The National SMETE Digital Library Program

Brandon Muramatsu
SMETE.ORG
University of California, Berkeley
3115 Etcheverry Hall
Berkeley, CA 94720-1750
+1 510 643-1817

mura@smete.org

Cathryn A. Manduca
DLESE Program Center
UCAR
P.O. Box 3000
Boulder, CO 80307
+1 507 252-8658

cmanduca@carleton.edu

Marcia Mardis
MERIT Network
4251 Plymouth Road
Suite 2000
Ann Arbor, MI 48105
+1 737 764-5384

mmardis@merit.edu

James H. Lightbourne
Div. Undergraduate Education
National Science Foundation
4201Wilson Blvd., Suite 835
Arlington, VA 22230
+1 703 292-8671

jhlightb@nsf.gov

Flora P. McMartin
SMETE.ORG
University of California, Berkeley
3115 Etcheverry Hall
Berkeley, CA 94720-1750
+1 510 643-2928

mcmartin@smete.org

David W. Mogk
DLESE Program Center
Dept. Earth Sciences
Montana State University
Bozeman, MT 59717
+1 406 994-6916

mogk@montana.edu

ABSTRACT

"To catalyze and support continual improvements in the quality of science, mathematics, engineering, and technology (SMET) education, the National Science Foundation (NSF) has established the National Science, Mathematics, Engineering, and Technology Education Digital Library (NSDL) program. The resulting digital library, a network of learning environments and resources for SMET education, will ultimately meet the needs of students and teachers at all levels—K-12, undergraduate, graduate, and lifelong learning—in both individual and collaborative settings, as well as formal and informal modes."

—National Science Foundation, 2001

The *national* in the NSDL program is quickly becoming a reality with the broad reach of the currently funded projects. This panel session will provide bring together the leaders developing the National SMETE Digital Library to provide a brief background and broad overview of the NSDL program. Panelists will discuss the overall vision and broad steps underway to develop the National SMETE Digital Library.

Building the National SMETE Digital Library presents many challenges:

- Developing a shared vision for the form and function of the NSDL;

- Meeting the needs of diverse learners and of the many disciplines encompassed by the NSDL;

- Acquiring input from the community of users to ensure that the NSDL is both used and useable;

- Evaluating progress and impacts;

- Integrating technologies that already exist, and the development of new technologies; and

- Providing mechanisms for sharing and cooperation of knowledge and resources among NSDL collaborators.

Keywords

National SMETE Digital Library, NSDL, Education, Teaching and Learning

[Note: This paper is excerpted from *Pathways to Progress: Vision and Plans for Developing the NSDL* Edited by Manduca, McMartin and Mogk. The full paper can be found at http://www.smete.org/nsdl/.]

1. INTRODUCTION

The National Science, Mathematics, Engineering, and Technology (SMET) Education Digital Library (NSDL) was conceived and is being constructed to support excellence in SMET education for all Americans. The NSDL will be a comprehensive information system built as a distributed network and will develop and make accessible collections of high-quality resources for instruction at all levels and in all educational settings. It will also establish and maintain communication networks to facilitate interactions and collaborations among all SMET educators and learners, and will foster development of new communities of learners in SMET education. Multiple services will be available to help users effectively access and use NSDL resources.

The potential impact of the NSDL on the quality of SMET education is great. However, building the NSDL to meet the diverse needs of its users presents many challenges, including:

- developing a shared vision for the form and function of the NSDL;

- meeting the needs of diverse learners;

- meeting the needs of the many disciplines encompassed by the NSDL;

- acquiring input from the community of users to ensure that the NSDL is both used and useable;

- developing a governance structure and Core Integration System that balances community needs with technical applications;

- integrating technologies that already exist, and promoting the development and integration of new technologies;

- providing mechanisms for sharing knowledge and resources, and building cooperation among NSDL collaborators;

- providing mechanisms for incorporating primary scientific research data;

- evaluating NSDL and its impact on SMET education; and

- coordinating these many interests and functions to provide an integrated whole.

