

## NSF CISE Institutional Infrastructure (Education) Grant Overview

NSF award number, amount and period of support: CDA-9312611, \$449,088+supp'ls,  
8/15/1993 - 7/31/1998

Project title: Interactive Learning with a Digital Library in Computer Science

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**Overview of Goals and Objectives:** Key concepts of our project [89] were to improve CS education by increasing interactivity and use of a DL. The main objectives/accomplishments were to:

- expand the content and software (especially user interfaces [178, 179, 210]) initially developed with NSF support of our “Envision” DL project, “A User-Centered Database from the Computer Science Literature” [130];
- 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 [198, 199, 224];
- 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);
- significantly change courses like “Computer Professionalism,” to make use of interactivity (e.g., asynchronous on-line debates) and DL support (e.g., adding to a large History collection);
- apply the key concepts to improve other courses.

**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” [130]. In 1993, Virginia Tech expanded its work on DLs 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 our WWW server, with the number of accesses exceeding 10 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 has helped Virginia Tech coordinate development of the Networked 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. 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—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, 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 [205, 206]), and a variety of illustrations and demonstrations.

In one old and two new courses, we have adapted Keller’s Personalized System of Instruction [141] 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. 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 courses.

In June 1997, a workshop to disseminate results was conducted in Blacksburg, VA with attendees from all over the nation. 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/>, recently funded by NSF.

**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. 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), an on-line debate system for managed dialog, and QUIZIT. A fourth result is the set of pages about EI projects, at <http://ei.cs.vt.edu/~csei/>. Finally, there are well over 10,000 WWW pages of CS courseware.

### Publications Summary

<i>Areas of Accomplishment</i>	<i>References</i>
Project Overviews	82, 83, 89, 95
Digital Library - General	21, 47, 63, 70, 81, 85, 86, 88, 94, 96, 97, 101
Digital Library - Architecture	82, 89, 92, 119, 120
Digital Library - Capture, Conversion	54
Digital Library - CS Tech. Reports	87, 97, 165, 166
Digital Library - Education	80, 83, 84, 90, 151
Digital Library - User Interface	178, 179, 180, 212
Digital Library - System	74, 93, 97, 130, 205
Interactive Applications	151, 153, 211, 212
Interactive Learning	198, 199, 206, 224
Networking	2, 3, 4, 91, 217

### Presentations by Project Investigators

Many presentations have been given over the course of the project, including 9 keynote/ distinguished lecture talks: Puebla Mexico (6/10/98), 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 more than 20 other presentations also were given.

## RELATED REFERENCES

1. Abdulla, G., L., Binzhang, and E. A. Fox, "Searching the WWW: Implications from studying different user behavior." In *Proceedings of the WebNet98 Conference*, Orlando, FL, November 7-12, 1998, (<http://www.aace.org/conf/webnet>), to appear.
2. Abdulla, G., E. A. Fox, and M. Abrams (1997), "Shared User Behavior on the World Wide Web." In *Proceedings of the WebNet97 Conference*, Toronto, Canada, November, 1997.
3. Abrams, M., C. R. Standridge, G. Abdulla, S. Williams, and E. A. Fox (1995), "Caching Proxies: Limitations and Potentials." In *Proceedings of the 4th International World-Wide Web Conference*, Boston, MA, December. (<http://ei.cs.vt.edu/~succeed/WWW4/WWW4.html>)
4. Abrams, M., S. Williams, G. Abdulla, S. Patel, R. Ribler, and E. A. Fox (1995), "Multimedia Traffic Analysis Using Chitra95." In *Proceedings of the 3rd International Multimedia Conference and Exhibition, Multimedia '95*, San Francisco, CA, November 5-9, pp. 267-276.
5. Allen, B. (1998), "Information Space Representation in Interactive Systems: Relationship to Spatial Abilities." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 1-10.
6. Andre, T., B.M. Kleiner, and R.C. Williges (1998), "A model for understanding computer-augmented distributed team communication and decision making." North Atlantic Treaty Organization (NATO) Research and Technology Agency/Human Factors and Medicine Panel 1st Symposium on Collaborative Crew Performance in Complex Operational Systems. Neuilly-sur-Seine, France: NATO Research and Technology Agency, Edinburgh, UK, April.
7. Ashlund, S. and D. Hix (1992). "IDEAL: A Tool to Enable User-Centered Design," In *Proceedings of the CHI Conference on Human Factors in Computing Systems* (Posters and Short Talks Supplement to Proceedings). New York: ACM, pp. 119-120.
8. Ashlund, S. and D. Hix (1992). "IDEAL: A Software Tool to Evaluate Interface Usability," In *Proceedings of the Annual Human Factors Society Conference*. Santa Monica: Human Factors Society, pp. 414-417.
9. Association of Research Libraries, Association of American Universities, and the Pew Higher Education Roundtable, "To Publish and Perish," *Special Issue of Policy Perspectives*, March 1998, 7(4): 1-11.
10. Averboch, G. A. "A system for document analysis, translation, and automatic hypertext linking," Master's thesis, Department of Computer Science, Virginia Polytechnic Institute and State University, Blacksburg, VA, 1995.
11. Balci, O. (1998), "Verification, Validation, and Testing." In *The Handbook of Simulation*, J. Banks, Editor, John Wiley & Sons, New York, NY, to appear.
12. Balci, O., C. Ulusaraç, P. Shah, and E. A. Fox (1998), "A Library of Reusable Model Components for Visual Simulation of the NCSTRL System." In *Proceedings of the 1998 Winter Simulation Conference*, IEEE, Piscataway, NJ, to appear.

