



2006 Annual Report
Leveraging Collaborative Networks



THE NATIONAL SCIENCE DIGITAL LIBRARY



2006 Annual Report

Leveraging Collaborative Networks

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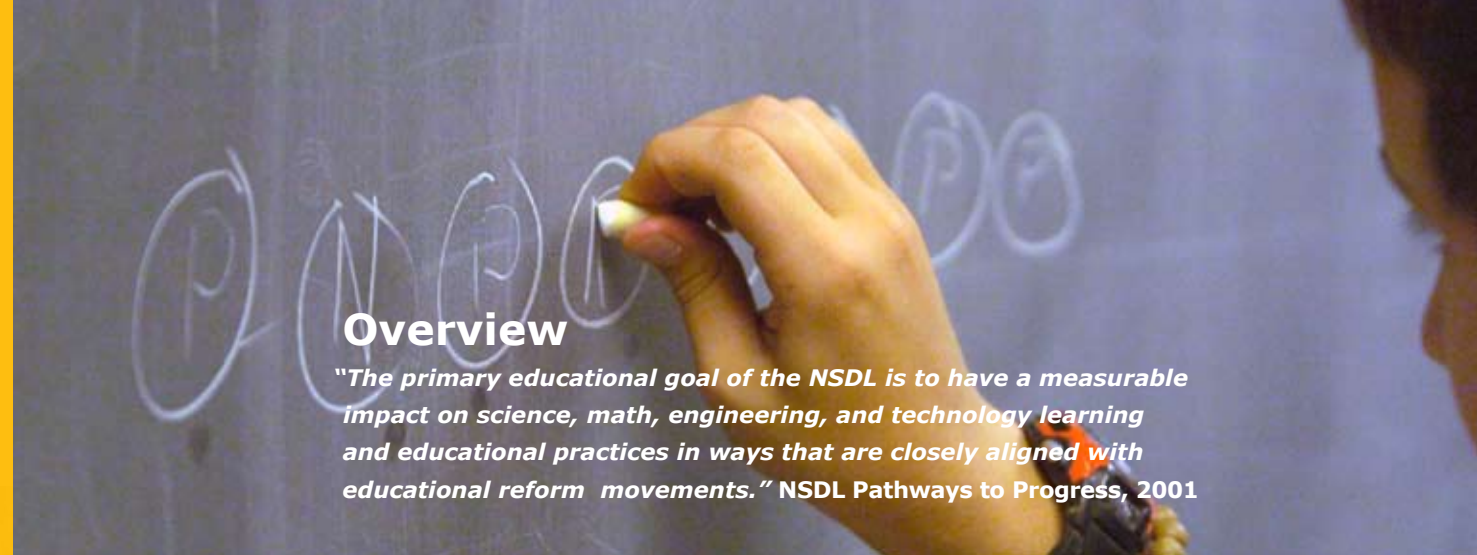
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Overview

"The primary educational goal of the NSDL is to have a measurable impact on science, math, engineering, and technology learning and educational practices in ways that are closely aligned with educational reform movements." NSDL Pathways to Progress, 2001



National education discussions have focused on the critical role of science and mathematics education in creating a globally competitive workforce for the future (NAS 2006) and the importance of information literacy skills at all levels of education (ACRL 2000). A workforce that has a solid knowledge of both science and mathematics, combined with analytical, problem-solving, and creative thinking skills, is essential to our economic and technological competitiveness. It is within the environment of these national education discussions that the National Science Digital Library (NSDL) has grown and evolved in recent years. NSDL increasingly plays a vital role in addressing these needs.

Founded by the National Science Foundation (NSF) in 2000 as its online library of exemplary resources for science, technology, engineering, and mathematics (STEM) education and research, NSDL offers an organized point of access to a wealth of online educational resources and services.

NSDL acts as an agent for leveraging partnerships and collaborations among a wide variety of stakeholders engaged in the educational enterprise—resource providers, technology builders, educational organizations, professional societies, publishers—and as a locus for technical innovations in science education and digital library research.

Managed by a partnership between Columbia University, Cornell University, and the University Corporation for Atmospheric Research (UCAR), NSDL integrates multiple partners, collections, services, research projects, and educational communities into a coherent library.

This 2006 Annual Report illustrates the versatility, breadth, and depth of NSDL. It describes the multiple roles NSDL serves in the national educational landscape: as resource repository; digital library service provider; education and outreach tool; communications hub; research and education integrator; teacher professional development source; technology incubator; locus for digital library research; and scaffold for collaboration.

The NSDL network of partners working together to improve STEM education comprise a kind of social middleware—a unique web of context, contribution, and collaboration—connecting end users with technology-based resources and services that promote active, inquiry-based teaching and learning.



Making Connections to Science and Math Communities



NSDL Pathways partners are aggregators of resources and user services appropriate for their communities. They are portal sites supporting resource discovery for broad categories of users, and are developed and managed in partnership with organizations and institutions that have a history and expertise in serving their target audiences. These partnerships demonstrate the value of NSDL in a wide variety of teaching and learning environments.

Pathways connect NSDL to specific learner communities and their cultures and provide in-depth knowledge of their educational needs.

The National Science Foundation initiated the Pathways strategy for further developing NSDL in 2004. Pathways are themselves partnerships among multiple institutions and/or professional societies, and are discipline-specific or audience-specific creators and aggregators of trusted resources and user services for their communities. They infuse vigor and focus in the library, while building on the foundation provided by more than 200 collections, services, and research projects funded through NSF's NSDL grant program.

NSDL Pathways partners provide opportunities to coordinate the distributed library building activities of multiple partners and serve key audiences and communities of practice in a more comprehensive way.



Pathways are working with NSDL on key points of intersection, including:

- **Community Sign-On.** The ability for a user registered and logged in at one NSDL Pathway or other partner site to move seamlessly to another NSDL site without additional logins is a primary goal within NSDL. User testing has shown that registration requirements and multiple logins are a significant barrier to users (Khoo 2006). Implementing Community Sign-On across NSDL is key to enabling interoperability between Pathways and NSDL and among multiple partners within Pathways.
- **Implementing methods of web metrics.** Tracking data about use across Pathway and NSDL sites paints pictures of how educators and students use NSDL. Web metrics also help to gauge the impacts of particular sites, web pages, features, and services, and contribute to telling the evaluation story of digital learning objects and digital libraries.
- **Integration with NSDL technical infrastructure, and the sharing of tools and services with multiple partners.** NSDL, Pathways, and other NSF-funded projects are key sources of powerful digital library services for educators. Adapting effective tools and services for use and reuse across NSDL is a fundamental goal of NSDL's educational mission.
- **Clarifying metadata issues.** Metadata is structured descriptive information about a resource (such as title, description, audience, keywords, resource type) that assists in discovery and use of resources. Enhancements and refinements to metadata and agreement on common vocabularies further promotes interoperability between Pathways and NSDL, supporting cross-collaboration.

NSDL Pathways partners are collaboratively addressing fundamental goals and needs in STEM education—developing high quality teaching materials, utilizing and associating educational standards to effective resources, developing assessments of student learning, and creating opportunities and programs that attract students to pursue careers in science, technology, engineering, and mathematics. NSDL Pathways provide a framework for addressing common goals that ensure adoption and successful use and reuse of resources in the classroom, lecture hall, and lab. These activities serve as a springboard for establishing effective collaborations with other participants dedicated to STEM advancement.

NSDL Pathways by the Numbers

- Number of Pathways: 10
- Number of partnering organizations within Pathways: 85
- Number of members of professional societies/organizations within Pathways: More than 1.2 million



NSDL Pathways



Applied Math and Science Education Repository (AMSER)

AMSER is an applied mathematics and science education portal of resource collections and integrated services designed specifically for use by faculty, staff, and students of community and technical colleges. Community colleges often serve a bridging function between public schooling and baccalaureate education, and train a significant percentage of the national workforce. AMSER's goals include the creation of professional development that promotes adjunct faculty skills in the application and use of digital resources.

Partners

Lead: Internet Scout Project, University of Wisconsin-Madison

MERLOT

American Association of Community Colleges (AACC)

American Association of Two-Year Colleges (AMATYC)

Advanced Technological Education projects of NSF (NSF ATE)

Pathway since 2004

Audiences: Community and technical colleges, faculty professional development

<http://amser.org/>



BiosciencesEdNet (BEN)

The BEN collaborative was originally established in 1999 by the American Association for the Advancement of Science, with eleven other professional societies and educational coalitions. Since then it has grown to 26 collaborating entities, with the BEN portal (www.biosciencednet.org) providing access to resources that help bioscience educators engage students, shorten lesson preparation time, provide concept updates, and develop curricula in line with national content standards.