This paper addresses the methods for meeting these challenges, and allows NSDL participants to identify the common and essential components of the social and technical infrastructure necessary to construct the NSDL. It discusses the primary educational goal of the NSDL, which is to have a measurable impact on SMET learning and educational practices in ways that are closely aligned with SMET educational reform movements. It also identifies the partners participating in the inaugural development of the NSDL and serves to formalize our own plans for the NSDL. It is further intended to engage the larger SMET community in building the NSDL by describing the needs, opportunities, vision, scope, and plans for development.

The contents of this document were derived and assembled from the contributions of the participants of various NSDL grantee meetings held during 2000/2001. First, we provide a brief review of the background of the NSDL. Next, we focus attention on those areas where there is broad consensus, namely the vision, scope, goals, and principles guiding the development of the NSDL.

[Note: This paper is excerpted from *Pathways to Progress: Vision and Plans for Developing the NSDL* Edited by Manduca, McMartin and Mogk. The full paper can be found at http://www.smete.org/nsdl//.]

2. BACKGROUND AND OVERVIEW

The NSDL effort has emerged from the confluence of technological advances, changing educational practice, and a recognition of the fundamental importance of SMET education to our highly technological society. Today we are faced with a nation-wide call for improvement of SMET education at all levels (Project 2061, AAAS, 1989; National Science Education Standards, NRC, 1996; Shaping the Future New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology, NSF, 1996). Simultaneously, information technology now offers remarkable opportunities to improve learning through simulations, visualization, modeling, access to real-world scientific problems, and by enabling new collaborations, interactive learning, and alternative pedagogical approaches (NSF 98-82).

In this context, the NSDL has the potential to:

- answer calls from educators for easy access to high-quality, organized, and accessible educational resources and the tools, interfaces and other services to help them effectively use these resources (Education Teachers of Science Mathematics and Technology, NRC 2001);

- enable student-friendly access to scientific data to support learning by direct experience with the methods and processes of inquiry and discovery—the method recognized as most effective by research on learning (NSF 96-139); and

- support a new integrated community addressing the full spectrum of SMET education.

Significant progress has been made in developing technology fundamental to a successful digital library such as interoperability, authentication, persistence, and archiving functions. A substantial research base emerging from the results of the NSF Digital Library Initiative Phase I and Phase II projects is available to support the development of the NSDL. Building on these bases, the National Science Foundation initiated the NSDL effort with a program solicitation (NSF 00-44) to establish an educational digital library for science, mathematics, engineering and technology:

> "To catalyze and support continual improvements in the quality of science, mathematics, engineering, and technology (SMET) education, the National Science Foundation has established the National Science, Mathematics, Engineering and Technology Education Digital Library (NSDL). The resulting digital library, a network of learning environments and resources for SMET education, will ultimately meet the needs of students and teachers at all levels—K-12, undergraduate, graduate, and lifelong learning—in both individual and collaborative settings."

In fall, 2000, 29 grants were awarded from this competition in four tracks (www.smete.org/nsdl/projects/index.html): 1) Core Integration System (CIS); 2) Collections; 3) Services; and 4) Targeted Research. Representatives of these projects met in Washington DC on September 22-24, 2000 to lay the foundation for building the integrated NSDL. Minutes of these meetings and

working group reports can be found at www.smete.org/nsdl/workgroups/index.html. These participants met again in Boulder, Colorado on November 1-2, 2000 to continue this formative work. The outcomes of these meetings include the creation of an interim governance structure; establishment of a set of working groups to examine the issues involved in collaboratively developing the NSDL; and a commitment to produce this document to communicate the vision, goals, and plans for NSDL.