13. Balci, O. (1997), "Principles of Simulation Model Validation, Verification, and Testing," *Transactions of the Society for Computer Simulation International* 14, 1, pp. 3-12.
14. Balci, O., Guest Editor (1997), Special Issue of *ACM Transactions on Modeling and Computer Simulation* on "Simulation for Training: Foundations and Techniques," 7, 3, July.
15. Balci, O., A. I. Bertelrud, C. M. Esterbrook, and R. E. Nance (1997), "The Visual Simulation Environment." In *Proceedings of the 11th European Simulation Multiconference*, SCS, San Diego, CA, pp. 61-68.
16. Balci, O., A. I. Bertelrud, C. M. Esterbrook, and R. E. Nance (1997), "Dynamic Object Decomposition in the Visual Simulation Environment." In *Proceedings of the 11th European Simulation Multiconference*, SCS, San Diego, CA, pp. 69-73.
17. Balci, O., A. I. Bertelrud, C. M. Esterbrook, and R. E. Nance (1997), "Developing a Library of Reusable Model Components by Using the Visual Simulation Environment." In *Proceedings of the 1997 Summer Computer Simulation Conference*, SCS, San Diego, CA, pp. 253-258.
18. Balci, O., A. I. Bertelrud, C. M. Esterbrook, and R. E. Nance (1997), "Introduction to the Visual Simulation Environment." In *Proceedings of the 1997 Winter Simulation Conference*. IEEE, Piscataway, NJ, pp. 698-705.
19. Balci, O., A. I. Bertelrud, C. M. Esterbrook, and R. E. Nance (1997), "The Visual Simulation Environment Technology Transfer." In *Proceedings of the 1997 Winter Simulation Conference*, IEEE, Piscataway, NJ, pp. 1323-1329.
20. Balci, O., A. I. Bertelrud, C. M. Esterbrook, and R. E. Nance (1995), "A Picture-based Object-oriented Visual Simulation Environment." In *Proceedings of the 1995 Winter Simulation Conference*, IEEE, Piscataway, NJ, pp. 1333-1340.
21. Balci, O. and R. E. Nance (1992), "The Simulation Model Development Environment: An Overview." In *Proceedings of the 1992 Winter Simulation Conference*, IEEE, Piscataway, NJ, pp. 726-736.
22. Balci, O. and R. E. Nance (1987), "Simulation Model Development Environments: A Research Prototype," *Journal of Operational Research Society* 38, pp. 753- 763.
23. Bayraktar, M., C. Zhang, B. Vadapalli, N. Kipp, and E. A. Fox, "A Web Art Gallery." In *Proceedings of the Third ACM Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, 1998, pp. 277-278.
24. Begole, J., C. Struble, and C. A. Shaffer (1997), "Leveraging Java Applets: Toward Collaboration Transparency in Java," *IEEE Internet Computing* 1, 2, pp. 57-64.
25. Begole, J., C. Struble, C. A. Shaffer, and R. Smith (1997), "Transparent Sharing of Java Applets: A Replicated Approach." In *Proceedings of the 1997 Conference on User Interface Software and Technology (UIST'97)*. Banff, Alberta, CA, October 1997.
26. Belkin, N. J., P. Kantor, E. A. Fox and J. A. Shaw, "Combining the Evidence of Multiple Query Representations for Information Retrieval," *Information Processing & Management*, 31(3), pp. 431-448, May-June 1995.

27. Berelson, B. (1960), "Graduate education in the United States," *New York: McGraw-Hill Book Company*.
28. Betrabet, S., E. A. Fox, and Q. Chen, "A query language for information graphs," Technical Report TR 93-03, Department of Computer Science, Virginia Polytechnic Institute and State University, 1993.
29. Boehm, B. (1988), "A Spiral Model of Software Development and Enhancement," *IEEE Computer*, 21(2), pp. 61-72.
30. Borgman, C., ed. (1996), "Social Aspects of Digital Libraries." A workshop hosted by UCLA, sponsored by NSF, Feb. 16-17, 1996, UCLA, CA. (<http://www-lis.gseis.ucla.edu/DL/>)
31. Brueni, D. J., B. Cross, E. A. Fox, L. S. Heath, D. Hix, L. T. Nowell, and W. C. Wake, "What if there were desktop access to the computer science literature?" In *Proceedings of the 21st Annual ACM Computer Science Conference*, pp. 15-22, 1993. Also available as Tech. Report TR 92-42, Department of Computer Science, Virginia Polytechnic Institute and State University.
32. Buneman, P., S. Davidson, K. Hart, C. Overton, L. Wong. "A Data Transformation System for Biological Data Sources." In *Proceedings of the 21st International Conference on Very Large Data Bases*, Zurich, Switzerland, pp. 158-169, September 1995.
33. Buneman, P., L. Libkin, D. Suci, V. Tannen, L. Wong. "Comprehension Syntax." In *ACM SIGMOD Record*, 23(1), pp. 87-96, March 1994.
34. Cao, L., M. K. Leong, Y. Lu, and H. B. Low, "Searching Heterogeneous Multilingual Bibliographic Sources," In *Computer Networks and ISDN Systems*, Vol. 30 (1998), pp. 612-615.
35. Carroll, J. M., Ed., (1998), "Minimalism Beyond: The Nurnberg Funnel," *MIT Press*, Cambridge, MA.
36. Carroll, J. M., M. B. Rosson, G. Chin, and J. Koenemann (1997), "Requirements Development: Stages of Opportunity for Collaborative Needs Discovery." In *Proceedings of the DIS'97*. (August 18-20, Amsterdam). New York: ACM, pp. 55-64.
37. Carroll, J. M., S. M. Mauney, and C. F. Rencsok (1997), "Learning by Design," Paper presented at the *Design Education Workshop*, Georgia Tech, Atlanta, Georgia, September 8-9.
38. Carroll, J. M., Ed. (1995), "Scenario-Based Design: Envisioning Work and Technology in System Development," John Wiley & Sons, New York, NY.
39. Carroll, J. M. and M. B. Rosson (1992), "Getting Around the Task-Artifact Cycle: How to Make Claims and Design by Scenario," In *ACM Transactions on Information Systems* 10, 2, pp. 181-212.
40. Carroll, J. M. and M. B. Rosson (1990), "Human-Computer Interaction Scenarios as a Design Representation." In *Proceedings of the 23rd Annual Hawaii International Conference on Systems Sciences*. (Kailua-Kona, HI, January 2-5). Los Alamitos, CA, IEEE Computer society Press, pp. 555-561.

41. Carroll, J. M. and R. L. Campbell (1989), "Artifacts as Psychological Theories: The Case of Human-Computer Interaction," *Behaviour and Information Technology* 8, pp. 247-256.
42. Castillo, J. C. (1998), "The User-Reported Critical Incident Method for Remote Usability Evaluation," M.S. Thesis, Department of Computer Science, Virginia Tech, Blacksburg, VA.
43. Castillo, J. C., H. R. Hartson, and D. Hix (1998), "Remote Usability Evaluation: Can Users Report Their Own Critical Incidents?" In *Proceedings of CHI Conference on Human Factors in Computing Systems* (Conference Companion), New York: ACM, pp. 253-254.
44. Castillo, J. C. and H. R. Hartson (1998), "Remote Evaluation."  
([http://hci.ise.vt.edu/~josec/remote\\_eval/](http://hci.ise.vt.edu/~josec/remote_eval/))
45. Chabert, A., E. Grossman, L. Jackson, S. Pietrowicz, and C. Seguin, "Java Object-Sharing in Habanero." In *Communications of the ACM*, 41(6), pp. 69-76, June 1998.
46. Chen, J., L. Wong, and L. Zhang, "A Protein Patent Query System Powered by Kleisli." In *Proceedings of the ACM SIGMOD International Conference on Management of Data*, Seattle, Washington, June 1998, pp. 593-595.
47. Chen, S., and E. A. Fox (1996), "Guest Editors' Introduction to Special Issue on Digital Libraries," *Journal of Visual Communication and Image Representation*, 7(1), March.
48. Chin, G. and M. B. Rosson (1998), "Progressive Design: Staged Evolution of Scenarios in the Design of a Collaborative Science Learning Environment." In *Proceedings of Human Factors in Computing Systems, CHI'98 Conference*, Los Angeles, CA, April.
49. Chin, G., M. B. Rosson, and J. M. Carroll (1997), "Participatory Analysis: Shared Development of Requirements from Scenarios." In *Proceedings of Human Factors in Computing Systems, CHI'97 Conference*, March 22-27, Atlanta, GA, New York: ACM, pp. 162-169.
50. Chin, J. P., V. A. Diehle, and K. L. Norman (1988), "Development of an Instrument Measuring User Satisfaction of the Human-Computer Interface." In *Proceedings of Human Factors in Computing Systems, CHI'88 Conference*, New York: ACM, pp. 213-218.
51. Council of Graduate Schools, "The role and nature of the doctoral dissertation: a policy statement," Washington, D.C.: Council of Graduate Schools, 1991.
52. Cousins, S., A. Paepcke, T. Winograd, E. Bier, and K. Pier (1997), "The Digital Library Integrated Task Environment (DLITE)." In *Proceedings of the 2<sup>nd</sup> ACM International Conference on Digital Libraries, DL'97*, Philadelphia, PA, July 23-26, ACM, New York, pp. 142-151.
53. Crowder, R. S. and N. E. Miller (1990), "The Quality of the ELCAP Engineering Data Set - Background Issues." Technical Report PNL-6203, Pacific Northwest Laboratory, Richland, WA.
54. Dalal, K., and E. A. Fox (1993). "Document Translation: Dissertations and Technical Reports," Technical Report TR-93-31, Department of Computer Science, Virginia Tech, Blacksburg, VA.
55. Darken, R. and D. Hix (1998), "Usability Evaluation Methods in a New Medium," In *Proceedings of Virtual Reality Annual International Symposium (VRAIS'98)*. Atlanta, GA.

