

Using the National Engineering Education Delivery System as the Foundation for Building a Test-Bed Digital Library for Science, Mathematics, Engineering and Technology Education

Final Report for NSF Grant IIS-9817406
(October 1, 1998 to September 30, 1999; no-cost extension to March 1, 2000)

Activities

1. Developed a test-bed SMETE Digital Library

System Design

As users in the digital learning space will be both instructors and learners, we designed the test-bed to be a focal point to locate resources and interact with other community members in multiple modes (e.g., learner-to-learner, instructor-to-learner or peer-to-peer). The core infrastructure of the database, software and hardware are designed to be flexible and scalable to support a wide range of uses and target audiences. We redesigned the existing NEEDS (National Engineering Education Delivery System) database from the ground up to support modular services and to function as a portal or gateway to the digital learning resources. The services and infrastructure are designed to support our existing engineering education user base while at the same time allow us to develop a test-bed federated system with a wide range of resources and users in the sciences, mathematics and technology. The current system design is a crucial step in our evolution toward ultimate vision of a digital learning community proposed for the National SMETE Digital Library (NSDL) [1, 2, 3, 4, 5].

The current system provides a base level of services from which users can search, retrieve and catalog learning resources. The interface is similar to Web-based search engines and supports novice users. After entering a *search* query and browsing the results, the user can access a wealth of information by selecting different ‘tabs’ on a learning resources’ catalog record (see Figure 1). The ‘tabbed’ interface separates the information describing and supporting the learning object into digestible segments. For example, the user can *download*, view *expert reviews*, access *support materials* or view *comments* by earlier users.

Key innovations in the system redesign are geared toward developing a critical mass of viewership, content and mechanisms to support the social interactions characterized by a

Figure 1 – Sample Learning Object Record



community of learners [6, 7, 8]. We believe the ability of the community to discuss the learning resources will stimulate them to adopt, adapt and re-use existing resources, as well as lead to new development and highlight potential acquisitions. The community can be a support system to address many of the concerns and challenges in cataloging and indexing digital learning resources (e.g., inadequate description or lack of supporting materials) by becoming a user-based education, support and evaluation system.

Collection Development

The test-bed successfully integrates content from multiple disciplines within our core infrastructure. As an initial step in expanding our collection of science, mathematics, engineering and technology learning resources, we built upon our work with a GE (General Electric) Foundation grant entitled “Integrating Calculus, Chemistry, Physics and Engineering Education through Technology Enhanced Visualization, Simulation and Design Cases and Outcomes Assessment.” This work helped us focus our attention on the conceptual overlaps between these disciplines and provided us the means to begin to understand and identify the different vocabulary and pedagogical approaches at the intersection between these disciplines [9, 10].

We worked with the nine-campus University of California System to identify and catalog materials developed system-wide in science, mathematics, engineering and technology. As a result of an All University Conference on Teaching and Learning [11, 12], the Office of the President supported our efforts to identify digital learning resources and other educational technology resources developed within the University of California system for sharing and re-use.

During the grant period we added 261 science, physics, biology and mathematics learning resources to our test-bed SMETE digital library (see Table 1) and 259 new engineering learning resources located under the NSF Action Agenda program [13]. Collectively to date, approximately 70% of the total records are engineering related and the other 30% are chemistry, physics, mathematics and biology related.

Table 1 – New Records thru 4/22/99

Chemistry	16	62%
	2	
Physics	78	30%
Biology	2	1%
Mathematics	19	7%

New SMETE 261

Records

Learning Object Metadata Standards Development

We participated in the development of learning object metadata standards through the IMS Project (now IMS Global Learning Consortium) [14]. The NEEDS/SMETE project is a member of the IMS Developer’s Network and the University of California is an investment member of IMS. These key memberships allowed us to play a strong role in the development of the IMS Metadata Specification. We hosted an IMS Metadata Toolbash and Tech Board Meeting on August 2–6, 1999 in Berkeley, CA [15]. Our work to develop and test the metadata specification ultimately lead to its official adoption by IMS in late August 1999.

Mathematics Community

We consulted with the mathematics community in their development of disciplinary subject vocabularies and metadata. The NEEDS/SMETE project has been involved with the Math

Metadata Working Group (now American Mathematics Metadata Task Force, see www.mathmetadata.org) since April 1998 [16, 17, 18, 19]. During the grant period we continued to provide guidance and expertise to assist the math community in developing subject specific metadata and subject vocabularies. We hosted a Math Metadata meeting on August 10–11, 1999 in Berkeley, CA [17].

Geosciences Community

We consulted with the Geoscience community in their development of the Digital Library for Earth Science Education (DLESE). The NEEDS/SMETE project has been involved with the DLESE efforts since their kick-off workshop, “Portal to the Future” on August 8–11, 1998 in Coolfont, West Virginia.

