIs

3.5.1 Deborah L. Knox

Deborah Knox completed her Ph.D. at Iowa State University in 1987. She has developed and used laboratories in support of the computer science curriculum for over ten years. In June, she will co-lead a working group on designing laboratory materials at the SIGCSE/SIGCUE Integrating Technology into Computer Science Education Conference (ITiCSE). Her selection to lead this group was based on a competitive proposal. Last year, she also co-led a working group at the same conference [Knox96a]. She began working with SIGCSE in 1995 as a member of the Working Group on Closed Labs, held at the National Education and Computing Conference. Her involvement with these working groups and her volunteering to develop the prototype SIGCSE Computing Laboratory Repository led to an invitation by the Chair of SIGCSE to serve as the editor of the Repository.

She has presented papers and posters and participated in panel discussions and birds-of-a- feather meetings at the SIGCSE Technical Symposium and at ITiCSE [Knox96b]. At the most recent Technical Symposium, she presented the Computing Laboratory Repository prototype during a regularly scheduled paper session and also announced its debut during the annual

Business Meeting [Knox97b]. At the upcoming ITiCSE, she is scheduled to demonstrate the prototype Repository and to present a paper on a lab based approach to teaching architecture [Knox97d].

3.5.2 Scott Grissom

Scott Grissom completed his Ph.D. in Computer Science at The Ohio State University in 1992 with a major in computer graphics and human-computer interaction. He has been teaching undergraduate and graduate courses in computer science for four years at the University of Illinois at Springfield. Grissom is a member of the SIGGRAPH Education Committee. The committee's mission is to enhance computer graphics education and the use of computer graphics in education. His experience and contacts with other computer science educators will be valuable for this project [Grissom95a, 95b, 96c, Wolfe96].

He received a 1995 grant from the University of Illinois Applied Learning Technology in Higher Education Program to develop a teaching tool for computer graphics [Grissom96a, 96b]. His most recent grant is also from the University of Illinois to begin development of the Visualization Resource Center.

3.5.3 Edward Fox

Edward Fox completed his Ph.D. at Cornell University, specializing in information retrieval, in 1983. He is a Professor of Computer Science, and Associate Director for Research at the Virginia Tech Computing Center. For ACM he served as vice chair and then chair of SIGIR from 1988-1995, founded the Multimedia and then the Digital Libraries conference series, was on

the Publications Board from 1988-91, and served as Editor-in-Chief for ACM Press Database and Electronic Products during that same period. He now serves on the SIGIR education committee and as co-chair of the SIG Multimedia education committee. Since 1991 he has been actively involved in digital library research, and served as program chair for Digital Libraries '96, ACM's first international conference in this area. He has been editor for various special issues/sections on digital libraries: JASIS in 1993, CACM in 1995 and 1998, JVCIR in 1996, and Information Processing and Management in 1998. He is widely published, and has served as PI on over 55 research grants.

3.6 Timetable for Implementation

Before the Grant Begins

Planning for progress of this project will start prior to the funding period. Several proposals will need to be submitted to conferences prior to the beginning of the grant. We will submit a panel proposal about the initial CSTC development to the annual SIGCSE Technical Symposium. We will submit a working group proposal about using digital libraries to share teaching resources to the annual SIGCSE/SIGCUE Integrating Technology into Computer Science Education conference (ITiCSE).

Year one

Focusing on development of the common framework of the CSTC, the PIs will collaborate on a regular basis and arrange electronic sessions with the Editorial Board for feedback. The user interface needs to be developed, the instructions for submission need to be

drafted, the instructions for reviewers need to be formulated, and the interface to the logging mechanisms must be established. HTML, Perl, and other systems programming will need to occur during this year. Ongoing development will be summarized and disseminated widely.

January - March 1998 Review recommendations from the ITiCSE ‘97 Working Group on Developing Laboratories for Computing Courses. Critique existing user interfaces (Visualization Resource Center and Laboratory Repository) and propose common approach. Evaluate search engines. Develop prototype(s) for review at SIGCSE. Attend SIGCSE ‘98 to disseminate our plans, recruit reviewers and meet with Editorial Board members.

April - June 1998 Review logging requirements and capabilities at Virginia Tech. Investigate and develop the support structure for a digital library. Submit paper to IEEE Frontiers in Education introducing the project. Draft submission guidelines and reviewer instructions. Review progress with the Editorial Board. Generate test data. Decide on formatting guidelines. Start discussions on continuing support for the project.

July - September 1998 Testing and debugging. Port materials to Virginia Tech.. Attend ITiCSE ‘98 to disseminate progress, recruit international volunteers and meet with Board members. Collect feedback from international participants. Develop visitor survey. Submit a proposal to SIGCSE ‘99. Review of CSTC by Editorial Board. Identify volunteers to submit beta-test submissions and beta-test searching and retrieval.

October - December 1998 Beta-testing of the CSTC. Evaluate the support structure, the user interface, and the logging mechanisms. Issue Calls for Participation for each Center. Editorship responsibilities begin as submissions arrive. Interface with Editorial Board as needed. Submit a working group proposal to ITiCSE ‘99.

Year Two

We will continue development of the CSTC. During this time frame, the editorship responsibilities will escalate, as submissions for review arrive and ultimate publication will occur. Continued recruitment of appropriate reviewers will occur, and coordination of reviews. In addition, data will be collected and analyzed. Experiences and results will be summarized for dissemination.

January - March 1999 Manage submissions, incoming reviews, acceptances and rejections. Announce availability of published materials. Review quarterly data from visitor profiles. Prepare proposals for CSTC sponsorship. Attend SIGCSE ‘99 to disseminate results, recruit reviewers and meet with Board members. Solicit materials from conference presenters and attendees. Modify the CSTC based on visitor feedback.