Partners

Lead: American Association for the Advancement of Science (AAAS)

American Physiological Society (APS)

Ecological Society of America (ESA)

American Society for Microbiology (ASM)

American Institute for Biological Sciences (AIBS)

Additional collaborators

AAAS Science's STKE - Signal Transduction Knowledge Environment

AAAS Science Online

Association for Biology Laboratory Education (ABLE)

American Phytopathological Society (APNet)

American Society for Biochemistry and Molecular Biology (ASBMB)

American Society for Cell Biology (ASCB)

American Society for Human Genetics

BioQUEST Curriculum Consortium (BCC)

Bio-Link (NSF ATE Center for Biotechnology)

Botanical Society of America (BSA)

Dolan DNA Learning Center (DNALC)

Entomology Digital Library (EntDL)

Faculty for Undergraduate Neuroscience (FUN)

Human Anatomy and Physiology Society (HAPS)

National Association of Biology Teachers (NABT)

National Association of Health Sciences Education Partners (NAHSEP)

National Health Museum-Access Excellence (NHMAE)

Society for Developmental Biology (SDB)

Society for Integrative and Comparative Biology (SICB)

Society of Toxicology (SOT)

Video and Image Data Access for Science Inquiry During Teacher Preparation (VIDA)

Pathway since 2005

Audiences: Undergraduate and high school

<http://www.biosciencednet.org>



ChemEd DLib

One new Pathway partner was added in 2006—the Chemical Education Digital Library (ChemEd DLib). Based at the University of Wisconsin, ChemEd DLib builds on the collections of the Journal of Chemical Education DLib (originally an NSDL Collections project) and the work of the American Chemical Society (ACS) Education Division. An innovative element of the project will be Textbook Tables of Contents browsing—utilizing these cornerstone tools of chemistry courses as a means of locating resources keyed to a specific textbook in use. The ACS is the largest scientific society in the world, with 158,000 members, and the JCE has become the premier pedagogical journal in the chemical sciences. ChemEd DLib will be engaging with other NSDL Pathways such as CSERD, Math Gateway, Teachers' Domain, ComPADRE, and MatDL on areas of cross-disciplinary interest.

Partners

Lead: Journal of Chemical Education (JCE)

American Chemical Society (ACS)

Chem-Collective

Pathway since 2006

Audiences: Undergraduate/graduate, high school

<http://www.jce.divched.org/JCEDLib>



ComPADRE—Communities for Physics and Astronomy Digital Resources in Education

The ComPADRE Pathway focuses on education resources, tools, and learning environments for Physics and Astronomy, from K–12 through undergraduate, and informal learning. Its community-based collections serve specific groups, such as teachers of introductory courses at the high school or college levels, undergraduate physics and astronomy majors, researchers in physics education, teachers and students in upper-level courses, and life-long learners. ComPADRE supports its audiences through content, communication, sharing, and professional development. It helps content developers by organizing, reviewing, disseminating, and sustaining resources; and promotes usage of NSDL and its services by physics and astronomy communities. New services provided by ComPADRE include databases of student research and professional development opportunities, flexible and sharable annotated personal filing cabinets, and an automated citation service using common citation formats (AIP, APA, Chicago, MLA, Endnote export) for referencing resources found in ComPADRE. ComPADRE is working with the Math Gateway on sharing resources that are of interest to audiences of both Pathways and with NSDL Core Integration to provide an NSDL-enabled wiki for curriculum development and dissemination.

Partners:

American Association of Physics Teachers (AAPT)

American Astronomical Society (AAS)

American Physical Society (APS)

Society of Physics Students (SPS)

American Institute of Physics (AIP)

Additional collaborators: MERLOT

Science Education Resource Center (SERC)

European Physical Society (EPS)

Pathway since 2005

Audiences: undergraduate, high school, lifelong learners

<http://www.compadre.org>



Computational Science Education Reference Desk (CSERD)

CSERD is a collaborative project of the Shodor Education Foundation and its partners. Their goal is to identify, develop, and sustain effective educational materials for computational science, technology, engineering, and mathematics. CSERD provides peer-reviewed content and easy-to-use navigation tools to find and use models, tools, and lesson plans tied to learning standards to support discovery-based teaching and learning. CSERD provides educators with expertise on how to build and validate computational models appropriate to a variety of learning levels (K–20). In partnership with the National Computational Science Institute (NCSI) more than 1,000 faculty and teachers have been trained in teaching with computational science through workshops that have introduced them to NSDL and its resources. Additionally, many NCSI participants are actively giving back to NSDL through the collection and review of content.



Engineering Pathway

A partnership between the National Engineering Education Delivery System (NEEDS) at the University of California-Berkeley, and TeachEngineering at the University of Colorado, the Engineering Pathway is a portal to high-quality teaching and learning resources in engineering, applied science and math, computer science/information technology, and engineering technology, designed for use by K–12 and university educators and students. The K–12 engineering curriculum uses engineering as a vehicle for the integration of hands-on science and mathematics through real-world designs and applications that inspire student creativity. Higher education resources include support for national board accreditation, research and scholarship, curricula development, and extracurricular activities for students. Additional services include outreach information and materials, diversity resources, and information about careers and professional societies. The Engineering Pathway has been instrumental in working with NSDL to address the technical and social challenges of Community Sign-On across NSDL sites.

Partners
Lead: Shodor Education Foundation, Inc.
National Computational Science Institute (NCSI)
Kean University
North Carolina Central University
Ohio Supercomputing Applications
National Center for Supercomputing Applications
Clemson University

Additional collaborators
Engaging People in Cyberinfrastructure (EPIC)
SCxy Education Program
TeraGrid
Sigma Xi
Burroughs Wellcome Fund
Pathway since 2004

Audiences: Undergraduate, K–12, lifelong learners
<http://cserd.nsd.org>

Partners
Lead: University of California-Berkeley
Lead: University of Colorado-Boulder
Colorado School of Mines
Duke University – Pratt School of Engineering
Oregon State University
Virginia Tech
Worcester Polytechnic Institute
American Society for Engineering Education
Pathway since 2005

Audiences: K–12, undergraduate/graduate, professional
<http://www.engineeringpathway.org>

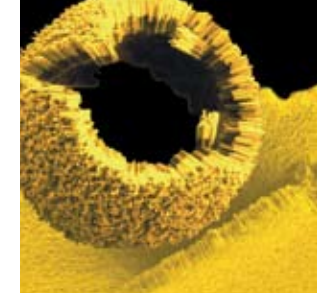


Materials Digital Library Pathway (MatDL)

The MatDL Pathway provides content and services needed across the materials science (MS) community, particularly directed to undergraduate and graduate students, educators, and researchers. MatDL is building an information infrastructure to support MS education, research, and interactions between the two as well as to disseminate resources generated by national and international government-funded teams and centers. In addition to its repository of materials science research articles and publications, MatDL, as part of the NSDL, has created several tools in 2006. The Soft Matter Wiki is publicly accessible information provided by experts in the nanoscience community offering content pertinent to soft matter and nanomaterials with specific focus on computational methods and modeling. MatForge is a collaborative code workspace for open access development of modeling and simulation software. MatDL has also established a Teaching Archive for collaborative development of core undergraduate MS teaching materials, and created services and content for virtual labs in large undergraduate introductory science courses. In these ways MatDL provides a key link with other research initiatives funded by NSF, and is helping to advance exploration of the services that NSDL can provide to the research community.

Partners
Lead: Kent State University
National Institute of Standards & Technology
Massachusetts Institute of Standards & Technology
University of Michigan
Purdue University
Iowa State University
Pathway since 2005

Audiences: undergraduate/graduate, research
<http://matdl.org>



MATH GATEWAY

Math Gateway

The Math Gateway of the Mathematical Association of America (MAA) offers more than 20,000 rich resources from twelve partner collections. MAA is the largest professional society focused on undergraduate math education. Math Gateway is a prospective user of the Expert Voices blogging environment produced by NSDL, to stimulate conversations around math topics; and Gateway partners are seeking solutions to the challenges of displaying mathematical formulas and processes on the web. Working with NSDL and other Pathways to craft solutions to cross-partner search and discovery of a wide variety of resources is a key goal for the Gateway. The Math Gateway held its first workshop for educators in 2006, introducing MAA member math faculty at the undergraduate and community college level—including those who work with K–12 teachers—to the MathDL library, the Math Gateway, and NSDL. The participants will, in turn, work to spread awareness and use of these resources to colleagues at regional MAA meetings and within their own institutions.

Partners
Lead: Mathematical Association of America
Mathematical Sciences Digital Library (MathDL)
Math Forum
MathWorld
Connected Curriculum Project
iLumina Digital Library
Mathematics Survey
Virtual Laboratories in Probability and Statistics
Demos with Positive Impact
causeweb.org
National Curve Bank
NSDL Middle School Portal
Ethnomathematics Digital Library
WebWork
Eduworks
MERLOT
College Board
webODE

Additional collaborator
Planet Math
Pathway since 2004

Audiences: undergraduate/graduate, K-12
<http://mathgateway.maa.org>



Middle School Portal

Putting content in context is the mission of the Middle School Portal at Ohio State University (OSU). The Middle School Portal was the prototype project that fostered the development of the Pathways strategy for building NSDL. The MSP continues some aspects of the work of the Eisenhower National Clearinghouse (ENC), which was funded by the U.S. Department of Education from 1992 until 2005. "We take materials on math, science, and technology topics that are taught in middle school, assign them to the appropriate educational standards, and put them in context so they are easy to use," says Kim Lightle, director of the Portal. For example, a section on aerodynamics has one link that describes the fundamentals of flight to teachers, and several other links that describe it in terms 7th-graders can understand. The Middle School Portal has also participated in NSDL's Expert Voices project, where teachers shared their ideas and skills about teaching math concepts through measurement exercises in a moderated weblog, Measuring at the Middle Level. Through the portal, OSU provides service for NSDL and other Pathways as a middle school level filter, and is also providing context and narrative around NSDL resources for a joint project with a major educational publisher.