2. Initiated Development of a SMETE Digital Library User Community

Focus Groups

In order for us to develop a test-bed SMETE digital library, it was important for us to better understand how the needs of users in the sciences and mathematics might differ from those in engineering and technology and to what extent they overlap. In January 1999, we implemented a needs assessment of educators from mathematics and statistics, chemistry, physics and biology. We conducted a series of focus groups at five respected professional conferences (see Table 2) associated with the sciences and mathematics. The focus group participants (primarily faculty members) were chosen because of their expertise in areas associated with innovation in teaching, technology and pedagogy. These selection criteria enabled us to create homogenous groups that reflect the current users of digital libraries. In all, ten focus groups were held and approximately 70 faculty participated in these discussions. The preliminary results of these groups were used in the development of the test-bed interface [20].

Table 2 – Focus Groups

Conference/Meeting	# of Participants & Description
American Math Society & Mathematical Association of America (January 14–16, 1999)	33 Faculty from research and teaching universities
American Association of Physics Teachers (January 11, 1999)	12 Faculty from research and teaching universities, community colleges and high school teachers
American Association for the Advancement of Science (January 23, 24, 1999)	12 Faculty from research and teaching universities, community colleges and high school teachers
Modular Chemistry Consortium (March 18, 20, 1999)	9 Faculty from small, private teaching institutions and community colleges
Learning on the Internet (April 9, 1999)	6 Faculty from community colleges

The needs assessment was also designed to provide recommendations in direct response to questions raised in the report of the National Research Council’s Workshop “Developing a Digital National Library for Undergraduate Science, Mathematics, Engineering, and Technology Education” [2]. Discussion topics centered on identifying and clarifying users’ needs regarding: content areas; types of standards and criteria for accepting materials; ease of use; perceptions

regarding the value of technology to learning; and identifying features to encourage development, adaptation, and adoption of digital learning resources. As a result of this needs assessment, we have a preliminary understanding of the needs of the higher education mathematics, physics and chemistry communities [20].

SMETE Information Portal Website

To focus community development activities we developed the SMETE Information Portal at www.smete.org. This Information Portal was initiated as a result of several workshops on the subject hosted by the National Science Foundation [3, 4]. The site's purpose is to gather and share information from all concerning existing SMETE digital libraries, tools and services, lessons learned, metadata standards used, user studies and publications [20, 21]. This site has developed into the focal point for the on-going development of the SMETE Digital Library

3. Evaluate the test-bed SMETE Digital Library

The focus of our evaluation efforts for the duration of this grant has been to develop a prototype process for evaluating NEEDS (including developing and testing tools) and the test-bed SMETE Digital Library. This has involved identifying the most critical questions necessary to guide the evaluation process and tool development, as well as help further the planning and development process of the site itself. Based on the goals of the library, the evaluation prototype has been designed to provide the library developers and designers with two main types of information: formative and planning (how to improve the project) and impact (how the library and its contents affecting education). Several of the questions guiding the process to date are:

- What services and programs are integral to the NSDL? How do these change as users do?
- How do learners use the NSDL? Do its services meet their needs?
- How does the NSDL support SMET learning? What resources and tools should the library support to help improve teaching and learning in SMET education?
- How do SMET educators view the NSDL as a community? What is the role of community in the NSDL and how can it be supported most effectively?
- What are the SMETE community's priorities regarding the content, creation, and storage of learning resources, indexing of these resources in relation to the economic and legal issues associated with NSDL.

4. Outreach and Public Relations Activities

We contributed to two NSF-sponsored workshops and made recommendations towards the further development of the SMETE digital library [3, 4]. We participated in the July 21–23, 1998 SMETE Library Workshop and the Digital Libraries and Education Working Group Meeting on January 4–6, 1999 [22]. We were an exhibitor at the IEEE Advances in Digital Libraries Conference on May 18–21, 1999 [23], organized and moderated a panel session at ACM Digital Library on August 11–14, 1999 [20, 21] and gave other presentations to a broad range of conferences and events [19, 24, 25, 26, 27, 28, 29].