56. Davidson, S., C. Overton, V. Tannen, L. Wong. "BioKleisli: A Digital Library for Biomedical Researchers." In *International Journal of Digital Libraries*, 1(1), pp. 35-53, April 1997.
57. del Galdo, E. M., R. C. Williges, B. H. Williges, and D. R. Wixon (1987), "A Critical Incident Evaluation Tool for Software Documentation." In L. S. Mark, J. S. Warm, and R. L. Huston (Eds.) *Ergonomics and Human Factors*, New York: Springer-Verlag, pp. 253-258.
58. Dessy, R.S. (1998a), "Centigrade 232," *Analytical Chemistry*, 70, pp. 209-210, 1998.
59. Dessy, R.S. (1998b), "Electronic Laboratory Notebooks." In *Encyclopedia of Computational Chemistry*, Paul von Schleyer, ed., John Wiley, New York, 1998.
60. Dessy, R.S. (1997), "The Code Makers," *Trends in Analytical Chemistry*, 16, pp. 1-9, 1997.
61. Dessy, R.S. (1996), "Computer Connections," *Laboratory Automation and Information Management*, 32, pp. 53-62, 1996.
62. Dessy, R.S. (1995), "Electronic Laboratory Notebooks," *Analytical Chemistry*, 67, pp. 428A-433A, 1995.
63. Dougherty, W. C., and E. A. Fox (1995), "TULIP at Virginia Tech," *Library Hi Tech* 13, 4, pp. 54-60.
64. Downey, G. L. (1998), "The Machine in Me: An Anthropologist Sits Among Computer Engineers," New York: Routledge.
65. Downey, G. L. and J. Dumit, Eds. (1998), "Cyborgs and Citadels: Anthropological Interventions in Emerging Sciences and Technologies," Santa Fe, NM, SAR Press.
66. Eaton, J., E. A. Fox, and G. McMillan, "Electronic Theses and Dissertations (ETDs) and Their Contribution to Graduate Education." In *Proceedings of the 53rd Annual Meeting Midwestern Association of Graduate Schools*, MAGS, 1997, pp. 73-78.
67. Ehrmann, S.C. and R.E. Zúñiga, "The Flashlight™ Evaluation Handbook: Including the Flashlight™ Current Student Inventory Version 1.0," The Flashlight Project, *Corporation for Public Broadcasting and AAHE*, Washington, D.C., November 1997
68. Fetterman, D. (1989), "Ethnography: Step by step," Newbury Park: Sage.
69. Fox, E. A. and O. Sornil (1999), "Digital Libraries," Chapter 11 in *Modern Information Retrieval*, AWL England, 1999: Ricardo Baeza-Yates and Berthier Ribeiro-Neto, eds., to appear.
70. Fox, E. A. and G. Marchionini, Eds. (1998), "Worldwide Digital Libraries," Guest Editors' Introduction to Special Section on Digital Libraries. *Communications of the ACM* 41, 4.
71. Fox, E. A., N. Kipp, and P. Mather, "How Digital Libraries Will Save Civilization," *Database Programming & Design*, 12(8), August 1998, to appear.
72. Fox, E. A., "Digital Libraries: The Networked Digital Library of Theses and Dissertations (NDLTD) and the Computer Science Teaching Center (CSTC)," Keynote for *Computer Science Workshop*,

sponsored by CONACyT and NSF, Puebla, Mexico, June 10-12, 1998.  
(<http://www.ndltd.org/talks/CONACyTNSF.pdf>)

73. Fox, E. A., "Networked Digital Library of Theses and Dissertations: A Framework for East-West Collaboration," In *Proceedings of An Asian Digital Library Workshop*, "East meets West," August 5-7, 1998, Hong Kong, hosted by University of Hong Kong, (<http://www.ndltd.org/pubs/Asia98.htm>), to appear.
74. Fox, E. A., J. Eaton, G. McMillan, N. Kipp, P. Mather, T. McGonigle, W. Schweiker, and B. DeVane (1997), "Networked Digital Library of Theses and Dissertations: An International Effort Unlocking University Resources," *D-Lib Magazine*, The Magazine of Digital Library Research, September 1997. (<http://www.dlib.org/september97/theses/09fox.html>)
75. Fox, E. A., "Digital Libraries and Virtual Universities," Invited presentation for *Information research for designing and planning virtual universities Seminar* at Centro Universitario de Investigaciones Bibliotecolgicas Universidad Nacional Autnoma de Mexico Cd. Universitaria, Mexico, D.F., Library and Information Research Center, National University of Mexico, August 11-15, 1997. (<http://fox.cs.vt.edu/talks/Mexico97.html>)
76. Fox, E. A., "Networked Digital Library of Theses and Dissertations: An International Collaboration Promoting Scholarship," *ICSTI Forum*, Quarterly Newsletter of the International Council for Scientific and Technical Information, No. 26, pp. 8-9, November 1997. (<http://www.icsti.nrc.ca/icsti/>)
77. Fox, E. A., R. Hall, and N. Kipp, "NDLTD: Preparing the Next Generation of Scholars for the Information Age," *The New Review of Information Networking* (NRIN), 3, pp. 59-76, 1997.
78. Fox, E. A., R. Hall, N. Kipp, J. L. Eaton, G. McMillan, and P. Mather, "NDLTD: Encouraging International Collaboration in the Academy." In *Special Issue on Digital Libraries*, DESIDOC Bulletin of Information Technology, 17(6), pp. 45-56, November 1997.
79. Fox, E. A., G. Abdulla, and W. Heagy, "Quantitative Analysis and Visualization Regarding Interactive Learning with a Digital Library in Computer Science," *ACM Digital Libraries'97* poster, Philadelphia, PA, July 23-26, 1997, pp. 256.
80. Fox, E. A. (1996), "Digital Library Support for Education – A Case Study of Advanced Networked Information Systems," Invited presentation for *Dagstuhl Workshop on Networked Information Systems - Discovery, Retrieval, Dissemination*, Feb. 26 - Mar. 1, Dagstuhl, Germany.
81. Fox, E. A. (1996), "Virginia Tech Department of Computer Science Information Access Laboratory," *ACM SIGIR Forum* 30, 1, Laboratory Report Special Section, Spring.
82. Fox, E. A. (1996), "Digital Libraries, WWW, and Educational Technology: Lessons Learned," Invited paper for *Proceedings of the ED-MEDIA 96, World Conference on Educational Multimedia and Hypermedia*, Boston, MA, June 17-22, pp. 246-251. (See also <http://ei.cs.vt.edu/~fox/EDMEDIA96>)
83. Fox, E. A. (1996), "Interactive Learning with a Digital Library in Computer Science," Invited paper for *Proceedings of the Frontiers in Education - FIE'96*, Salt Lake City, Utah, November 6-9.
84. Fox, E. A., J. Eaton, G. McMillan, N. Kipp, L. Weiss, E. Arce, and S. Guyer (1996), "National Digital Library of Theses and Dissertations: A Scalable and Sustainable Approach to Unlock University