3. VISION AND SCOPE

The NSDL is a digital learning place that encourages and supports users in their efforts to create, discover, explore, and interact with the digital resources that support teaching and learning SMET education in all arenas. In this capacity, it will be a gateway to diverse digital collections of quality SMET educational content and services developed by a rich array of SMET educators. The NSDL is both a virtual and 'real' organization supporting educational partners who collaborate to provide collections of SMET educational materials, services that support the use and re-use of those materials, and collaboration among NSDL participants and users (i.e., educators; learners; scientists, mathematicians, and engineers; resource developers; and resource providers). The NSDL is organized around goals to create and enable the connections and synergies that emphasize inter- and multi-disciplinary approaches to SMET education, provide exciting new SMET educational opportunities in formal and informal educational settings, and ultimately make a positive impact on student learning.

4. NSDL Educational Goals

The primary educational goal of the NSDL is to increase scientific literacy for all Americans. The NSDL must support excellence in SMET education encompassing all disciplines in the physical, life, and social sciences, mathematics, and engineering and technical disciplines, and in all educational settings. The integrated delivery of resources and services to the SMET education community offers unique opportunities.

First and foremost, there is the opportunity to develop a SMET education community that is interdisciplinary. There is intrinsic value in recognizing and accentuating the connections among the knowledge bases, skills, and methodologies employed by those disciplinary communities that contribute to the NSDL. The NSDL can make a substantive contribution towards bridging current disciplinary boundaries by effectively integrating concepts, knowledge and methods across the SMET disciplines. In this way, the NSDL will create a synergistic resource that is greater than a simple collection of connected but disparate discipline-based libraries.

An opportunity also exits to seamlessly integrate SMET education at all levels, including K–12, undergraduate, graduate, professional development and informal education. The information and communication systems of the NSDL will provide a spectrum of educational opportunities for all learners – "from K to gray." Learners will be able to pursue topics of interest to any desired level of sophistication by creating learning paths reflective of their personalized needs, interests, and capabilities.

Building on these broad themes, participants at the Washington, DC and Boulder, CO meetings defined the following educational goals for the NSDL:

- *Provide quality assurance of resources in the collections.* Accuracy and validity of content must be addressed, providing at minimum the source of information, integrity of the product, and information about pedagogy.
- *Enable contextual learning.* Users of resources must have the opportunity to review each learning object in the context of its use; both objective and subjective contextual descriptions (metadata) should be included.
- *Empower critical literacy skills.* Users must be allowed to make decisions and to draw independent conclusions regarding the use and quality of materials. The contents and tools must provide opportunities for students to reason scientifically.
- *Support new pedagogical approaches.* Collections and services must embrace innovative pedagogies, e.g., active learning, as well as support more traditional pedagogical modes, e.g., lecture.
- *Advance scientific knowledge and understanding.* As our scientific knowledge base expands, pedagogies associated with the library must be able to change and adapt to meet the educational challenges associated with this expansion.
- *Enable inter- and multi-disciplinary educational opportunities.* Connections between diverse subject areas in new and innovative ways must be made more effective through using digital technologies.
- *Implement the National Science Education Standards (NRC, 1996), Shaping the Future (NSF, 1996) and related SMET education reform programs.* The library must be a primary means for disseminating standards and reform efforts, as well as providing the subsequent and necessary professional development for teachers and instructors.
- *Support independent learning.* Learning plans must be adaptable according to personal needs, abilities, and aptitudes.
- *Support learning that is active, and that involves inquiry and discovery.* The library must provide support for current research in SMET education that calls for use of these new pedagogical methods.
- *Foster a sense of excitement about life-long learning.* Users from all walks of life must be able to look to the NSDL to be a primary resource for learning SMET.
- *Provide access for all.* The NSDL must adopt access goals associated with learning and physical disabilities, language needs, as well as needs of under-represented populations, and implement processes to meet those goals. In providing equal access for all, it must guard against creating an even broader digital divide.
- *Empower users.* Distributed services such as help desks, FAQ's, and ask-an-expert must be available to support novice users.
- *Support communities of scholars.* The NSDL must not be prescriptive in its educational mission. Recognizing that new advances in SMET education will emerge from communities of users, the NSDL must embrace an educational mission that builds upon and promotes excellence and innovation in SMET education.

