Exploratorium Online
Exhibit-Based Science Learning and Teaching Digital Library

Statement of Need

A. Background. The Exploratorium’s museum-based digitized assets offer unique interactive and inquiry-based science learning (Bazin and Tamez, 2002; Kluger-Bell, 1995; NSF Foundations, 2000). Since its opening in 1969, the Exploratorium has been a nexus of activity that nurtures experiential learning, informal science discovery, and personal inquiry via play with thoughtfully designed interactive exhibits (Oppenheimer, 1968; Semper, 1990). A corpus of educational materials and resources continues to grow at the Exploratorium to support exhibit-based science teaching, teacher professional development, and informal lifelong learning.

In particular, resources and activities that comprise teacher professional development programs at the Exploratorium contain inquiry-based classroom activities, workshop instructions, field trip lesson plans, pedagogical insights, and inquiry-based assessments. These have reached over 10,000 educators, and been tested and refined by over 2,000 teachers and teacher educators who regularly use museum resources for their professional and classroom development. Educators personally experience hands-on inquiry at the museum, and continue their investigations via the Exploratorium online exhibits and online educator communities (Ash and Klein, 1999; Falanga and Hunt, 2002) (Figures 1 and 2).

Although there is no shortage of science content available in digital collections, materials that are particularly useful, applicable, and relevant to elementary science teachers, secondary science teachers, and K-12 teacher educators are limited. Science museums offer unique resources for teachers that capture knowledge about natural phenomena, cultural relevance, and the social contexts of informal learning. A digital library as an “institutional repository” can extend and augment the physical counterparts of exhibits by enabling new forms of interaction, creation, and innovation (Lynch, 2003; Nickerson, 2002.) Exploratorium Online will create access to broader audiences of informal learners, new forms of scholarship in science teaching, and new opportunities for global exchange of science teaching media if these resources are made available as part of the national digital library.

B. Online Resources for Teachers

In an age now driven by the relentless necessity of scientific and technological advance, the current preparation that students in the United States receive in mathematics and science is, in a word, unacceptable.

—National Commission on Mathematics and Science Teaching for the 21st Century

International and national studies continue to find that the science and mathematics learning, achievement, and performance of students and teachers are among the lowest in the United States compared to other nations (Gonzales et al., 2000; TIMSS-Schmidt et al., 1997; NCES, 2000-01) One can imagine that the public’s understanding of science is at the same level, if not lower.

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1 The Exploratorium is a hands-on museum of science, art, and perception founded by physicist and educator Frank Oppenheimer. The museum is currently directed by Dr. Goery Delacôte, a renowned French physicist, science educator, and public servant.
There is a consensus among policy makers, parents, researchers, and teachers that the quality of teaching is one of the most important determinants of student learning, achievement, and success (Black and William, 1998; Darling-Hammond, 2000). Effective professional development gives teachers the opportunity to learn how to implement inquiry-based approaches, standards-based curricula, and assessments in order to improve student learning and receive constructive feedback on effective teacher practice (Krajcik, Czerniak, and Berger, 1998). Skillful consistently produce high levels of student learning while also addressing state and national standards. Unfortunately, a larger portion of teachers rarely experience research-informed, hands-on professional development nor science inquiry in their own schooling. This is a major obstacle to improving science education in formal and informal settings.

Many creative efforts to provide sustained, high-quality teacher professional development are turning to distance learning technologies and online solution (e.g., VISIT, TERC Science Online, NTEN, LessonLab, Jason Academy). However, there is still no cumulative knowledge base of freely available, high-quality inquiry-based science learning resources and K-12 science teaching media to draw on to construct online experiences for teacher learning in the sciences. Digital resources for science teaching and learning could benefit from linkage to research-informed “pragmatic pedagogical principles” or learner-centered/instructional design principles to support instructional uses of digital resources and science media (Bonk and Cunningham, 1998; Linn and Hsi, 2000; Wiley, 1999).

As a free-standing Web resource, Exploratorium Online would be a digital collection of teacher-tested, teacher-valideated professional development science teaching resources accessible in a uniform, searchable database coordinated with curricular standards. Informal and lifelong learners will also have access to this rich, well-indexed collection. As more Exploratorium-inspired digital assets are tested by educators and added to the digital library, these can be indexed by pedagogical approaches, instructional design principles, curricular goals, lesson plan subject, standards, learner assessments, and grade levels. As a living database for onsite and online museum communities, we believe Exploratorium Online will be an invaluable national resource as well as a catalyst for other enterprises that rely on rich collections to create effective teacher education.