Partners
Lead: Ohio State University
Additional collaborator
Math Gateway
Pathway since 2003
Audiences: Middle school, K-12, teacher professional development
<http://msteacher.org>

teachers'domain®

Teachers' Domain

Teachers' Domain is a service of WGBH Boston, the producer of many of PBS's most popular programs. Free video segments from programs such as *NOVA* and *ZOOM!*, plus a wealth of interactive features, have helped make Teachers' Domain a key provider of online educational resources. WGBH's usage statistics suggest that one out of three K-12 schools in the U.S. have used Teachers' Domain media resources, lesson plans, or professional development courses. Teachers' Domain now provides more than 1,000 classroom-ready multimedia resources including video and audio clips, interactives and images, and lesson plans and tools. Each resource comes with an explanatory background article and correlations to state and national curriculum standards. Teachers' Domain is a key participant in NSDL collaborations that are creating a suite of tools to help resource developers align their content to K-12 educational standards.

Partners
Lead: WGBH Educational Foundation
Other public television stations
Pathway since 2004
Audiences: K-12, teacher professional development
<http://www.teachersdomain.com>



Positioning NSDL in Broader Contexts

Strengthening and leveraging core partnerships and forging new alliances that increase usage and broaden key audience exposure to the library are essential to the long-term success of NSDL.

Partnerships with national agencies are being expanded and agreements with science education publishers are adding new content to NSDL and enlarging its role nationally. NSDL is creating alliances with museums and other centers of informal education. NSDL serves as a provider of resource content for these organizations and their education initiatives and activities, offers advice and assistance in the development of special collections, and acts as a dissemination mechanism for education and outreach efforts.

NSDL is collaborating with professional societies such as the National Science Teachers Association (NSTA) to provide professional development opportunities and teacher training events on NSDL resources, tools, and services. With the educational technology organization Project Tomorrow, NSDL is working to have teachers and students in schools across the country use and provide feedback on NSDL resources.

NSTA/NSDL Web Seminars 2006

NSTA and NSDL offered five jointly sponsored online web seminars in 2006, with a total participation of 259 attendees.

- NSDL Online: Hurricanes (DLESE; NSDL)
- Birds: Bringing the Field to the Classroom (Cornell Lab of Ornithology)
- The Virtual Bone Lab: eSkeletons (eSkeletons, University of Texas at Austin)
- Plate Tectonics Made to Order (Scripps Institution of Oceanography, Ohio State University)
- Learning by Doing: Computational Science (Shodor Education Foundation; CSERD)

Average number of participants per seminar: 52

Highest participation: 88 (Plate Tectonics)

Number of NSDL presenters: 11

Participants judged the value of the seminars on a 1–5 scale: 1=Poor and 5=Excellent. Averaged scores over the five seminars given to date:

Overall seminar value
4.62

Seminar content relevant
4.64

Interactive nature of seminar:
4.64

% who want to see more seminars like those offered:
100%

Comments from participants

Learning about the digital library system search engines was great. That they are free is marvelous...the slides were incredible and fantastic visual and interactive tools.

Access to experts is invaluable. Enjoyed learning about the variety of resources available through NSDL.

I like hearing from scientists who actually are in the field now, while my students need the information. I love for students to see and hear science that is happening right now...



Supporting K–12 Teachers in the Classroom

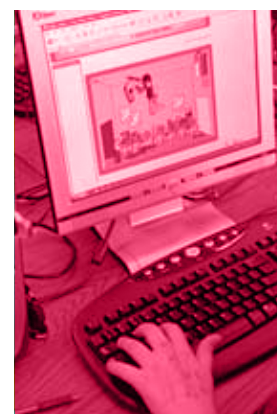
NSTA Web Seminars

NSDL is partnering with the National Science Teachers Association (NSTA) to present a series of online Web Seminars in 2006 and 2007. Web Seminars are 90-minute, live professional development experiences for teachers that use online learning technologies. NSTA/NSDL Web Seminars encourage participants to interact with scientists, engineers, and education specialists, all from a desktop computer. Highly interactive, the seminars are scheduled at times to allow convenient participation from all U.S. time zones.

Facilitated by an NSTA or NSDL coordinator, experts review specific science content or methods and strategies to teach science. Teachers have the chance to get real-time answers to questions and use online tools. Seminars are available on the NSTA web site (http://institute.nsta.org/web_seminars.asp) and linked to from NSDL.org. NSTA/NSDL seminars feature some of the exemplary collections and resources in NSDL.

Digital Libraries Go to School

Teaching effective use of web-based technologies in the classroom is one of the goals of a project funded by NSF's Teacher Professional Continuum program. NSDL is partnering with Utah State University and the State University of New York at Cortland on the Digital Libraries Go to School (DLGTS) project. DLGTS holds workshops designed to improve the online information-seeking and resource design skills of middle school science and math teachers, as well as to widen understanding among developers about teachers' needs and uses of technology. The workshops feature NSDL resources in combination with Utah State's Instructional Architect tool (<http://ia.usu.edu>), which helps teachers create lessons as web pages with built-in links to NSDL resources. Throughout this three-year project, teacher-created content will be posted on NSDL sites for other teachers to use and review. Initial workshops were held in rural areas of Utah and New York, to focus on providing benefit from online teaching tools in less urbanized locations. Additional workshops will include students in teacher training programs at SUNY Cortland and Utah State.



Project TestDrive

Another component of the NSDL Digital Libraries Go To School workshops, Project TestDrive, will ask teachers and students in 50 schools across the country to identify and use NSDL resources and provide feedback not only on the resources but the classroom context in which they were used. Project Tomorrow, an educational technology organization partnering with NSDL, is developing a rubric for evaluating current and future NSDL resources, and will design and implement teacher and student surveys. "It's going to be a year-long process," says Julie Evans of Project Tomorrow, who will conduct the research. The process aims to gain important information necessary to further develop strategies for meeting the changing needs of K–12 teachers. "I think the potential for NSDL is huge," says Evans. "But you must compete to get people's attention because they have so many other priorities. Students are pulled in all different directions, and not all teachers are comfortable using online resources. So we're going to be identifying specific ways to win over hearts and minds to NSDL."

Supporting Educational Reform

Throughout the nation's K–12 schools, there has been increasing emphasis over the past ten years on aligning curricula and assessments to centrally established content standards aimed at improving student learning. Scientific literacy for all citizens is the goal of the National Science Education Standards (NSES) and the foundation upon which individual state content standards are generally premised. In mathematics, the National Council of Teachers of Mathematics (NCTM) Standards serve as a similar reference point. NSDL partners have consistently worked to address the needs of educators, but for many the activity of detailing how their individual resources support each of the 49 sets of established state standards has been prohibitively complex. Different sets of state standards exist for core subjects, but among these there are few indices, and little cross-referencing among different state efforts. A collaboration between NSDL, Syracuse University, and JES & Co.'s Achievement Standards Network (ASN) database project is combining standards-based efforts to craft solutions to the challenges of associating resources to standards, both state and national.

An understanding of science makes it possible for everyone to share in the richness and excitement of comprehending the natural world. Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. And the economic productivity of our society is tightly linked to the scientific and technological skills of our work force.

–National Science Education Standards (NSES)

Achievement Standards Network

Several years ago NSF funded a project based at the University of Washington that included development of the Achievement Standards Network (ASN), an authoritative web-based collection of learning standards for primary and secondary schools at both state and national levels. JES & Co., a private non-profit, along with researchers at the University of Washington developed the ASN and is now distributing it through the State Educational Technology Directors Association (SETDA) (<http://www.thegateway.org/setdatoolkit>). The ASN includes an online forum where standard-writers can discuss topics such as what makes a good standard, and the best ways to correlate a standard to a resource.

Content Assignment Tool

The Center for Natural Language Processing (CNLP) at Syracuse University has been developing software that recognizes patterns in human language so it can be translated into terms computers can understand. Their Content Assignment Tool (CAT) uses Natural Language software to suggest state standards that might be supported by any file or web page that can be processed electronically. Users simply enter the URL for a web page or a link to a document, then choose the appropriate state or national standards that are recommended by the tool. An NSDL partner library and a partner with Syracuse on the CAT project, the Digital Library for Earth System Education (DLESE), has developed a web interface integrated with CAT that allows users to revise, edit, and enhance the standards that CAT assigns to online content.

Combining Services for Standards

With coordination by NSDL, developers from Teachers' Domain, the Content Alignment Tool project at Syracuse, and the ASN project are collaborating with the common goal of building extensible services on the work accomplished by each of these standards alignment and assignment projects. Supplemental NSF funding granted in 2006 is enabling these NSDL projects to polish existing tools and services for final integration into NSDL. These developers are creating methodologies and adapting their various individual project capabilities for correlating resources to standards, and aligning standards to standards (state to national and state-to-state). This foundational back-end technological work will enable the sharing of information for comparison of alignments; promote the development of a common application programming interface (API); result in a set of descriptions for the methodologies used; and will be informed by user testing. Several Pathways projects (Engineering and Teachers' Domain) are experimenting with these services—testing these system

abilities using their own resource collections. Taken together, these efforts create a solid platform of standards-related work that can be adapted to unique needs by individual Pathways or other partners, and integrated into NSDL as an adaptable service to its education communities.

Context, Contribution, and Collaboration: NSDL 2.0

NSDL is already a highly useful library of almost two million vetted science resources, but until now it has followed the traditional library model of search and discovery of resources. To find out about a resource, users must either consult the brief information in the catalog, or else examine the resource itself. Over the past five years of operation, we have heard a strong and consistent message from our community: "I don't just want a list of resources; I want to understand how to use them." The context of a resource—what benchmarks or educational standards it meets; how it relates to other resources; how other teachers have incorporated it into a lesson plan; and what teachers, scientists and librarians have to say about it—are all critical to allowing NSDL users to make effective use of the library.