Resources,” *D-Lib Magazine*, ISSN 1082-9873, September 1996,  
(<http://www.dlib.org/september96/theses/09fox.html>)

85. Fox, E. A. and G. Marchionini, Eds. (1996), *Proceedings of the First ACM International Conference on Digital Libraries, DL'96*, Bethesda, MD, March 20-23.
86. Fox, E. A. (1995), “World-Wide Web and Computer Science Reports.” In *Communications of the ACM* 38, 4, pp. 43-44.
87. Fox, E. A. (1995), “Hypermedia Support for a Digital Library in CS,” *SIGLINK Newsletter* 4, 2, Special Issue on Digital Libraries.
88. Fox, E. A., R. Akscyn, R. Furuta, and J. Leggett (1995), “Guest Editors' Introduction to Digital Libraries,” *Communications of the ACM* 38, 4, pp. 22-28, April 1995.
89. Fox, E. A., N. Barnette, C. Shaffer, L. Heath, W. Wake, L. Nowell, J. Lee, D. Hix, and H. Hartson (1995), “Progress in Interactive Learning with a Digital Library in Computer Science,” Invited paper for *Proceedings of the ED-MEDIA 95, World Conference on Educational Multimedia and Hypermedia*, Graz, Austria, June 17-21, pp. 7-12.
90. Fox, E. A. and L. Kieffer (1995), “Multimedia Curricula, Courses and Knowledge Modules,” *ACM Computing Surveys* 27, 4, pp. 549-551.
91. Fox, E. A. (1994), “Seamless Multimedia Integration for Digital Libraries,” Invited position paper for *Dagstuhl Seminar on Fundamentals and Perspectives of Multimedia Systems, International Conference and Research Center for Computer Science*, Dagstuhl Castle, Germany, July 4-8, pp. 118-123.
92. Fox, E. A. (1994), “A Digital Library Connecting Envision, KMS, and Mosaic with Interfaces, Communications, and Data Interchange,” Invited presentation for *1994 Workshop on Digital Libraries: Current Issues*, sponsored by: Rutgers and Purdue Universities, AT&T and Bellcore, at Rutgers Univ., Newark, NJ, May 19-20. Abstract in *SIGOIS Bulletin* 15, 1, 6.
93. Fox, E. A. (1994), “How to Make Intelligent Digital Libraries.” In *Methodologies for Intelligent Systems*, In *Proceedings of the 8th International Symposium, ISMIS'94*, Charlotte, NC, October. In *Lecture Notes in Artificial Intelligence* 869, Springer-Verlag, Berlin, pp. 27-38.
94. Fox, E. A. and G. Abdulla (1994), “Digital Video Delivery for a Digital Library in Computer Science.” In *High-Speed Networking and Multimedia Computing Workshop, IS&T/SPIE Symposium on Electronic Imaging Science and Technology*, February 6-10, San Jose, CA, 7 pages.
95. Fox, E. A. and D. Barnette (1994), “Improving Education through a Computer Science Digital Library with Three Types of WWW Servers.” In *Proceedings of the Second International WWW '94: Mosaic and the Web, WWW'94*, Chicago, IL, October 17-20.
96. Fox, E. A. (1993), “Digital Libraries (“hot topics”),” *IEEE Computer* 26, 11, pp. 79-81.
97. Fox, E. A., Ed. (1993), “Sourcebook on Digital Libraries: Report for the National Science Foundation,” Technical Report TR-93-35, Dept. of Computer Science, Virginia Tech, Blacksburg, VA., December. (Available by FTP from directory pub/DigitalLibrary on fox.cs.vt.edu)

98. Fox, E. A., D. Hix, L. Nowell, D. Brueni, W. Wake, L. Heath, and D. Rao (1993), "Users, User Interfaces, and Objects: Envision, a Digital Library," *J. American Society Information Science* 44, 8, pp. 480-491.
99. Fox, E. A. and L. Lunin (1993), "Introduction and Overview to Perspectives on Digital Libraries," *Journal of the American Society for Information Science (JASIS)* 44, 8, pp. 441-443.
100. Fox, E. A., R. France, E. Sahle, A. Daoud, and B. Cline (1993), "Development of a Modern OPAC: From REVTOLC to MARIAN." In *Proceedings of the 16th Annual International ACM SIGIR Conference on R&D in Information Retrieval, SIGIR'93*, Pittsburgh, PA, pp. 248-259. Also available as Tech. Report TR 93-06, Department of Computer Science, Virginia Polytechnic Institute and State University.
101. Fox, E. A., "From information retrieval to networked multimedia information access." In G. Knorz, J. Krause, and C. Womser-Hacker, editors, *Information Retrieval '93, Proceedings of the der 1. Tagung Information Retrieval '93*, pp. 116-124. Univ. of Konstanz Press, 1993. Keynote address, 13-15 September, 1993, University of Regensburg, Germany.
102. Fox, E. A., "A user-centered hypermedia database from the computer science literature." In *Proceedings of the 159th National Meeting of the AAAS, AAAS'93: Science and Engineering for the Future*, pp. 145, 1993. Invited presentation.
103. Fox, E. A., L. S. Heath, and D. Hix, "A user-centered database from the computer science literature." In W. W. Chu, A. F. Cardenas, and R. K. Taira, editors, *Proceedings of the NSF Scientific Database Projects 1991-1993*, pp. 70-75, February 1993. AAAS Workshop on Advances in Data Management for the Scientist and Engineer, Boston, Massachusetts.
104. Fox, E. A., Q. F. Chen, and L. S. Heath, "A faster algorithm for constructing minimal perfect hash functions." In *Proceedings of the 15th Annual International Conference on Research and Development in Information Retrieval*, pp. 266-273, 1992.
105. Fox, E. A., Q. F. Chen, and L. S. Heath, "LEND and faster algorithms for constructing minimal perfect hash functions," Technical Report TR 92-02, Department of Computer Science, Virginia Polytechnic Institute and State University, 1992.
106. Fox, E. A., L. S. Heath, Q. F. Chen, and A. M. Daoud, "Practical minimal perfect hash functions for large databases." In *Communications of the ACM*, 35(1), pp. 105-121, January 1992.
107. Fox, E. A., "Advances in Interactive Digital Multimedia Systems," *IEEE Computer*, Oct. 1991, 24(10): 9-21. Reprinted in *Readings in Groupware and Computer Supported Cooperative Work*, ed. Ron Baecker, Morgan Kaufmann, San Mateo, CA, 1993, 342-354 and as Chapter 1 of *Multimedia Computing: Preparing for the 21st Century*, ed. Sorel Reisman, Idea Group Publishing, Harrisburg, PA, 1994, pp. 3-33.
108. Fox, E. A., Q. F. Chen, A. M. Daoud, and L. S. Heath, "Order-preserving minimal perfect hash functions and information retrieval." In *ACM Transactions on Information Systems*, 9(3):281-308, 1991.
109. Fox, E. A., "How to Proceed Toward Electronic Archives and Publishing," *Psychological Science*, November 1990, 1(6): 355-8.