C. Exploratorium Resources. The existing Exploratorium collection covers a broad range of topics in science, and digital exhibit-based activities that have been “hardened” and “validated” over many year by teachers and a diverse audience of students and informal learners.

Since the introduction of networked-based new media technologies in the 1980s, the Exploratorium
has developed CD-ROMs, instructional digital videos, and over 14,000 Web pages\(^2\) around particular science topics, and science education projects, many from projects funded by NSF. The museum also hosts live Webcasts that feature topics on everyday science (e.g., the science of candy making, pickles, seeing, music, baseball) and captures scientific research processes and practices from the field (e.g., Scientific Journeys from McMurdo to Antarctica, field biology in the Jungle Lab in Belize, 50\(^{th}\) Anniversary of the Discovery of DNA) (Figure 3). Other digital exhibit-based resources exist in project-specific databases. For example, the Exploratorium Imaging Station generates primary scientific data in the form of high-resolution microscopy images on animal and plant specimens that visitors select. The Exploratorium exhibit cross-reference database captures science explanations (at different levels of scientific expertise) about each of 650 exhibits and shares how one exhibit is conceptually related to other exhibits (e.g., by science topic, scientific phenomena, exhibit area, exhibit designer, etc.).

Although these materials reside at the Exploratorium, we hope to share these resources broadly with science teaching institutions, museum partners, and the general public.

Another digital exhibit-based resource is the Field Trip Pathways, a collection of support and assessment materials for teachers who bring students to the museum. Pathways provide direction and structure for the field trip, focus the attention of students on a set of exhibits or a topic, and provide a method of learner assessment, as well as suggest links to related materials and additional experiments for pre- and post-trip learning. An online learner can take a conceptual pathway through exhibit-based content that is either guided with pedagogical scaffolds or follow an open-ended pathway. Other digital assets include the School in the Exploratorium series of teacher professional development materials that help educators in formal and informal settings use a science museum’s learning environment.

Given the rich, growing mass of digital resources at the Exploratorium, there exists the opportunity to disseminate this ever-expanding collection of exhibit-based resources to a broader national audience via NSDL to engage and motivate interest in

\(^2\) Exploratorium Home Page: http://www.exploratorium.edu/.

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**Fig. 3:** Sample project site from Exploratorium Web site: Antarctic science, stories, and Webcasts from the South Pole.
D. Synergies. Indexing assets to the National Science Educational Standards will make Exploratorium resources more accessible and valuable to educators and teacher educators. The Exploratorium has been developing, testing, and implementing an Exploratorium Digital Asset Management program (EDAM), to establish a long-term institution-wide initiative to digitize and catalog its extensive collection of science resources to both the State and National Standards (Falanga, 2002). With prior support from IMLS, 7000 assets (e.g., digital image files, sounds, text documents, and movies) have been identified, selected, and digitized (into Canto Cumulus, a commercially available software-cataloging tool.)

With NSDL, Exploratorium Online will seek synergies with other efforts that support K-12 science teachers including Eisenhower National Clearinghouse, MERIT at Michigan, and the Harvard-Smithsonian Center for Astrophysics, which is establishing a library of 350 hours of digital video materials supporting STEM education and indexing these videos using the National Science Education Standards. The Exploratorium will index the digital collection to NSES to improve accessibility and applicability to educators and their learners; we foresee synergistic collaborations to support science teaching drawing on informal science learning media.

E. Exhibit Resources. Current metadata standards for cataloging digital resources with educational descriptors might lack categories that are important to tagging and searching across museum exhibit-based science resources. Many of the digital assets are complex objects with embedded scientific and pedagogical information that embodies the Exploratorium approach to designing interactive exhibits, constructivist activities, and inquiry-based materials as shown in Figure 4. To date, we have collected simple objects such as digital photographs, movies, and text documents. However, digital learning objects that have the most pedagogical value are complex objects with inherent instructional design relationships in multiple files including conceptual links, explanations, visualizations, and other learning objects. To catalog a Web site on a single Web site topic at the Exploratorium (e.g., Global Climate Change) would require a sophisticated set of meta-descriptors and other elements.

Although we hope to make use of existing standards for organizing educational learning objects such as IEEE LOM (IEEE 2000, 2001), we will likely discover unique aspects to the Exploratorium’s exhibit-based resources because of the nature in which they were invented, and how they address informal science learning, encourage scientific experimentation, promote integrated understanding of science (Linn and Hsi, 2000), and constructivist activity (Resnick and Kafai, 1996). Valuable information behind the exhibit-design such as the designer’s rationale, ways to “see” the phenomena, tips and strategies for engaging with the exhibit, ways to use the exhibit to address naïve conceptions in science may impact existing LOM standards.