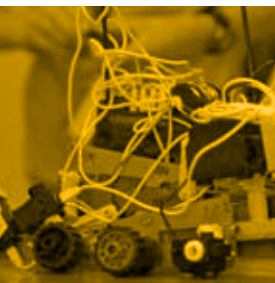
Building Technologies to Support Educational Context

The second major release of the NSDL technical infrastructure, NSDL 2.0, supports creating this web of context around the resources in the library. Users will be able to discover resources by their context—for example, by their association with a science education benchmark. Users will also be able to explore the context around a resource: reviews, teaching tips, related resources that were used in the same lesson plan, and much more. There are two critical features of NSDL 2.0: it will easily represent the web of related information around and among library resources, and it will make it very easy for qualified library users to add new context and content to the library.

The key component of NSDL 2.0 is the new NSDL Data Repository (NDR). The NDR is implemented using the Fedora middleware (<http://fedora.info>), an open-source Flexible, Extensible, Digital Object Repository Architecture that is being used and enhanced by libraries, universities, and firms around the world. After several years in development, NSDL switched over to the Fedora-based NDR in January 2007.

Contextualization is a critical component in active learning. Gaining an understanding of a concept includes the process of relating in a meaningful way to an idea, of seating it cognitively in personal experience or understanding. NSDL 2.0 tools and services will allow users to not only locate resources but to discover and create related information about science resources that can enhance understanding of a topic.





Creating Collaborative Spaces

Often referred to as Web 2.0, many new features in today's technology landscape are characterized by high user participation in content creation combined with deeper and broader access to interrelated information. NSDL 2.0's architecture and library services enable NSDL to build on social networking tools and participatory services such as bookmarking and tagging, wikis, blogs, podcasts, and RSS feeds. By allowing these tools to specifically reference, discuss, and organize library resources, and by capturing that information in the NDR, qualified NSDL users will be able to quickly and easily embed these resources in a web of context.

The integration of these social networking tools into the fabric of the library brings another major benefit. It will be easy for communities of interest to form around subsets of resources in the library and collaborate on enhancing library resources as well as context. This is already beginning to happen with NSDL blogs and wikis, even as NSDL works to fully integrate these tools into the NDR.

NSDL's Expert Voices (<http://expertvoices.nsd.org>) service uses blogging technology to support online conversations among scientists, teachers, students, and others. These conversations then become discoverable context around STEM topics. Expert Voices (EV) offers multiple models of use, some short-term focused on one-time events, or long-term for ongoing collaboration. EV can be used for topic-based discussions with links to related resources; as a way for resources to be reviewed and annotated; as a method of discovery for resources and news; as a mechanism to record and disseminate research results among collaborators; or as a question-and-answer forum.

A variety of discussion threads for different NSDL audiences have been piloted in the past year, utilizing three-person "discovery teams" as editors/moderators. Discovery teams can be almost any configuration of experts that come together to promote online conversation on STEM topics: K-12 teachers, university faculty, librarians, media specialists, or library developers. Expert Voices blogs provided follow-up discussion forums for NSTA/NSDL Web Seminars in 2006, and the *Meeting Web Kids on Their Own Turf* blog explores the many ways students utilize social media and other technology.

The MatDL Pathway's Soft Matter Wiki (<http://matdl.org/matdlwiki>), is a collaboration tool to create a locus for sharing research and resources on nanotechnology. This service shows how the educational technology of the NDR can offer unique communities of interest ways to create and organize collections of new or existing materials in the library, with the ability to more easily add metadata, annotations, and related information. NSDL is currently working with the MatDL Pathway on building the wiki extensions to fully integrate wiki resources, annotations, and

organization into the NDR. An NSDL-wide NDR-integrated wiki, called *OurNSDL*, will be released in the first half of 2007. *OurNSDL* is a groupware solution using the Media Wiki platform. Groupware is technology designed to facilitate the work of groups, either at the same time (synchronous) or at different times (asynchronous); and either face-to-face (co-located) or at a distance. This system will allow NSDL partners to collaborate and to create new STEM education resources and reflect them back into the NDR.

Another service in development is *MyNSDL*, built on the open-source Connotea system (Nature Publishing Group 2006), a social bookmarking and reference management service adapted to scientific use. Social bookmarking technologies allow users to bookmark and organize, as well as recommend resources through the use of *folksonomies* (as opposed to the use of a taxonomy). Folksonomies are user-generated labels (called tagging), that categorize content like web pages or links in a way that offers ease of search, discovery and navigation. Another example of folksonomic tagging is Del.icio.us (Schachter 2003).

Exploring Strand Maps: Making Connections

In 1993 the American Association for the Advancement of Science (AAAS) Project 2061 published a set of educational frameworks called *Benchmarks for Science Literacy* (AAAS 1993). It specified 853 science and math goals that students ought to reach by the time they graduate from high school. NSDL's Strand Map Service—a partnership between the University of Colorado at Boulder, the Digital Library for Earth System Education, and AAAS—organizes the AAAS benchmarks visually, shows how they interrelate, and ties them to appropriate related resources in the NSDL.

The Strand Map Service offers interactive web pages organized by subject. The text of each benchmark is contained inside a box that is connected with lines to other conceptually related benchmarks. For example, a standard for high school students that says, "matching coastlines and similarities in rock types and life forms suggest that today's continents are separated parts of what was long ago a single continent" leads to another standard that says "the solid crust of the earth . . . consists of separate plates that ride on a denser, hot, gradually deformable layer of the earth."

The Strand Map Service models connections between learning goals that were established by Project 2061 in its *Atlas of Science Literacy* (AAAS 2001). Each AAAS standard is linked to several related resources from NSDL, as well as to the National Science Education Standards (NSES) that are closely associated with it. Collaborating with DLESE, NSDL is working to integrate the Strand Map Service into NSDL, providing the capability to make strand maps available to a much wider audience and to inspire the adaptation of this powerful and innovative technology in a variety of educational settings.





The technological capabilities provided by the NDR offer previously unavailable flexibility and variety in the ways that the many projects, tools, and services that comprise NSDL can be integrated, adapted for use, and customized to the unique needs of multiple communities of practice in support of STEM education.

Digital Library Research and NSDL

NSDL and its partners continue to make fundamental contributions to digital library research. Throughout 2006, NSDL researchers have provided key participation at digital library conferences and workshops around the world. NSDL researchers were the recipients of the Vannevar Bush Best Paper Award at the Sixth ACM/IEEE Joint Conference on Digital Libraries (JCDL 2006) for the paper *Metadata Aggregation and "Automated Digital Libraries": A Retrospective on the NSDL Experience* (Lagoze et al. 2006a). This paper summarized the major lessons learned over a number of years of research and development work on the initial version of NSDL. At another major digital library conference of 2006, the 10th European Conference on Research and Advanced Technology for Digital Libraries (ECDL 2006), NSDL researchers again won the Best Paper award for *Representing Contextualized Information in the NSDL* (Lagoze et al. 2006b). This paper presents the architecture and design of NSDL 2.0.

In addition to the work summarized in these papers, significant NSDL research projects and contributions have included the Content Assignment Tool; the Strand Map Service; resolving scalability issues for Fedora repositories; research in the automated assignment of grade levels to science resources, and the iVia/Data Fountains project, a technology that crawls web sites and generates automatic forms of metadata. Both the Middle School Portal and MatDL Pathways have experimented with and served as test beds for iVia, which holds the promise of helping to alleviate time- and labor-intensive metadata generation by humans, and offers a way to help conserve limited project resources. Finally, the new NSF/Mellon-funded OAI Object Re-Use and Exchange Initiative (OAI 2006) grew, in part, out of the work involved in designing the digital object architecture of NSDL 2.0.



Educational Cyberinfrastructure

The Office of Cyberinfrastructure (OCI) at the National Science Foundation serves as the locus for coordination and collaboration focused on advances in computing and related information technology. *Cyberinfrastructure* describes the hardware, software, scientific data, and advanced computing technologies (such as those utilized in the TeraGrid Science Gateways Initiative), combined with essential social infrastructure—organizational models and processes of collaboration enabling scientific discovery that are multi-disciplinary and multi-institutional in scope. Many aspects of cyberinfrastructure are applicable and apparent in educational technology trends: open education resources, reuse and remixing of resources, blurring of formal and informal

learning, collaborations between professionals and amateurs, and understanding what the gaming world can apply to educational technology (Atkins 2006).

NSDL itself is one example of cyberinfrastructure: it provides a collaborative scaffold for people to create multiple combinations of technology, content, and services to support learning in all its dimensions. As NSDL continues to play a role in the development of a national cyberinfrastructure, there are multiple opportunities to partner with or provide services on the national level to other science gateways in the NSF community—serving a data stewardship role within the cyber world; and to other privately and publicly supported education initiatives—sharing

promising practices for using online STEM resources in a variety of education settings. Ultimately, as part of the national cyberinfrastructure, NSDL will have a role in closing the loop between applying innovative research in a variety of education settings.

An aspect of educational cyberinfrastructure that is fundamental within NSDL is the Community Sign-On (CSO) initiative. Community Sign-On describes the ability for a user registered and logged in at one NSDL Pathway or other partner site to move seamlessly to another NSDL site without additional logins. NSDL has been working with partner projects, at the technical, design, and policy levels to ensure that the full potential of this powerful, yet complex technology solution is realized. Leading the way among the partner sites, the Engineering Pathway has completed CSO integration and now has a fully functional system in production. A number of other projects are close to completion and are expected to reach production in the first half of 2007.