110. Fox, E. A., "ACM Press Database and Electronic Products – New Services for the Information Age." In *Communications of the ACM*, August 1988, 31(8): 948-951.
111. Fox, E. A. and R. France, "Architecture of an Expert System for Composite Document Analysis, Representation and Retrieval." In *International Journal of Approximate Reasoning*, 1987, 1(2):151-175.
112. French, J., E. A. Fox, K. Maly, and A. Selman, "Wide Area Technical Report Service – technical reports online." In *Communications of the ACM*, April, 1995, 38(4):45.
113. Furnas, G., and S. Rauch. (1998), "Considerations for Information Environments and the NaviQue Workspace." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 79-88.
114. Furuta, R., "Defining and using structures in digital libraries." In J. L. Schnase, J. J. Leggett, R. K., Futura, and T. Metcalfe, Eds., *Proceedings of the Digital Libraries '94: The First Annual Conference on the Theory and Practice of Digital Libraries* (Texas A&M, College Station, TX), June, 1994, pp. 139-145.
115. Ganley, J. L. and L. S. Heath, "Local search for the retrieval layout problem." Submitted to *OR Spektrum*. Also available as Tech. Report TR 93-28, Department of Computer Science, Virginia Polytechnic Institute and State University, 1993.
116. Ganley, J. L. and L. S. Heath, "Heuristics for laying out information graphs," *Computing*, 52:389-405, 1994. Also available as Tech. Report TR 93-27, Department of Computer Science, Virginia Polytechnic Institute and State University.
117. Ganley, J. L. and L. S. Heath, "Optimal and random partitions of random graphs," *The Computer Journal*, 37:641-643, 1994. Also available as Tech. Report TR 93-24, Department of Computer Science, Virginia Polytechnic Institute and State University.
118. Giles, C., K. Bollacker, and S. Lawrence (1998), "CiteSeer: An Automatic Citation Indexing System." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 89-98.
119. Gladney, H., Z. Ahmed, R. Ashany, N. Belkin, E. A. Fox, and M. Zemankova (1994), "Digital Library: Gross Structure and Requirements (Report from a Workshop)," IBM Research Report RJ9840, IBM Almaden Research Center, May. Virginia Tech Dept. of Computer Science Technical Report 94-25, June.
120. Gladney, H., E. A. Fox, Z. Ahmed, R. Ashany, N. Belkin, and M. Zemankova (1994), "Digital Library: Gross Structure and Requirements: Report from a March 1994 Workshop," *Digital Libraries '94*, June 19-21, College Station, TX, Ed. J. Schnase, J. Leggett, R. Furuta, T. Metcalfe, pp. 101-107.
121. Grudin, J. (1994), "Groupware and Social Dynamics: Eight Challenges for Developers," *Communications of the ACM* 37, 1, pp. 92-105.
122. Guglielmo, E. J. and N. C. Rowe, "Natural language retrieval of images based on descriptive captions." In *ACM Transactions on Information Systems*, 14, 3, May 1996, pp. 237-267.

123. Hacker, M. E. and B. M. Kleiner (1996), "Identifying critical factors impacting virtual work group performance." In *Proceedings of the International Engineering Management Conference*, Institute of Electric and Electronics Engineers (IEEE), pp. 196-200, Piscataway, New Jersey, IEEE.
124. Halverson. 1993. "ELCAP Operational Experience." *Energy in Buildings 19*, pp. 167-178.
125. Hammontree, M., P. Weiler, and N. Nayak (1994), "Remote Usability Testing," *Interactions*, pp. 21-25.
126. Han, S. H., B. H. Williges, and R. C. Williges (1997), "A Paradigm for Sequential Experimentation," *Ergonomics 40*, 7, pp. 737-760.
127. Hartson, H. R. and J. C. Castillo (1998), "Remote Evaluation for Post-Deployment Usability Improvement." In *Proceedings of AVI '98 (Advanced Visual Interfaces)*. L'Aquila, Italy, pp. 22-29.
128. Hartson, H. R., J. C. Castillo, J. Kelso, J. Kamler, and W. C. Neale (1996), "Remote Evaluation: The Network as an Extension of the Usability Laboratory." In *Proceedings of CHI Conference on Human Factors in Computing Systems*. New York: ACM, pp. 228-235.
129. Heagy, W., "WWW Server Log Data Visualization and Evaluation for the Improvement of Educational Web Sites," Masters thesis, Virginia Tech, Dept. of Computer Science, 1998, in review.
130. Heath, L., D. Hix, L. Nowell, W. Wake, G. Averboch, and E. A. Fox (1995), "Envision: A User-Centered Database from the Computer Science Literature," *Communications of the ACM 38*, 4, pp. 52-53.
131. Hetzler, B., P. Whitney, L. Martucci, and J. Thomas, "Multi-faceted Insight Through Interoperable Visual Information Analysis Paradigms." In *Proceedings of the IEEE '98 Information Visualization*, Research Triangle Park NC, October 1998. To appear.
132. Hetzler, B., W. M. Harris, S. Havre, and P. Whitney, "Visualizing the Full Spectrum of Document Relationships." In *Structures and Relations in the Full Spectrum of Document Relationships*. In: Structures and Relations in Knowledge Organization, *Proceedings of the 5th Int. ISKO Conference*, Lille, August 1998, to appear.
133. Hitchcock, A., L. Carr, S. Harris, J. Hey, and W. Hall (1997), "Citation Linking: Improving Access to Online Journals." In *Proceedings of the 2<sup>nd</sup> ACM International Conference on Digital Libraries, DL'97*, Philadelphia, PA, July 23-26, ACM, New York, pp. 115-122.
134. Hix, D., J. N. Templeman, and R. J. K. Jacob (1995), "Pre-Screen Projection: From Concept to Testing of a New Interaction Technique." In *Proceedings of CHI Conference on Human Factors in Computing Systems*. New York: ACM, pp. 226-233.
135. Hix, D. and H. R. Hartson (1994), "IDEAL: An Environment for User-Centered Development of User Interfaces." In *Proceedings of EWHCI'94: Fourth East-West International Conference on Human-Computer Interaction*, pp. 195-211.
136. Hix, D. and H. R. Hartson (1993), "Developing User Interfaces: Ensuring Usability Through Product and Process," New York: John Wiley & Sons, Inc.