5. References

- 1 National Science Foundation, "Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology," Report of the Review of Undergraduate Education by the Advisory Committee to the NSF Directorate for Education and Human Resources, NSF 96-139, Arlington, VA: National Science Foundation, 1996.
- 2 National Research Council, "Developing a Digital Library for Undergraduate Science, Mathematics, Engineering and Technology Education," Report of a Workshop, Washington, D.C.: National Research Council, 1998.
- 3 National Science Foundation, "NSF SMETE-Lib Study," Report of the SMETE Library Workshop, July 21-23, 1998. URL: <http://www.dlib.org/smete/public/report.html>.
- 4 National Science Foundation, "Digital Libraries and Education Working Group Meeting," Report of a Working Group Meeting, Jan. 4-6, 1999. URL: <http://www.dli2.nsf.gov/dljanmtg.pdf>.
- 5 Muramatsu, B. and A.M. Agogino, "The National Engineering Education Delivery System: A National Digital Library for Engineering Education," *D-LIB Magazine*, April 1999, Vol. 5, Issue 4, ISSN: 1082-9873.
- 6 Synthesis Coalition, "Synthesis National Engineering Education Coalition," NSF Cooperative Agreement No. 9053807, 1990. And Agogino, A. M., "Institutionalization, Evaluation, and Dissemination of Educational Innovations Developed through the Synthesis Coalition," NSF Cooperative Agreement No. EEC 9625456, 1996
- 7 Lyman, P., "Designing Libraries to be Learning Communities: Toward an Ecology of Places for Learning," For the June 1998 meeting of UKOLN. URL: <http://www.sims.berkeley.edu/~plyman/articles/UKOLN1.pdf>.
- 8 Shaffer, C.R. & Anundsen, K. *Creating Community Anywhere: Finding Support and Connection in a Fragmented World*. Los Angeles, CA: Tarcher/Perigee, 1993.
- 9 Price, B., "Improving the Gateway Courses in Chemistry, Mathematics, and Physics," NSF Grant, 1996.
- 10 Gray, P. and B. Price, "Integrating Calculus, Chemistry, Physics and Engineering Education through Technology Enhanced Visualization, Simulation, and Design Cases and Outcomes Assessment," GE Foundation Grant, 1997.
- 11 University of California, "Future Directions for Teaching and Learning Technologies at the University of California," April 17, 1997. URL: <http://www.ucop.edu/ucophome/auc/aucreport.html>.
- 12 Christ, C., "The Interactive University: The UC Berkeley Community Service Network," Department of Commerce's Telecommunications Infrastructure Assistance Program, April 1995.
- 13 Agogino, A. M., "Expanding the National Engineering Education Delivery System as the Foundation for an On-Line Engineering Education Community," NSF Grant EEC-9872570, 1998.
- 14 IMS Project Briefing, Cupertino, CA, December 7, 1998.
- 15 IMS Metadata Toolbash and Tech Board Meeting, Berkeley, CA, August 2-6, 1999.
- 16 Math Metadata Meeting, San Francisco, CA, April 1999.
- 17 Math Metadata Meeting, Berkeley, CA, August 10-11, 1999.

-
- 18 Math Metadata Meeting, Columbus, OH, November 1999
 - 19 Muramatsu, B., A.M. Agogino, E. Klotz, F. McMartin, R. Robson, L. Simutis, "A National Digital Library for Science, Mathematics, Engineering, and Technology Education," Presentation at the American Mathematical Association/Mathematical Association of America Joint Meeting, Washington, D.C., January 2000.
 - 20 McMartin, F. "Preliminary findings from Science, Mathematics, Engineering, and Technology Education Digital Library Use Study Focus Groups," April 2000. URL: http://www.smete.org/smete/info/survey/user_study_dl.html.
 - 21 Agogino, A.M., "Visions for a Digital Library for Science, Mathematics, Engineering and Technology Education (SMETE)," Panel Session, Fourth ACM Conference on Digital Libraries, Berkeley, CA, August 11-14, 1999.
 - 22 Agogino, A.M., F. McMartin and B. Muramatsu, "SMETE Information Portal: A Digital Library for Science, Mathematics, Engineering and Technology Education," NSF DLI-2 All Projects Meeting, Cornell University, Ithaca, NY, October 17-18, 1999.
 - 23 Agogino, A.M., F. McMartin and B. Muramatsu, NEEDS Exhibit, IEEE Advances in Digital Libraries Conference, Baltimore, MD, May 18-21, 1999.
 - 24 Muramatsu, B., F. McMartin and A.M. Agogino, "Developing a Digital National Library for Education: Building upon NEEDS — The National Engineering Education Delivery System," Poster Session, Webnet: World Conference on WWW and the Internet, Honolulu, HI, Sunday, October 24-30, 1999.
 - 25 Muramatsu, B., "SMETE Information Portal: A Digital Library for Science, Mathematics, Engineering and Technology Education," Webnet: World Conference on WWW and the Internet, Honolulu, HI, Preconference Mini Course: Using Metadata to Facilitate Educational Resource Discovery and Reuse, Sunday, October 24, 1999.
 - 26 Muramatsu, B., F. McMartin and A.M. Agogino, "A National Digital Library for Science, Mathematics, Engineering, and Technology, Education," Poster Session, Educause Annual Conference, Long Beach, CA, October 27, 1999.
 - 27 Agogino, A.M., "Teaching, Learning and Libraries on Internet Time," Society of Women Engineers - Evening with Industry, November 19, 1999, Berkeley, CA.
 - 28 Agogino, A.M., "Teaching, Learning and Using Libraries on Internet Time," Coalition for Networked for Information, Phoenix, Arizona, December 14, 1999.
 - 29 Muramatsu, B., "A Digital Learning Space for Science, Mathematics, Engineering and Technology Education," Invited Talk, Mathematics/Science Educational Technology 2000, San Diego, CA, February 2000.