CSO has extensive implications for all projects, and dependencies that are the subject of ongoing discussion at all levels within NSDL. Key issues include data collection and sharing, user privacy, and integration of services. There is now a great deal of understanding within the NSDL on these complex issues and policies

In 2006 Science.gov acquired access to NSDL catalog records. Science.gov is a collaborative effort by a dozen federal science agencies; its database includes more than 50 million pages of research in a wide range of categories, as well as links to more than 1,800 web sites. "The NSDL addition expands and enhances our science education emphasis," says Eleanor Frierson, co-chair of the Science.gov alliance and deputy director of the National Agricultural Library.





and recommended practices are being developed for release in the coming year. These will be instrumental in ensuring that the NSDL community, projects and users alike, derives full benefit from CSO.

NSDL is working with the National Science Foundation directly as well as via Pathways partners with connections in research arenas to more ably support the agency and the research community overall. There are rich opportunities for NSDL to expand its role as a repository and archive for NSF-funded online STEM content and both scientific and educational research results. In addition, NSDL provides NSF's Office of Legislative and Public Affairs (OLPA) a service published on the NSF site called Classroom Resources (<http://www.nsf.gov/news/classroom>)—a multi-disciplinary collection of STEM lessons and web resources from the NSDL for teachers and students.

Alliances with the Scholarly Publishing Community

Scholarly journals, textbooks, and educational software have long been the foundation of research and academic activities in science, technology, engineering, and mathematics. For this reason, NSDL has, since its inception, worked to build productive alliances with a broad variety of publishers, a growing number of whom are contributing metadata and/or endorsing or facilitating educational development of full text content through linkages to the library's central collection and Pathways collections. The past year saw significant growth in the number and depth of the relationships NSDL has with publishers.

The strengths of scientific publishers afford natural points for collaboration with NSDL: mechanisms for acquiring and peer-reviewing content from scientists and science teachers; effective systems for editorial development, design, and production; excellent market research and evaluation services; established models for contracts, licenses, copyright, and intellectual-property management; and reliable systems for marketing and sustainability. Many publishers also work with vendors who provide technical infrastructure and support for schools, providing additional avenues into classrooms. Building on existing editorial arrangements and collaboratively exploring the possibilities in these activities with science publishers helps ensure that NSDL reaches its full potential as a functional and highly valued resource.

NSDL agreements with science publishers

- Scientific American
- Oxford University Press Journals
- HighWire Press
- Springer
- Elsevier Books
- John Wiley Books
- Blackwell Publishing
- Tool Factory
- Cambridge University Press Books
- Cambridge University Press Journals
- Houghton-Mifflin/McDougal-Littell
- Nature Publishing Group
- Tom Snyder Productions
- The Teaching Company
- BioOne
- National Academy Press
- McGraw-Hill Higher Education
- Prentice Hall



NSDL in the Future

Strengthening and leveraging NSDL's core partnerships and forging new strategic alliances are critical for the long-term success of the National Science Digital Library. Leveraging the expertise, tools and services, reputations, audience bases, and other resources of the NSDL network of partners strengthens each part as well as the whole. Improving the user experience at NSDL.org and across partner sites, enhancing NSDL's educational utility, and creating centralized services from which all parts of the network can gain benefit and efficiencies are the key goals in NSDL's strategies for building a strong future for the library.

Specific areas of work in 2007 will leverage the strong components of NSDL that this report has cited—collaborative areas of development with Pathways, including web metrics/usage tracking, accessibility, and Community Sign-On; search and discovery enhancement; tools and services integration with NSDL 2.0 infrastructure; collaborative mechanisms and services for user/contributors; extensible services supporting standards-based education; powerful tools such as the Strand Map project, and the expansion of strategic partnership-building efforts and publisher relations. All of these activities serve to create a critical mass of value between and among the network of partners and participants in the NSDL.

The vitality of NSDL has always been its community—a diverse and creative network of people and projects dedicated to effective STEM education and to building, maintaining, and improving the information landscape for new generations.

NSDL Projects 2000–2006

State	Institution	Project Name	Investigator	Fiscal Year
AZ	Center for Image Processing in Education	SIMPLE Science: Image-Based Learning Tools for K-12 Education http://www.simplescience.org	Moore, Stephen	2003
	University of Arizona	An Active Object-Based Digital Library for Microeconomics Education http://www.econport.org:8080/econport/request?page=web_home	Cox, James	2003
		The Tree of Life Project: A Digital Library of Biodiversity Information http://tolweb.org	Maddison, David	2003
		On-line Resources for Geotechnical Engineering, Rock Engineering, and Water and Its Use: Toward a National Civil Engineering Resource Library http://www.grow.arizona.edu	Budhu, Muniram	2001
		Intelligent Collection Services for and about Educators and Students: Logging, Spidering, Analysis and Visualization http://ai.eller.arizona.edu/research/dl/getsmart.htm	Chen, Hsinchun	2001
CA	California State University	Scaling the Peer Review Process for National STEM Education Digital Library Collections http://www.merlot.org	Hanley, Gerard	2002
		The NSDL Collaboration Finder: Connecting Projects for Effective and Efficient NSDL Development http://www.smete.org/smete/nsdl/collabfinder	Hanley, Gerard	2002
		Peer Review of Digital Learning Materials: Critical Service for Digital Libraries http://www.merlot.org	Hanley, Gerard	2000
	Design Science, Inc.	Enhancing the Searching of Mathematics http://www.dessci.com/en/reference/searching	Miner, Robert	2003
	Exploratorium	Professional Development Institutes to Increase Afterschool Educators' Use of the NSDL	Hsi, Sherry	2005
		Exploratorium Online: Exhibit-Based Science Learning and Teaching Digital Library http://www.exploratorium.edu/educate/dl.html	Hsi, Sherry	2003
	Foothill College	Collaborative Project: To Gather, Document, Filter and Assess the Broad and Deep Collection of the Digital Library for Earth System Education (DLESE) http://www.dlese.org	DiLeonardo, Christopher	2002
		Collaborative Project: To Enhance the Depth, Breadth, and Quality of the Collections of the Digital Library for Earth System Education (DLESE) http://www.dlese.org	DiLeonardo, Christopher	2000
	The Long Now Foundation	Collaborative Project: The Rosetta Project - ALL Language Archive http://www.rosettaproject.org	Mason, James	2003
	McLean Media	Creating Interactive Educational Activity Templates for Digital Libraries http://www.storyline.com/cc	McLean, Lois	2004
	New Media Studio	Collaborative Project: Personal Collections: Enhancing the Utility of the NSDL http://newmediastudio.org/DataDiscovery	Landsfeld, Martin	2004
		Data Discovery Toolkit and Foundry http://www.rosettaproject.org	Caron, Bruce	2001
	Stanford University	Collaborative Project: The Rosetta Project - ALL Language Archive	Keller, Michael	2003
	University of California, Berkeley	Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education http://engineeringpathway.org/ep	Agogino, Alice	2005
		Collaborative Research: Developing a Learner-Centered Metathesaurus for Science, Mathematics, Engineering and Technology Education	Agogino, Alice	2001
		Collaborative Project: Enhancing Interoperability of Collections and Services http://www.smete.org	Agogino, Alice	2001
		Developing a Core Integration System for a National Science, Mathematics, Engineering, and Technology Education Digital Library at www.smete.org	Agogino, Alice	2000

State	Institution	Project Name	Investigator	Fiscal Year
CO	University of California, Los Angeles	The Digital Chemistry Library http://socrates.berkeley.edu/~kubinec	Kubinec, Mark	2003
		A Digital Library: Collection for Visually Exploring United States Demographic and Social Change http://www.socialexplorer.com	Halle, David	2002
	University of California, Office of the President, Oakland	Collaborative Research: Health Education Assets Library http://www.healcentral.org	Uijtdehaage, Sebastian	2002
		Adding Value to the NSDL by Integrating It Into Academic Libraries: A Business Proposition and a Service Enhancement http://www.cdlib.org/inside/projects/metasearch/nsdl	Greenstein, Daniel	2003
		Collaborative Project: Assessing the User-base and Expanding the Usability/Reach of the Analytical Sciences Digital Library through Developmental Workshops	Larive, Cynthia	2004
	University of California, San Diego	Mobilizing Enduring NSDL Resources in Plate-Tectonics Research for Earth Science Education http://earthref.org/ERESE	Miller, Stephen	2003
	University of California, Santa Barbara	Bridging the Gap Between Libraries and Data Archives http://nsdl.sdsc.edu	Schottlaender, Brian	2001
		Textual - Geospatial Integration Services for NSDL http://www.alexandria.ucsb.edu/	Frew, James	2001
		Electronic Encyclopedia of Earthquakes http://www.scec.org/e3	Jordan, Thomas	2003
		Electronic Encyclopedia of Earthquakes http://www.scec.org/e3	Jordan, Thomas	2001
Colorado School of Mines	Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education http://engineeringpathway.org/ep	Mooney, Michael	2005	
	Collaborative Research: TeachEngineering - Hands-on Resources for K-12 http://teachengineering.org	Mooney, Michael	2003	
	Colorado State University	Water in the Earth System (WES): An NSDL K-12 Collection Project (current project title: Digital Water Education Library (DWEL)) http://www.dlese.org/library/query.do?q=&s=0&ky=0e	Geary, Ed	2001
		A Lightweight, Flexible, and Web-Based Approach to Supporting Workflow in Digital Libraries http://www-serl.cs.colorado.edu/metis	Anderson, Kenneth	2001
	Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education http://engineeringpathway.org/ep	Sullivan, Jacquelyn	2005	
	Collaborative Research: TeachEngineering - Hands-on Resources for K-12 http://teachengineering.org	Sullivan, Jacquelyn	2002	
	Enhancing NSDL.org with Concept-browsing Interfaces based on AAAS Strand Maps	Sumner, Tamara	2006	
	Strand Maps as an Interactive Interface to NSDL Resources http://preview.dlese.org/sms	Sumner, Tamara	2002	
	University Corporation for Atmospheric Research	Collaborative Research: THREDDS Second Generation http://my.unidata.ucar.edu/content/projects/THREDDS	Domenico, Ben	2003
		Thematic Real-time Environmental Data Distributed Services (THREDDS) http://my.unidata.ucar.edu/content/projects/THREDDS	Domenico, Ben	2001
		Collaborative Project: Core Integration of the National SMETE Digital Library http://nsdl.org	Fulker, David	2001
	Core Integration Services for a Federated NSDL http://webphysics.iupui.edu/jitt/jitt.html	Fulker, David	2000	
	Collaborative Project: Core Integration - Leading NSDL toward Long-Term Success http://nsdl.org	Howe, Kaye	2003	
United States Air Force Academy	JITDDL: The Just-in-Time Teaching Digital Library	Patterson, Evelyn	2003	