137. Isenhour, P., J. Begole, W. S. Heagy, and C. A. Shaffer (1997), "Sieve: A Java-Based Collaborative Visualization Environment." In *IEEE Visualization '97 Late Breaking Hot Topics Proceedings*, October 22-24, pp. 13-16.
138. Isenhour, P. (1997), "Sieve: A Java-Based Framework for Collaborative Component Composition," M.S. Thesis, Department of Computer Science, Virginia Tech, Blacksburg, VA. (see <http://scholar.lib.vt.edu/theses/>)
139. Jones, S., S. Cunningham, and R. McNab (1998), "Usage Analysis of a Digital Library." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 293-294.
140. Keenan, S. L. (1996), "Product Usability and Process Improvement Based on Usability Problem Classification," Ph.D. Dissertation, Dept. of Computer Science, Virginia Tech, Blacksburg, VA.
141. Keller, F. (1968), "Good-bye, Teacher ...," *J. of Applied Behavioral Analysis* 1, 1, pp. 79-89.
142. Kies, J. K., R. C. Williges, and M. B. Rosson (1998), "Coordinating Computer-Supported Cooperative Work: A Review of Research Issues And Strategies," *Journal of the American Society for Information Science* 49, 9, pp. 776-791.
143. Kies, J. K., R. C. Williges, M. B. Rosson (1997), "Evaluating Desktop Video Conferencing for Distance Learning," *Computers and Education* 28, 2, pp. 79-91.
144. Kirschenbaum, M. and E. A. Fox (1997), "Electronic Theses and Dissertations in the Humanities." In *Proceedings of the Joint Annual Conference of the Association for Computers and the Humanities and the Association for Literary and Linguistic Computing, ACH-ALLC'97*, June 3-7, 1997, Queen's Univ., Kingston, Ontario.
145. Kleiner, B. M. (1998), "Macroergonomic Analysis of Formalization in a Dynamic Work System," *Applied Ergonomics*.
146. Kleiner, B. M. (1997), "An Integrative Framework for Measuring and Evaluating Information Management Performance," *International Journal of Computers and Industrial Engineering* 32, 3, pp. 545-555.
147. Koenemann, J., J. M. Carroll, C. A. Shaffer, M. B. Rosson, and M. Abrams (1998), "Designing Collaborative Applications for Classroom Use: The LiNC Project." In A. Druin, Ed., *The Design of Children's Technology*. Morgan-Kaufmann, San Francisco, CA, to appear.
148. Korfhage, R. R., "Information Storage and Retrieval," New York: Wiley, 1997. Chapter 11, *Output Presentation*.
149. Kumar, V., R. Furuta, and R. Allen (1998), "Metadata Visualization for Digital Libraries: Interactive Timeline Editing and Review." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 126-133.
150. Lagoze, C., D. Fielding, and S. Payette (1998), "Making Global Digital Libraries Work: Collection Services, Connectivity Regions, and Collection Views." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 134-143.

151. Laughton, S (1996), "An Ethnographic Study of Internet-Based Applications in Education," PhD Dissertation, Dept. of Computer Science, Virginia Tech, Blacksburg, VA, May.
152. Lavinus, J. W., "Heuristics for laying out information graphs," Master's thesis, Department of Computer Science, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, August 1992.
153. Lee, J. A. N. (1997), "Professionalism in Computing: A Web-based Learning System," Selected papers from the Eighth National Conference on College Teaching and Learning, Florida Community College, Jacksonville, FL.
154. Leggett, J., J. Schnase, J. Smith, and E. A. Fox, "Final report of the NSF workshop on hyperbase systems," Department of Computer Science, Texas A& University, Hypermedia Research Lab Report TAMU-HRL 93-002, July 1993. For workshop on October 15-16, 1992, in Washington, D.C., 1993.
155. Leong, M. K., L.Cao, Y.Lu, "Distributed Chinese Bibliographic Searching." In *Communications of the ACM*, 41(4), April 1998.
156. Leong, M. K., "Concrete Queries in Specialized Domains: Known item as feedback for query formulation." In *Proceedings of the TREC-6*, 1997.
157. Leong, M. K., H. Zhou, "Preliminary Qualitative Analysis of Segmented vs. Bigram Indexing in Chinese." In *Proceedings of the TREC-6*, 1997.
158. Lesk, M., "Practical Digital Libraries: Books, Bytes & Bucks," San Francisco: Morgan Kaufmann, 1997.
159. Levy, D. M. and C. C. Marshall, "Going digital, a look at assumptions underlying digital libraries." In *Communications of the ACM*, 38 (4), 1995, pp. 77-84.
160. Liu, B., G. Abdulla, T. Johnson, and E. A. Fox, "Web Response Time and Proxy Caching." In *Proceedings of the WebNet98 Conference*, Orlando, FL, November 7-12, 1998, (<http://www.acee.org/conf/webnet>), to appear.
161. Lynch, C. and H. Garcia-Molina, Ed. (1995), "Interoperability, Scaling, and the Digital Libraries Research Agenda: A Report on the 1995 IITA Digital Libraries Workshop," (Palo Alto, CA, August 22, 1995), Stanford University, 1995. (<http://www.diglib.stanford.edu/diglib/pub/reports/iita-dlw/main.html>)
162. MacLeod, M. and N. Bevan (1993), "MUSIC Video Analysis and Context Tools for Usability Measurement." In *Proceedings of INTERCHI Conference on Human Factors in Computing Systems*. New York: ACM, 55.
163. Machine-Readable Bibliographic Information Committee (1996), "The USMARC Formats: Background and Principles." In conjunction with Network Development and MARC Standards Office. November 1996. (<http://lcweb.loc.gov/marc/96principl.html>)
164. Maes, P. (1994), "Agents That Reduce Work and Information Overload," *Communications of the ACM* 37, 7, pp. 31-41.