April - June 1999 Initial testing of surveys. Analyze feedback. Editorship responsibilities. Review quarterly data from visitor profiles. Distribute visitor survey. Start data collection.

July - September 1999 Review quarterly data from visitor profiles. Editorship responsibilities. Modify the CSTC based on visitor feedback. Data analysis. Attend ITiCSE ‘99 to disseminate progress, meet with Editorial Board and solicit international submissions. Submit proposals to SIGCSE ‘00.

October - December 1999 Review quarterly data from visitor profiles. Editorship responsibilities. Submit proposals to ITiCSE ‘00. Prepare final project report to NSF.

3.7 Facilities Available to Support the Project

All three institutions have sufficient computing and networking infrastructure to complete this project. The University of Illinois at Springfield and The College of New Jersey have facilities to develop web content on several platforms. Software includes HTML editors, graphic design tools, CGI programming capability, and a wide variety of browsers and platforms. Virginia Tech has extensive resources for hosting the CSTC. Under the Connections '97 program VT has vBNS / Internet 2 connectivity to provide high bandwidth access to a rich multimedia collection. From their other digital library efforts they have extensive hardware and software to act as a digital library server site, for example, servers so that each digital object can have a URN (Universal Resource Name, not URL). The Department of Computer Science at VT has an Information Access Lab, Usability Methods Research Lab, and an Interaction Technology Lab. In addition, there are resources shared with the Computing Center that are fully available for this project, such as a $420K IBM SMP system with six processors, 4 Tbytes hierarchical storage, and IBM digital library software. Redundancy of the CSTC through mirrored sites is possible. The College of New Jersey has supported the SIGCSE Laboratory Repository, and would be able to serve as a backup site.

4.0 EVALUATION

This project will demonstrate a working framework for developing and distributing peer reviewed reusable teaching resources. Our evaluation will focus on the usability of the CSTC as well as the quality and diversity of resources. We will use several methods to evaluate this project.

1. The Editorial Board -- We will draw upon the expertise of our Editorial Board (Section 3.1) to provide feedback during the development of the user interface and review process. They also will review the preliminary submissions. Board members represent a variety of institutions and their input will strengthen our project. If a need arises for additional viewpoints, we will invite appropriate people. ACM members have a long standing reputation for volunteerism.

2. Visitor Feedback -- Visitors will be encouraged to leave comments in a digital *suggestion box*. Both prototype centers already support this feature. This feedback will be discussed at scheduled meetings of the PIs, and acted upon as appropriate. When deemed necessary, we will channel these comments through the Editorial Board for further action.

   We will also distribute a yearly survey to assess the needs of our audience. The electronic survey will be sent to former visitors and appropriate mailing lists such as the SIGCSE members list and the SIGGRAPH Education Committee.

3. Usability Testing -- Usability of the CSTC will be evaluated on a variety of platforms. Although Web documents are supposed to be platform independent, it is our experience that they are often not. We will design the CSTC to appear and behave the same across as many platforms as feasible. Grissom has experience with software usability evaluation [Grissom89, Grissom95c]. Virginia Tech has extensive resources to support a robust usability evaluation (Section 3.7).

4. Site Activity -- In a more formal approach to assessment, we will log site activity for each Center. Commercial software is available to analyze and summarize web server activity. In addition, Virginia Tech has developed tools for logging and log analysis [Abrams95]. This information will include which materials are being accessed, frequency of access, frequency

of submission and visitor profiles. Data will be accumulated on a rolling basis, and will allow us to modify the CSTC as necessary.

Additionally, we will classify the type of access, for example, when an abstract is viewed versus when the published material is retrieved. We will require that adopters identify themselves to analyze visitor profiles. Items of interest from followup surveys include:

- adoption of material for a course, and which course,
- materials used for self study and/or continuing education,
- extent of modification needed for adoption of materials,
- success of use,
- numbers of students using materials,
- whether the availability of materials lead to improved communication network,
- and faculty satisfaction with the material.

5.0 DISSEMINATION

We have developed a dissemination plan with a variety of targets, including:

- digital dissemination via the web,
- announcements in ACM publications,
- publication in the SIGCSE Bulletin, and
- presentation at conferences (SIGCSE, ITiCSE, SIGGRAPH, IEEE FIE).

Each of these areas is discussed in more detail below.

This project lends itself to a natural course of dissemination on the Web. Following the lead of the SIGCSE Computing Laboratory Repository, the CSTC will be accessible from the SIGCSE home page as well as the SIGGRAPH Education Committee's home page. We will register the CSTC with leading search engine sites and send announcements to appropriate electronic mailing lists.

With endorsement of the ACM Education Board, we will arrange announcements in appropriate publications, such as the ACM MemberNet supplement to the Communications of the ACM, and in the Message from the Chair in the SIGCSE Bulletin. The SIGCSE Computing Laboratory Repository has been mentioned in both of these publications within the past year [Cassel96, Benton97].

To insure widespread awareness and familiarity, we will pursue traditional venues to publicize our experiences with developing and implementing the CSTC. Papers will be prepared to inform specific groups on the submission process and use of the Resource Centers. During our development phase, we will present progress reports at the SIGCSE Technical Symposium. Other avenues for presentation are the annual SIGGRAPH conference and IEEE Frontiers in

Education, which has sponsored sessions on web based learning and other ways of integrating technology into education.

Since the CSTC will be available for use worldwide, we want to encourage participation by an international group of educators, and therefore will propose a working group or panel discussion at the annual IRiCSE conference. This conference is held in Europe each year, and provides a diverse population of educators.

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