State	Institution	Project Name	Investigator	Fiscal Year
DC	American Association for the Advancement of Science	BioSciEd Net (BEN) Collaborative: Cycle 3 (Pathway) http://www.bioscienednet.org	George, Yolanda	2005
		BioSciEd Net (BEN) Collaborative: Cycle 2 http://www.bioscienednet.org	George, Yolanda	2002
		Biosciences Education Network (BEN) http://www.bioscienednet.org	George, Yolanda	2000
	American Chemical Society	Collaborative Project: ChemEd Digital Library: An NSDL Pathway for Chemical Sciences Education http://www.jce.divched.org/JCEDLib/index.html	Kirchhoff, Mary	2006
	American Psychological Association	Online Psychology Laboratory http://opl.apa.org	McCarthy, Maureen	2004
	Association of Research Libraries	Developing a National Science Digital Library (NSDL) LibQUAL+ Protocol http://www.libqual.org/Publications/index.cfm	Webster, Duane	2001
	Mathematical Association of America	The Math Gateway http://mathgateway.maa.org	Moore, Lawrence	2004
		MATHDL: A Library of Online Learning Materials in Mathematics and Its Applications http://www.mathdl.org	Moore, Lawrence	2000
	National Academy of Sciences	Annals of Research on Engineering Education (AREE) http://www.reeonline.org/	Fortenberry, Norman	2004
	GA	Emory University	Collaborative Project: The OCKHAM Library Network, Integrating the NSDL into Traditional Library Services http://www.ockham.org	Halbert, Martin
Kennesaw State University		Collaborative Project: Nuclear Pathways - A Model for Composite Collections http://www.nuclearpathways.org	Peterson, Laurence	2004
HI	Pacific Resources for Education and Learning	Ethnomathematics Digital Library http://www.ethnomath.org/	Lane, Nancy	2001
IA	Eastern Iowa Community College District	(NSDL) Advanced Technology Environmental Education Library (ATEEL) http://www.eerl.org	Kabat Lensch, Ellen	2002
IL	Argonne National Laboratory	Atmospheric Visualization Collection http://www.dlese.org/library/query.do?q=&s=0&ky=01	Klaus, Christopher	2000
	Northwestern University	Collaborative Research: THREDDS Second Generation http://my.unidata.ucar.edu/content/projects/THREDDS/	Edelson, Daniel	2003
	University of Illinois, Urbana-Champaign	Collaborative Project: Assessing the User-base and Expanding the Usability/Reach of the Analytical Sciences Digital Library through Developmental Workshops	Scheeline, Alexander	2004
Second Generation Digital Mathematics Resources with Innovative Content for Metadata Harvesting and Courseware Development http://mathworld.wolfram.com		Mischo, William	2002	
IN	Indiana University	Project ENABLE: Learning through Associations in a Grid-based Bioinformatics Digital Library http://lair.indiana.edu/research/enable	Mostafa, Javed	2003
		Reciprocal Net-- A Distributed Molecular Database http://www.reciprocalnet.org	Huffman, John	2001
KS	Kansas State University	Collaborative Project: Physics Teaching Web Advisory (Pathway) - A Digital Video Library for Enhancement and Preparation of Physics Teachers http://www.physicspathway.org	Zollman, Dean	2002
	University of Kansas Center for Research, Inc.	Analytical Sciences Digital Library http://www.asdlib.org	Kuwana, Theodore	2001
MA	Education Development Center	CaREN: Career Resources Education Network for STEM http://www2.edc.org/GDI/CaREN.htm	Nair, Sarita	2003
		Effective Access: Using Digital Libraries to Enhance High School Teaching in STEM http://www2.edc.org/GDI/effectiveaccess.htm	Hanson, Katherine	2002
		Gender and Science Digital Library http://www.gsdl.org	Hanson, Katherine	2001
	Harvard-Smithsonian Astrophysical Observatory	Harvard-Smithsonian Digital Video Library http://hsdvl.org	Schneps, Matthew	2002

State	Institution	Project Name	Investigator	Fiscal Year
MD	Marine Biological Laboratory	Collaborative Project: Digital Educational Resources in Microbial Ecology, Evolution and Diversity (DERMEED1) http://serc.carleton.edu/microbelife/index.html	Patterson, David	2003
	TERC Inc.	Earth Exploration Toolbook Workshops to Facilitate the Use of Earth Science Data in Education http://serc.carleton.edu/eet/index.html	McAuliffe, Carla	2005
		Earth Exploration Toolbook: A Collection of Examples of Educational Uses of Earth System Science Tools, Datasets and Resources http://serc.carleton.edu/eet	Ledley, Tamara	2002
	Tufts University	Collaborative Research: Managing Authority Lists for Customized Linking and Visualization: A Service for the National SMETE Digital Library http://nils.lib.tufts.edu/scale	Sauer, Anne	2002
	University of Massachusetts Amherst	Customizing Resources for NSDL http://mathforum.org	Wolf, Beverly	2005
		Question Triage for Experts and Documents: Expanding the Information Retrieval Function of the NSDL http://ciir.cs.umass.edu/research/triage.html	Croft, W. Bruce	2002
	Worcester Polytechnic Institute	Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education http://engineeringpathway.org/ep	Cyr, Martha	2005
		Collaborative Research: TeachEngineering - Hands-on Engineering http://teachengineering.org	Cyr, Martha	2002
	WGBH Educational Foundation	Fire Science Multimedia Library	Woycheese, John	2003
		Teachers' Domain Educational Standards Enhancement http://www.teachersdomain.org	Sicker, Theodore	2006
Teachers' Domain Pathways to Science: Rich-Media Sources for K-12 Teachers http://www.teachersdomain.org		Sicker, Theodore	2004	
Access NSDL http://accessnsdl.org		Kirkpatrick, Andrew	2002	
MD	American Association of Physics Teachers	Teachers' Domain - Physical Science and Engineering http://www.teachersdomain.org	Korf, Michele	2002
		Teachers' Domain Collection: Life Sciences, K-12 http://www.teachersdomain.org	Korf, Michele	2001
	ComPADRE Pathway for Physics and Astronomy Education http://www.compadre.org	Mason, Bruce	2005	
Johns Hopkins University	ComPADRE: Communities for Physics and Astronomy Digital Resources in Education http://www.compadre.org	Mason, Bruce	2002	
	Collaborative Proposal: Managing Authority Lists for Customized Linking and Visualization: A Service for the National SMETE Digital Library http://nils.lib.tufts.edu/scale	Choudhury, Golam	2002	
	University of Maryland	Collaborative Research: Developing a Learner-Centered Metathesaurus for Science, Mathematics, Engineering and Technology Education	Wood, William	2001
Universities Space Research Association	Virtual Telescopes in Education (TIE) http://vtie.gsfc.nasa.gov	Hoban, Susan	2001	
	Implementing an Electronic Peer-reviewed Journal of Earth System Science Education Resources (JESSE) http://jesse.usra.edu	Johnson, Donald	2000	
ME	Maine Mathematics and Science Alliance	PRISMS- Phenomena and Representations for the Instruction of Science in Middle Schools	Keeley, Page	2004
MI	Eastern Michigan University	Collaborative Research: DLConnect: Connecting Underserved Teachers and Students with NSDL Learning Resources and Tools http://dlconnect.usu.edu	Hoffman, Ellen	2004
		Infusing NSDL in Middle Schools: Obstacles and Strategies http://www.terc.edu/work/167.html	Hoffman, Ellen	2003
	Collaborative Project: The Rosetta Project - ALL Language Archive http://www.rosettaproject.org	Aristar-Dry, Helen	2003	