165. Maly, K., J. French, A. Selman, and E. A. Fox (1994), "The Wide Area Technical Report Service." In *Proceedings of the Second International WWW '94: Mosaic and the Web, WWW'94*, Chicago, IL, October 17-20, pp. 523-533. Also available as Tech. Report TR 94-13, Department of Computer Science, Old Dominion University
166. Maly, K., E. A. Fox, J. J. French, and A. L. Selman, "Wide area technical report service," Technical Report TR 92-44, Department of Computer Science, Old Dominion University, 1992.
167. Marchionini, G., V. Nolet, H. Williams, W. Ding, J. Beale Jr., A. Rose, A. Gordon, E. Enomoto, and L. Harbinson (1997), "Content + Connectivity => Community: Digital Resources for a Learning Community." In *Proceedings of the 2<sup>nd</sup> ACM International Conference on Digital Libraries, DL'97*, Philadelphia, PA, July 23-26, ACM, New York, pp. 212-220.
168. McCreary, F., R. Reaux, R. Ehrich, K. Rowland, and S. Hood (1998), "PCs for Families: A Case Study in the Participatory Design of a Technology-Rich Elementary School Classroom." In *Proceedings of 42nd Annual Human Factors and Ergonomics Society Meeting*.
169. McMillan, G., "Electronic Theses and Dissertations: Merging Perspectives," *Cataloging and Classification Quarterly*, New York: Haworth, 1996: 22(3/4). Also as "Electronic Theses and Dissertations: Merging Perspectives," invited chapter in *Electronic Resources: Selection and Bibliographic Control*, Pattie, Ling-yuh W. (Miko), and Bonnie Jean Cox, eds. New York: Haworth, 1997, pp. 105-125.
170. Miller, N., B. Hetzler, G. Nakamura, and P. Whitney, "The need for metrics in visual information analysis." In *Workshop on New Paradigms in Information Visualization and Manipulation*, November 1997, Las Vegas, NV, to appear.
171. Miller, N. E, J. Liljegren, T. Shippert, S. Clough, and P. Brown (1994), "Quality Measurement Experiments Within the Atmospheric Radiation Measurement Program." In *Proceedings of the 74th Annual Meeting American Meteorological Society*, January 23-28.
172. Neale, D. C. and J. M. Carroll (1997), "The Role of Metaphors in User Interface Design," In M. Helander, T.K. Landauer, and P. Prabhu (Eds.) *Human-computer interaction (2nd Edition)*, pp. 441-462, Amsterdam: Elsevier Science.
173. Neuwirth, C. M., D.S. Kaufer, R. Chandhok, & J.H. Morris (1990), "Issues in the design of computer support for co-authoring and commenting." In *Proceedings of CSCW'90*, ACM, New York, pp. 183-195.
174. Nielsen, J. (1993), "Usability Engineering," San Diego, CA: Academic Press, Inc.
175. Norman, D. A. (1994), "How Might People Interact With Agents," *Communications of the ACM*, pp. 68-71.
176. Norman, D. A. (1986), "Cognitive Engineering." In D. A. Norman & S. W. Draper (Ed.), *User Centered System Design*, Hillsdale, NJ: Erlbaum, pp. 31-61.
177. Nowell, L. (1997), "Graphical Encoding for Information Visualization: Using Icon Color, Shape and Size to Convey Nominal and Quantitative Data," Ph.D. Dissertation, Dept. of Computer Science, Virginia Tech, Blacksburg, VA.

178. Nowell, L., D. Hix, R. France, L. Heath, and E. A. Fox (1996), "Visualizing Search Results: Some Alternatives to Query-Document Similarity." In *Proceedings of the SIGIR'96*, Zurich, Switzerland, Aug. 18-22.
179. Nowell, L., E. A. Fox, L. Heath, D. Hix, W. Wake, and E. Labow (1994), "Seeing Things Your Way: Information Visualization for a User-Centered Database of Computer Science Literature," Technical Report TR-94-06, Dept. of Computer Science, Virginia Tech, Blacksburg, VA, January.
180. Nowell, L. and D. Hix, "Visualizing search results: User interface development for the project Envision database of computer science literature." In *Human-Computer Interaction: Software and Hardware Interfaces*, volume 19B of *Advances in Human Factors/Ergonomics, Proceedings of HCI International '93, 5th International Conference on Human Computer Interaction*, pp. 56-61. Elsevier, 1993.
181. Nowell, L. and D. Hix, "Query composition: Why does it have to be so hard?" In *Proceedings of the East-West International Conference on Human-Computer Interaction*, volume I, pp. 226-241, 1993. Moscow, Russia, August, 1993. Also available as Tech. Report TR 93-19, Department of Computer Science, Virginia Polytechnic Institute and State University.
182. Nowell, L. and D. Hix, "User interface design for the project Envision database of computer science literature." In *Proceedings of the Twenty-second Annual Virginia Computer Users Conference*, pp. 29-33, 1992.
183. Olson, J. S., G. M. Olson, M. Storrosten, & M. Carter (1993), "Groupwork up close: A comparison of the group design process with and without a simple group editor," *ACM Transactions on Information Systems*, 11(4), 321-348.
184. Powell, J. (1998a), "Virginia Tech Federated Searcher," (<http://jin.dis.vt.edu/fedsearch/>).
185. Powell, J. (1998b), "Networked Digital Library of Theses and Dissertations: Federated Search," accessible from <http://www.theses.org>
186. Redman, T. C., "Data Quality: Management and Technology," New York: Bantam and AT&T Bell Labs, 1992.
187. Robertson, G. G., S. K. Card, and J. D. MacKinley (1993), "Information Visualization Using 3D Interactive Animation." In *Communications of the ACM* 36, 4, pp. 57-71.
188. Robertson, S., S. Jitan, and K. Reese (1997), "Web-Based Collaborative Library Research." In *Proceedings of the 2<sup>nd</sup> ACM International Conference on Digital Libraries, DL'97*, Philadelphia, PA, July 23-26, ACM, New York, pp. 152-160.
189. Rogers, B., S. Cunningham, and G. Holmes (1994), "Navigating the Virtual Library: A 3D Browsing Interface for Information Retrieval." In *Proceedings of the 1994 Second Australian and New Zealand Conference on Intelligent Information Systems*, pp. 467-471, Piscataway, NJ: IEEE.
190. Rowe, N. C. and T. Galvin, "An authoring system for intelligent tutors for procedural skills," *IEEE Intelligent Systems*, 13, 3, May/June 1998, pp. 61-69.

191. Rowe, N. C. and B. Frew, "Automatic classification of objects in captioned descriptive photographs for retrieval," Chapter 4 in *Intelligent Multimedia Information Retrieval*, ed. M. Maybury, pp. 65-79, Cambridge, MA: AAAI Press, 1997.
192. Rowe, N. C., "Using local optimality criteria for efficient information retrieval with redundant information filters." In *ACM Transactions on Information Systems*, 14, 2, April 1996, pp. 138-174.
193. Sánchez, J., J. Leggett, and J. Schnase (1997), "AGS: Introducing Agents as Services Provided by Digital Libraries." In *Proceedings of the 2<sup>nd</sup> ACM International Conference on Digital Libraries, DL'97*, Philadelphia, PA, July 23-26, ACM, New York, pp. 75-82.
194. Sandusky, W. F., E. W. Pearson, N. E. Miller, R. S. Crowder, G. B. Parker, R. P. Mazzucchi, G. M. Stokes, J. J. Thomas, R. G. Pratt, G. J. Schuster, and M. A. Halverson (1993), "ELCAP Operational Experience," *Energy in Buildings 19*, pp. 167-178.
195. Satanek, B. L. (1998) "The Effects of Multidimensional Navigational Aids and Individual Differences on WWW Hypertext Navigation," M.S. Thesis, May.  
(<http://scholar.lib.vt.edu/theses/public/etd-42098-213026/etd-title.html>)
196. Schilit, B., M. Price, and G. Golovchinsky (1998), "Digital Library Information Appliances." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 217-226.
197. Shafer, K. (1998), "The Scorpion Project," *OCLC Office of Research*,  
(<http://orc.rsch.oclc.org:6109/>)
198. Shaffer, C. A., L. S. Heath, and J. Yang (1996), "Using the Swan Data Structure Visualization System for Computer Science Education." In *Proceedings of the SIGSCE '96*, Philadelphia PA, February.
199. Shaffer, C. A., L. S. Heath, J. Nielsen, and J. Yang (1996), "SWAN: A Student-Controllable Data Structure Visualization System." In *Proceedings of the ED-MEDIA 96, World Conference on Educational Multimedia and Hypermedia*, Boston, June 17-22, pp. 632-637.
200. Shah, A. "Symphony: A Java-based composition and manipulation framework for distributed legacy resources," MS thesis, Virginia Tech, March 1998.
- 200a. Shattuk, L. W. and D. D. Woods (1994), "The Critical Incident Technique: 40 Years Later," In *Proceedings of 38<sup>th</sup> Annual Meeting of the Human Factors Society*, pp. 1080-1084.
201. Snow, M. P. and R. C. Williges (1998), "Empirical Models of Perceived Presence in Virtual Environments Based on Free-Modulus Magnitude Estimation," *Human Factors* (in press).
202. Snow, M. P., J. K. Kies, D. C. Neale, and R. C. Williges (1996), "A Case Study in Participatory Design," *Ergonomics in Design 4*, 2, pp. 18-24.
203. Taylor, C.D., Moore, J.F., Roy, L. "ACCESS: Asynchronous Communication Courses to Enable Student Success," Report for Sloan Foundation, July 1997, Virginia Tech.  
(<http://www.edtech.vt.edu/access>)