5. PRINCIPLES UNDERLYING DEVELOPMENT

A coordinated effort engaging the information technology, library, SMET, and education communities is required to achieve the

educational goals outlined above and to establish an integrated digital library serving the collective needs of the broad SMET educational community. SMET education is a highly complex system that is currently fragmented by both disciplines and educational levels. Robust linkages are needed to allow discovery of resources across disciplines and educational communities. In addition, tools and resources are needed to meet the varied needs and goals of individual learners, programs, and communities that range from integrated interdisciplinary learning to detailed, specific knowledge from a particular specialty.

No single educational or technical group has the intellectual resources required to create such a large, complex, interconnected digital resource. This challenge is increased by the need for rapid development of the NSDL to meet the immediate and changing needs of SMET education. The initial contributors to NSDL recognize the value of and need for collaboration in building the NSDL. As a group they are committed to initiating a coordinated and distributed building process to meet these challenges. This group of 42 projects forms the current core of the NSDL community that is guided by these underlying principles:

- The goal of the NSDL is to enhance, enrich and enable excellence in SMET education.

- Rapid development of the NSDL is best accomplished through a coordinated, cooperative and distributed effort.

- Our strength is in the variety of communities engaged in the NSDL. A governance structure is necessary to balance the collective needs and goals with the over-arching management of the library.

- Meeting NSDL educational and technical goals requires active interplay among the library's users, contributors and developers.

- The NSDL adds value through the human networks and other relationships among NSDL components as well as through its contents and services.

- The NSDL initiating partners share a core set of values, all of which will be reflected in the resulting digital library development.

The NSDL partners encompass a wide spectrum of talent able to address the complex technical, educational, and social problems inherent in creating this comprehensive, interdisciplinary, web-based learning resource. While this group is diverse and represents many disciplines and specialties with different approaches and goals, we share this common set of values.

- *A commitment to promoting excellence in SMET education for all learners*. NSDL is an experiment in the application of technology to learning. Of critical importance will be the application of rigorous research methods to understanding how people learn, and the effective use of information technology and learning resources.

- *A commitment to the value of sharing and to the collaborative development of the NSDL*. Implicit in this value is the understanding that participation involves both receiving and contributing. We recognize that effective collaboration is costly in both time and money, but we strongly believe it enables results otherwise not possible.

- *A desire to create a SMET educational digital library that serves the public good*. We believe that the NSDL should serve the needs of a diverse population representing a variety of learning goals and needs, including those with limited access to technology. This requires that decision making focus on the needs of end users (i.e., above those of serving our own research needs or individual intellectual interests).

These commonly held values make the NSDL collaboration possible. However, even with this strong base, success is not assured. Tensions exist among and between education, technical, and research goals, as well as among the diversity of communities that the NSDL is designed to serve. A balance must be struck between uniformity and diversity. Similarly, the desire to allow individual creativity and competing approaches must be balanced by policies that enable development of a working integrated digital library. We must design a structure to assure that individual projects and communities can function autonomously to reach their own goals while enabling the benefits of working together as a NSDL community. Collaboration does not require common ownership of all things. However, to be successful, the NSDL collaboration must appear to be a coherent entity to the outside world and to its users.

Collaboration among members of the NSDL community can be made easier by developing a common culture, one in which individuals make responsible representations of what they can do, maintain a sustained commitment to the project including timely communication between meetings, and adopt a shared etiquette for communication. This commitment will greatly enhance our ability to work together. A strong set of tools for long-distance communication and effective facilitation of working groups will both simplify and enhance collaboration and should be priorities. In addition, multiple pathways to achieving goals, flexible approaches, and diverse tools can greatly relieve the tensions between individual and community needs. Robust communication mechanisms are needed to ensure input from stakeholders in the education, research and development realms. Finally, a design cycle approach can facilitate this type of decision making while allowing timely progress in development of the NSDL.

6. ACKNOWLEDGMENTS