State	Institution	Project Name	Investigator	Fiscal Year
		TeacherLIB - Digital Community and Collections for Science and Mathematics Teacher Education http://mtn.merit.edu	Hoffman, Ellen	2000
	Merit Network, Inc.	Viewing the Future: Aligning Internet2 Video to K-12 Curriculum	Mardis, Marcia	2002
	Michigan State University	An Intelligent Digital Environment for Groundwater Education and Research http://www.egr.msu.edu/igw	Li, Shu-Guang	2003
	University of Michigan, Ann Arbor	Web Lecture Archiving System for Professional Society Meetings	Neal, Homer	2003
		A Digital IdeaKeeper For K-12: NSDL Scaffolded Portal Services for Information Analysis and Synthesis http://hice.org/ideakeeper	Quintana, Chris	2002
	Wayne State University	Collaborative Proposal: DLConnect: Connecting Underserved Teachers and Students with NSDL Learning Resources and Tools http://dlconnect.usu.edu	Mardis, Marcia	2006
		Unleashing Supply: Services for Collaborative Content Development http://www.opencourse.org	Stephenson, Robert	2002
MN	Carleton College	Pedagogic Services for Digital Libraries http://serc.carleton.edu/sp/index.html	Manduca, Cathryn	2005
		Linking Pedogogy, Resources and Community Interaction to Support Entry-Level Undergraduate Geoscience Courses http://serc.carleton.edu/introgeo	Manduca, Cathryn	2002
MO	University of Missouri	Enhancing Interoperability of NSDL Collections and Services	Chen, Su-Shing	2001
		Digital Library for Learning Life Sciences http://dlbox.nudl.org	Chen, Su-Shing	2000
MT	Montana State University	Collaborative Project: Digital Educational Resources in Microbial Ecology, Evolution, and Diversity (DERMEED-1) http://serc.carleton.edu/microbelife/index.html	Mogk, Dave	2003
NC	Duke University	Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education http://engineeringpathway.org/ep	Ybarra, Gary	2005
	North Carolina State University	PER-CENTRAL: A Digital Library Supporting Physics Education Research http://www.per-central.org/index.cfm	Beichner, Robert	2003
	Shodor Education Foundation Inc	The Computational Science Education Reference Desk http://www.shodor.org/refdesk	Panoff, Robert	2004
	University of North Carolina, Wilmington	Integrating Digital Libraries and Traditional Libraries: A Model for Sustaining NSDL Collections	Ward, Charles	2003
	Winston-Salem State University	NSDL: Towards Reusable and Shareable Courseware: Topic Maps-based Digital Libraries http://compsci.wssu.edu/iis/nsdl	Dicheva, Darina	2003
ND	North Dakota State University, Fargo	The Digital Archive Network for Anthropology (DANA) http://www.dana-wh.net	Clark, Jeffrey	2001
NH	Dartmouth College	Collaborative Project: To Gather, Document, Filter and Assess the Broad and Deep Collection of the Digital Library for Earth System Education (DLESE) http://www.dlese.org	DeFelice, Barbara	2002
		Collaborative Project: To Enhance the Depth, Breadth, and Quality of the Collections of the Digital Library for Earth System Education http://www.dlese.org	DeFelice, Barbara	2000
NJ	New Jersey Institute of Technology Foundation	Integral (Integrating Libraries): Expanding the NSDL's Reach to Traditional Libraries through Resource Integration http://www.is.njit.edu/integral	Bieber, Michael	2004
		Digital Library Service Integration http://is.njit.edu/dlsi	Bieber, Michael	2002
		General Recommendation Engine (GRE) for NSDL http://www.is.njit.edu/integral	Im, Il	2004
	Rutgers University New Brunswick	The Moving Image Gateway http://gondolin.rutgers.edu/MIC	Agnew, Grace	2002

State	Institution	Project Name	Investigator	Fiscal Year
NM	Integre Technical Publishing Company, Inc.	Techexplorer and MathDL: Robust Support for Dynamic Web-based Mathematics http://www.integretechpub.com/techexplorer	DeLand, Donald	2003
NY	Columbia University	Adding Value to NSDL Resources through Pedagogical Content Knowledge Annotations	Kim Kastens	2006
		Collaborative Project: To Enhance the Depth, Breadth, and Quality of the Collections of the Digital Library for Earth System Education (DLESE) http://www.dlese.org	Kastens, Kim	2002
		Collaborative Project: To Gather, Document, Filter and Assess the Broad and Deep Collection of the Digital Library for Earth System Education http://www.dlese.org	Kastens, Kim	2000
		Collaborative Project: Core Integration - Leading NSDL toward Long-Term Success http://nsdl.org	Wittenberg, Kate	2003
		Collaborative Project: Core Integration of the National SMETE Digital Library http://nsdl.org	Wittenberg, Kate	2001
		Columbia Pubscape: A Core Integration System for a National Science Digital Library Publishing Center	Wittenberg, Kate	2000
	Cornell University	Collaborative Project: Core Integration of the National SMETE Digital Library http://nsdl.org	Arms, William	2001
		The NSDL Central System	Arms, William	2000
		Kinematic Models for Design Digital Library (K-MODDL) http://kmoddl.library.cornell.edu	Saylor, John	2002
		Collection and Dissemination of Geoscience Data and Knowledge for the National Science Digital Library http://atlas.geo.cornell.edu	Seber, Dogan	2001
		Collection and Distribution of Geoscience (Solid Earth) Data Sets for the National Science Digital Library http://atlas.geo.cornell.edu	Seber, Dogan	2000
		Digital Mathematics Library http://www.library.cornell.edu/dmlib	Thomas, Sarah	2002
	Cornell University - Endowed Colleges	Collaborative Project: An NSDL Registry: Supporting Interoperable Metadata http://eg2.ischool.washington.edu/registry	Hillman, Diane	2005
		Collaborative Project: Core Integration - Leading NSDL toward Long-Term Success http://nsdl.org	Arms, William	2003
		Enabling Large Scale Coherency Among Mathematical Texts in the NSDL	Constable, Robert	2003
	Cornell University - NYS Land Grant Colleges	Facilitating K-12 Selection in an Annotated Rich Media Library of Animal Behavior http://www.vivo.cornell.edu/entity?home=1&id=14450	Bradbury, Jack	2005
		A Digital Rich Media Library of Animal Behavior http://www.birds.cornell.edu/macaulaylibrary/	Bradbury, Jack	2003
		The Science Knowledge and Education Network Building a User Base around Scientific Publications: Editing Online Content and Annotating Scientific Materials http://www.sken.org	Kelling, Steven	2004
	City University of New York	Collaborative Research: A Digital Library Collection for Visually Exploring United States Demographic and Social Change http://www.sociaexplorer.com	Beveridge, Andrew	2002
	solutions-united.com	Breaking the Metadata Generation Bottleneck	Paik, Woojin	2000
	Syracuse University	Computer-Assisted Content Standard Assignment and Alignment http://www.cnlp.org/research/project.asp?recid=48	Diekema, Anne	2004
		Students Using NSDL (SUN): Science Information Literacy and the NSDL http://www.nsdlsun.org	Silverstein, Joanne	2003
		Integrating Expertise into the NSDL http://ask.nsdsl.org	Lankes, Richard	2001
		MetaTest: Evaluating the Quality and Utility of Metadata http://www.cnlp.org/research/project.asp?recid=40	Liddy, Elizabeth	2002

State	Institution	Project Name	Investigator	Fiscal Year
		Collaborative Project: StandardConnection - Mapping NSDL Educational Objects to Content Standards http://www.cnlp.org/research/project.asp?recid=35	Liddy, Elizabeth	2001
		Breaking the Metadata Generation Bottleneck http://www.cnlp.org/research/project.asp?recid=32	Liddy, Elizabeth	2000
OH	Kent State University	NSDL Materials Digital Library Pathway: Hub for Materials Education and Research http://www.matdl.org	Bartolo, Laura	2005
		Materials Digital Library: MatDL.org http://www.matdl.org	Bartolo, Laura	2003
		Quality Analysis of Metadata Records in the NSDL Metadata Repository http://appling.kent.edu/nsdlmetadataquality	Zeng, Marcia	2003
		Green's Functions Research and Education Enhancement Network (GREEN) http://appling.kent.edu/NSDLGreen	Shreve, Gregory	2001
	Ohio State University Research Foundation	Connecting NSTA K-16 Science Content to NSDL	Lightle, Kimberly	2005
		Collection Building and Capacity Development for K-12 Federally-Produced Mathematics and Science Education Digital Resources	Lightle, Kimberly	2002
		National Digital Library for Undergraduate Mathematics, Science, and Technology Teacher Preparation and Professional Development	Lightle, Kimberly	2000
		CAUSEweb: A Digital Library of Undergraduate Statistics Education http://www.causeweb.org	Pearl, Dennis	2003
		Marine Mammal Commission Digital Library of International Environmental and Ecosystem Policy Documents http://nsdl.tierit.com/	Berkman, Paul Arthur	2002
	University of Dayton	A Digital Library of Ceramic Microstructures http://www.udri.udayton.edu/dlcm	Wills, Roger	2001
OK	University of Oklahoma	Collaborative Research: TeachEngineering - Hands-on Resources for K-12 http://teachengineering.org	Mooney, Michael	2002
	University of Oklahoma Health Sciences Center	Collaborative Research: Health Education Assets Library http://www.healcentral.org	Summers-Ables, Joy	2002
OR	Eduworks Corporation	Collaborative Proposal: Personal Collections: Enhancing the Utility of the NSDL	Robson, Robert	2004
		Fostering Reuse and Interoperability for the NSDL http://www.reusablelearning.org	Robson, Robert	2003
	Oregon Health and Science University	Collaborative Project: Superimposed Tools for Active Arrangement and Elaboration of Educational Resources	Delcambre, Lois	2004
	Oregon State University	Collaborative Project: The OCKHAM Library Network, Integrating the NSDL into Traditional Library Services http://www.ockham.org	Frumkin, Jeremy	2003
PA	Carnegie-Mellon University	Collaborative Project: ChemEd Digital Library: An NSDL Pathway for Chemical Sciences Education http://www.jce.divched.org/JCEDLib/index.html	Yaron, David	2006
		Using Digital Libraries to Build Educational Communities http://www.chemcollective.org	Yaron, David	2003
		Collaborative Project: A Component Repository and Environment for Assembly of Teaching Environments (CREATE)	Yaron, David	2000
		Collaborative Project: Physics Teaching Web Advisory (Pathway) - A Digital Video Library for Enhancement and Preparation of Physics Teachers http://www.physicspathway.org	Stevens, Scott	2002
		Threading Information Pathways Through NSDL Video (Services Proposal) http://www.informedia.cs.cmu.edu/dli1/resource.html	Wactlar, Howard	2000