204. Thompson, R., K. Shafer, D. Vizine-Goetz (1997), "Evaluating Dewey Concepts as a Knowledge Base for Automatic Subject Assignment." In *Proceedings of the 2<sup>nd</sup> ACM International Conference on Digital Libraries, DL'97*, Philadelphia, PA, July 23-26, ACM, New York, pp. 37-46.
205. Tinoco, L. C., E. A. Fox, and N. D. Barnette (1997), "Online Evaluation in WWW-based Courseware." In *SIGCSE '97, Proceedings of the 28th SIGCSE Technical Symposium on Computer Science Education*, San Jose, pp. 194-198. (<http://ei.cs.vt.edu/papers/sigcse97.pdf>)
206. Tinoco, L. C., E. A. Fox, R. Ehrich, and H. Fuks (1996), "QUIZIT: An Interactive Quiz System for WWW-based Instruction," (<http://pixel.cs.vt.edu/~ltinoco/quizit/quizit.pdf>)
207. van Aken, E.M. and B. M. Kleiner (1997). "Determinants of effectiveness for cross functional design teams," *Quality Management Journal*, 4(2), pp. 51-79.
208. van Rens, L. S. (1997), "Usability Problem Classifier," M.S. Thesis, Information Systems, Tilburg University, Tilburg, The Netherlands (work done at the Department of Computer Science, Virginia Tech, Blacksburg, VA).
209. Vaske J. J., D. B. Gaede, and G. Haas (1997), "An Empirical Comparison of World Wide Web and Telephone Surveys," Paper presented at the Annual Meeting of the American Association for Public Opinion Research, Norfolk, VA.
210. Wake, W. and E. A. Fox (1995), "SortTables: A Browser for a Digital Library." In *Proceedings of the 4th International Conference Information and Knowledge Management, CIKM '95*, Baltimore, MD, November 28 - December 2, pp. 175-181.
211. Wake, W., "Account number: A pattern." In J. O. Coplien and D. C. Schmidt, editors, *Pattern Languages of Programs*. Addison-Wesley, Reading, MA, May 1995.
212. Wake, W., B. D. Wake, and E. A. Fox (1995), "Improving Responsiveness in Interactive Applications Using Queues." In Vlissides, Coplien, and Kerth, Eds., *Pattern Languages of Program Design 2*, Addison-Wesley, New York, NY. Previously published in *Proceedings PLOP '95*.
213. Waters, D. and J. Garrett, co-chairs. "Preserving Digital Information: Report of the Task Force on Archiving of Digital Information," Commissioned by The Commission on Preservation and Access and The Research Libraries Group, Inc., Washington, D.C., May 1, 1996, (<http://www.rlg.org>)
214. Waterworth, J. and M. Chignell (1997), "Multimedia Interaction." In T.L. M. Helander, and P. Prabhu (Ed.), *Handbook of Human-Computer Interaction*, pp. 915-946, Elsevier Science.
215. Williges, R. C. (1995), "Review of Experimental Design," In J. Weimer (Ed.), *Research Techniques in Human Engineering*, Englewood Cliffs: Prentice Hall, NJ, pp. 49-71.
216. Wilkinson, R., and M. Fuller, "Integration of information and retrieval and hypertext via structure." In M. Agosti and A. Smeaton, Eds., *Information Retrieval and Hypertext*, Boston: Kluwer Academic Publishers, 1996, pp. 257-278.
217. Williams, S., M. Abrams, C. Standridge, G. Abdulla, and E. A. Fox (1996), "Removal Policies in Network Caches for World-Wide Web Documents." In *Proceedings of the SIGCOMM '96*, Palo Alto, CA, August 28-30.

218. Williges, R.C. (1998), "Advancing scholarly research through the electronic world," Blacksburg, VA: Virginia Polytechnic Institute and State University, Hypermedia Technical Report HCIL-98-03. (<http://hci.ise.vt.edu/~williges/eworld/electronic.html>)
219. Williges, R.C. (1995), "Review of experimental design." In J. Weimer (Ed.), *Research techniques in human engineering*, pp. 49-71, Englewood Cliffs: Prentice Hall PTR.
220. Wise, J. A., J. J. Thomas, K. Pennock, D. Lantrip, M. Pottier, A. Schur, and V. Crow (1995), "Visualizing the non-visual: spatial analysis and interaction with information from text documents." In *Proceedings of the IEEE '95 Information Visualization*, pp. 51-58, Atlanta GA, October 1995. IEEE Service Center.
221. Wixon, D. and C. Wilson (1997), "The Usability Engineering Framework for Product Design and Evaluation." In M. Helander, T. K. Landauer, and P. Prabhu (Eds.) *Human-computer interaction (2nd Edition)*, pp. 653-688, Amsterdam: Elsevier Science.
222. Wong, L., "An Introduction to the Kleisli Query System and a Commentary on the Influence of Functional Programming on its Implementation." In *Journal of Functional Programming*, to appear, 1998.
223. Xu, J., Y. Cao, E. Lim, and W. Ng (1998), "Database Selection Techniques for Routing Bibliographic Queries." In *Proceedings of the 3rd ACM International Conference on Digital Libraries, DL'98*, Pittsburgh, PA, June 23-26, ACM, New York, pp. 264-273.
224. Yang, J., C. A. Shaffer, and L. S. Heath (1995), "SWAN -- A Data Structure Visualization System." In *Proceedings of the Graph Drawing '95*, Passau, Germany, pp. 520-523.
225. Zhang, H. J., C. Y. Low, S. W. Smoliar, J. H. Wu, "Video Parsing, Retrieval and Browsing: An Integrated and Content-Based Solution." In *Proceedings of the ACM Multimedia 95*, San Francisco, CA, pp. 15-24.
226. Zhendong, D. and G. Jin, "Construction and Application of SenseWeb-- A multi-lingual semantic database," A tutorial in *International Conference on Chinese Computing*, 1996, Singapore.