F. Although reuse intention is high among stakeholders in the Exploratorium’s museum and educator network, reinvention is the norm because of the lack of distributed access. Reinventing existing educational content and resources is both expensive and unproductive (Sumner and Dawe, 2001.) The power of this future collection is when it inspires discovery, creativity, collaboration, local adaptations and new customizations across our user audiences whether they choose to reuse a single image or a whole curriculum. This project aims to make available in a technologically efficient and sensible way to ‘work smarter’ by giving educators access to these digital resources so they can adapt these resources rather than searching or creating materials that already exist. Curriculum and content developers alike can spend more time learning and innovating rather than reinventing educational resources that already exist if the collection can provide archival access to the resource, and reference the resource rather than multiple copies (Besser, 2002; Fischer, 2002; Smelser and Baltes, 2001.)
Results from Prior NSF Support

Dr. Sherry Hsi’s research—in designing Web-based science curricula, online learning communities, online teacher professional development, and ubiquitous learning via wireless handhelds to support deeper inquiry, science learning, and reflection—has been supported by NSF through the Computers as Learning Partner Project, the Web-based Integrated Science Environment, and Center for Innovative Learning Technologies. She is currently the research director for the Exploratorium’s NSF ITR grant “iGuides: Extending the Museum Experience Using Portable Devices, Wireless Networks, and Web Technology.” As a graduate student, she created and evaluated multimedia engineering education case studies supported by the NSF Synthesis Engineering Education Coalition.

Dr. Robert Semper is Director of the Exploratorium Center for Media and Communication, which has been at the forefront of developing technology-based programs that extend the museum’s educational reach to remote audiences. He has been PI on many NSF grants exploring the uses of technology for informal education. He is currently PI on “The I-Guide Project: Extending Museum Experience” with HP Labs (NSF ITR 0205664, $700,000, 9/1/02-8/31/04), on “The Accidental Scientist” a series of Webcasts (NSF ISE, $987,991, 10/1/01-9/30/04, Live@Exploratorium:Origins (NSF ISE 9980619, $1,432,287, 3/1/00-2/29/04) and the Center for Informal Learning and Schools (NSF CLT $3,465,285, 1/1/02-12/31/06).

An IMLS National Leadership Grant supported the current digital library interface and digitization effort at the Exploratorium (Figure 5).
Target Audience: Exploratorium’s Broad Reach in Educator and Learning Communities

The audience for this project focuses primarily on educators in formal and informal learning settings. This includes those who work with elementary and secondary science educators in their local communities. The audience includes professionals in formal education systems (teachers, librarians, media specialists, and students), peer institutions (museums, science centers, and universities), and individual learners (onsite and online visitors). This audience encompasses educators, graduate students, and teacher education faculty who are part of the Center for Informal Learning and Schools (CILS) based at the Exploratorium. It also includes ExNET museum partners that serve ethnically diverse audiences, and those online audiences who visit the Exploratorium via the Educator Portal, the Partners’ Portal, and directly via the digital assets management gateway. The secondary target audience is the general public, including families, home schoolers, hobbyists, scientists, artists, science writers, retirees, and other lifelong learners. (52% adults, 48% children.)

The Exploratorium has a constellation of nationally recognized programs, partners, and collaborators that will enable the digital library collection to have an immediate national and international impact. Conversely, links to the NSDL will increase the pool of educators and lifelong informal science learners who have access to those rich resources and services offered by NSDL.

The Exploratorium currently has a network of 13 existing national partner museums and six international partners via the Exploratorium Network for Exhibit-Based Teaching (ExNET) program and the Center for Informal Learning and Schools projects. ExNET is a partnership among museums committed to supporting local school systems and teachers through programs using informal resources, collections, and teaching strategies. Partners lease annually rotating sets of pedagogically rich Exploratorium exhibits, receive 40 days of Exploratorium consulting and co-

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3 Educator’s Portal URL: http://www.exploratorium.edu/educate/index.html
4 Partner Portal URL: http://www.exploratorium.edu/partner/index.html
5 EDAM: Exploratorium Digital Assets Management Project http://www.exo.net/edam/
teaching time, have access to the Exploratorium digital collection, and actively collaborate on a number of projects generated by ExNET partners. The Center for Informal Learning and Schools (funded by NSF-CLT in 2002) is a graduate and research program that also provides a two-year professional development program to approximately 140 museum-based teacher educators, representing about 100 museums from around the country. The program for museum educators supports their capacity and leadership to design teacher programs that build on museum collections to support standards-driven reforms. Museum educators are also connected with a network of research faculty and graduate students who are exploring the nature of informal learning, and how informal science institutions can support formal K-12 science.