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	Drexel University	Leadership Development for Technology Integration: Developing an Effective NSDL Teacher Workshop Model	Klotz, Eugene	2005
		Math Tools Project http://www.mathforum.org/mathtools	Klotz, Eugene	2002
		Collaboration Services for the Math Forum Digital Library	Stahl, Gerry	2003
		Improving Knowledge Transfer: Prioritizing Content Creation in Digital Libraries Using Competitive Intelligence Systems	Atwood, Michael	2000
	Swarthmore College	NSDL: A Digital Library Collection for Computer Vision Education http://www.cved.org	Maxwell, Bruce	2002
	Villanova University	Collaborative Project: Superimposed Tools for Active Arrangement and Elaboration of Educational Resources	Cassel, Lillian	2004
RI	Brown University	ReMarkable Texts: A Digital Notepad for the NSDL http://graphics.cs.brown.edu/research/ReMarkableTexts/	van Dam, Andries	2002
		Collaborative Project: A Component Repository and Environment for Assembly of Teaching Environments (CREATE)	van Dam, Andries	2000
TN	University of Tennessee, Knoxville	An Active Mathematical Software Collection for Inquiry-based Computational Science and Engineering Education http://icl.cs.utk.edu/activenetlib	Dongarra, Jack	2001
		Integrating the NSDL Into Undergraduate Science Education by Creating a Collaborative Learning Environment http://web.utk.edu/~tenopir/nsf/presentations.html	Tenopir, Carol	2001
TX	Rice University	Advanced Placement Digital Library for Biology, Physics and Chemistry http://apdl.rice.edu	Kumari, Datla Siva	2002
	Texas A&M	Using Spatial Hypertext as a Workspace for Digital Library Providers and Patrons http://www.csdl.tamu.edu/VKB	Shipman, Frank	2002
		Design and Evaluation of Maintenance Tools for Distributed Digital Libraries http://www.csdl.tamu.edu/walden	Shipman, Frank	2001
		Integrating Digital Library Resources into Online Courses	Smisko, Ann	2002
		Metadocuments as Communicative Artifact to Enable Use of a Research Digital Library in Undergraduate STEM Education http://www.csdl.tamu.edu/walden	Furuta, Richard	2000
	University of Texas, Austin	www.eSkeletons.org: An Interactive Digital Library of Human and Primate Anatomy http://www.eSkeletons.org	Kappelman, John	2002
	University of Texas, Medical Branch at Galveston	Ceph School: A Pedagogic Portal for Teaching Biological Principles with Cephalopod Molluscs	Lee, Phillip	2002
UT	University of Utah	Collaborative Research: Health Education Assets Library http://www.healcentral.org	Dennis, Sharon	2002
		A Digital Multimedia Library for Health Sciences Education http://www.healcentral.org	Dennis, Sharon	2000
	Utah State University	Services to Link OpenCourseWare Repositories and the NSDL	Muramatsu, Brandon	2005
		Collaborative Proposal: DLConnect: Connecting underserved teachers and students with NSDL learning resources and tools http://dlconnect.usu.edu	Recker, Mimi	2004

State	Institution	Project Name	Investigator	Fiscal Year
		Integrating and Extending the Instructional Architect: An Instructional Service for NSDL http://ia.usu.edu	Recker, Mimi	2003
		The Instructional Architect: A System for Discovering, Recommending, and Combining Learning Objects http://ia.usu.edu	Recker, Mimi	2000
VA	American Geological Institute	Collaborative Research: To Enhance the Depth, Breadth, and Quality of the Collections of the Digital Library of Earth System Education (DLESE) http://www.dlese.org	Tahirkheli, Sharon	2002
		Collaborative Project: To Gather, Document, Filter and Assess the Broad and Deep Collection of the Digital Library for Earth System Education http://www.dlese.org	Tahirkheli, Sharon	2000
	American Indian Higher Education Consortium	Digital Library Services for American Indians	Billy, Carrie	2001
	International Technology Education Association	National Digital Library for Technological Literacy	Sterry, Len	2001
	National Association of Biology Teachers	Biology Education Online - An Interactive Electronic Journal http://www.accessexcellence.org/	Carley, Wayne	2000
	Old Dominion University Research Foundation	A Self-sustainable Digital Library for Evolving Communities	Zubair, Mohammad	2003
		An OAI-Compliant Federated Physics Digital Library for the NSDL http://archon.cs.odu.edu	Maly, Kurt	2001
	University of Virginia	Decentralized Image Retrieval for Education (DIRECT) http://viva.ee.virginia.edu/projects_direct.htm	Acton, Scott	2001
	Virginia Polytechnic Institute and State University	Personalization of Content Bridging the Gap between NSDL and its Users through the Course web site http://www.teachengineering.org	Perez, Manuel	2005
		Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education http://engineeringpathway.org/ep	Tront, Joseph	2005
		Collaborative Project: The OCKHAM Library Network, Integrating the NSDL into Traditional Library Services http://www.ockham.org	Fox, Ed	2003
		Computing and Information Technology Interactive Digital Educational Library (CITIDEL) http://www.citidel.org/	Fox, Ed	2001
	Washington and Lee University	A Digital Library Network for Engineering and Technology http://www.dlnet.vt.edu	Rahman, Saifur	2000
		Collaborative Project: Nuclear Pathways - A Model for Composite Digital Collections	Settle, Frank	2004
		The Development and Use of Digital Collections to Support Interdisciplinary Education http://home.wlu.edu/~blackmere/NSDL/Planning_Digital_Collections.htm	Settle, Frank	2002
		The Alsos Digital Library http://alsos.wlu.edu	Settle, Frank	2000
WA	University of Washington	Collaborative Project: An NSDL Registry: Supporting Interoperable Metadata http://metadataregistry.org	Sutton, Stuart	2005
		Collaborative Project: StandardConnection - Mapping NSDL Educational Objects to Content Standards http://www.ischool.washington.edu/sasutton/NSDL/StandardConnection	Sutton, Stuart	2001
WI	University of Wisconsin, Madison	Collaborative Project: ChemEd Digital Library: An NSDL Pathway for Chemical Sciences Education http://www.jce.divched.org/JCEDLib/index.html	Moore, John	2006
		The Journal of Chemical Education Digital Library http://jce.divched.org/JCEDLib	Moore, John	2002
		AMSER: Applied Math and Science Education Repository http://www.amser.org	Bower, Rachael	2004

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		CoMPASS-DL: Design and use of a concept map interface for helping middle school students navigate digital libraries http://www.compassproject.net/info/NSDL_overview.htm	Puntambekar, Sadhana	2004
		Faculty Participation in the NSDL - Lowering the Barriers	Wolf, Alan	2004
		The Internet Scout Project's Targeted Information Provision Service http://scout.wisc.edu	Strikwerda, John	2003
		Optimizing Workflow and Integration in NSDL Collections	Strikwerda, John	2002
		The Internet Scout Project's Personalized Content Delivery System http://scout.wisc.edu/Projects/NSDLReports	Strikwerda, John	2001

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NSDL Funding FY2000–FY2006

	Core Integration	Subcontracts	Pathways	Collections	Services	Research	Total
FY2000							
Number of Awards	6	0		13	9	1	29
Percentage of Funding	32%	0%		42%	24%	2%	100%
Dollar Amount	4,398,381	0		5,780,925	3,222,401	249,945	13,651,652
FY2001							
Number of Awards	3	4		18	14	4	39
Percentage of Funding	18%	1%		57%	21%	3%	100%
Dollar Amount	4,626,700	285,279		14,291,772	5,204,161	722,766	25,130,678
FY2002							
Number of Awards	3	5		35	11	6	55
Percentage of Funding	3%	5%		68%	15%	9%	100%
Dollar Amount	945,789	1,226,114		18,080,901	4,159,299	2,351,705	26,763,808
FY2003							
Number of Awards	3	5		22	11	8	44
Percentage of Funding	20%	5%		47%	16%	12%	100%
Dollar Amount	4,488,183	1,197,183		10,843,363	3,578,130	2,695,172	22,802,031
FY2004							
Number of Awards	3	6	4		14	6	27
Percentage of Funding	34%	6%	14%		34%	12%	100%
Dollar Amount	6,612,270	1,184,885	2,668,473		6,537,438	2,214,480	19,217,546
FY2005							
Number of Awards	3	7	8		8	2	21
Percentage of Funding	32%	7%	31%		26%	5%	100%
Dollar Amount	5,507,702	1,168,259	5,402,530		4,481,029	909,912	17,469,432
FY2006							
Number of Awards	3	9	9		8	0	20
Percentage of Funding	44%	9%	43%		5%	0%	100%
Dollar Amount	5,370,869	1,121,675	5,252,915		597,120	0	12,342,579

Note: Subcontract figures are a part of the Core Integration budget but are separated here to discern between CI and community tasks.

As such, Subcontracts Awards are not listed in the total number of awards.

Acknowledgements

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