The Exploratorium Children's Educational Outreach Program, started in 1984, is a major link between the Exploratorium and community-based organizations in San Francisco and Oakland that serve inner city children, teens, and their families. Museum staff teaches in these neighborhoods on a regular basis as well as invites participants to the Exploratorium for special field trips, family events, and, in some cases, extended study. Urban youth are trained to use hand tools and simple machinery, and learn how to wire circuits. Girls and boys build zoetropes, wind chimes, spectroscopes, kaleidoscopes, toy cars, mechanical insects, robot arms, kites, membranophones, and much more. Another important component of Children's Educational Outreach is the young, ethnically and culturally diverse staff who work in neighborhoods and the museum, serving as role models to underrepresented children in the fields of science, math, and technology. This staff also contributes to online content with their explanations and strategies for communicating difficult science concepts to urban youth.

Via the Institute for Inquiry and Teacher Institutes, the Exploratorium provides direct professional development and teacher education to more than 2,000 teachers and teacher developers annually and indirectly to another 10,000 teachers served by these teacher developers.

The Learning Studio⁶ at the Exploratorium houses, manages, and disseminates museum-related resources. The primary users of the facility are local teachers. The institutional plans to develop the Learning Studio as the base for online support of educators will serve as another access point for audiences with limited technology access to reach digital collections.

The Exploratorium Web site has been one of the most visited science sites on the Web, with a current annual audience of more than 17 million distinct visits. The site has been awarded three consecutive Webby Awards for Best Science Site (1997, 98, 99), the Webby Award for Best Educational Site (2002), and garnered the 2000 Award for Innovation from the Association of Science-Technology Centers for worldwide leadership in the field of Internet-based education. Web-based access to Exploratorium digital assets, powered by search tools, personalization, and other services offered by the SMETE Digital Library (Dong and Agogino, 2001; Muramatsu et al., 2001), and our plan to map the Web site resources to state and national standards would further serve these online audiences who could benefit from access to a high-quality collection of hands-on exhibit-inspired digital science resources.

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⁶ Learning Studio at the Exploratorium: http://www.exploratorium.edu/ls/
Project Goals, Project Design, and Deliverables

The objectives of this Collections proposal are to:

1) identify, select, and catalog assets from the Exploratorium’s existing digital assets databases to curate digital exhibit-based science resources into a digital library collection for informal science learning targeted to end users of all ages

2) establish digital library interoperability mechanisms to enable the widest possible dissemination of item-level metadata to NSDL portals including the central main portal

3) test the usability, accessibility, and applicability of the digital library and the digital exhibit-based science resources to educators, teacher educators, and lifelong learners.

Work Package 1: Define user requirements by conducting a field study of science teachers and teacher educators

Our first step will be to conduct a field study of science teachers and science teacher educators to better identify their needs, their current search behaviors, and digital media consumption patterns. Based on well-established practices in computer-human interaction research (Draper and Norman, 1986; Barnum and Dragga, 2001) and user evaluation (Borgmann et al., 2002; Budha and Coleman, 2002; Kilker and Gay, 1998; McMartin, 1999; OERL), we will observe educators in their instructional or workplace settings. We will interview them about their uses of the Internet for search, their criteria for selecting high-quality content, and their pedagogical practices with respect to using and reusing online media/content (N=30). Selected educators will represent diverse cultural/social learning contexts, a range of fluency in information technology and Internet access, and a range of prior teaching experience.

At the Exploratorium Teacher Institute, middle and high school teachers spend time in the Learning Studio using digital assets to create lesson plans or resources that help translate their professional development experiences in inquiry-based instruction to their classroom setting. We plan to observe these activities in an authentic setting while teachers are engaged in inquiry-based design, as well as ask them to perform different kinds of target tasks in a lab setting (e.g., find an image of a virus, find an explanation of diffraction and refraction of light, plan a lesson, prepare for a field trip). This will allow us to build a “user model” of how teachers search for science resources on the Internet and how they use the Exploratorium Web site. To get a breadth of educator experiences, we will define user requirements via an online survey linked to the Educator’s Portal (N=200). We will ask teachers which kinds of digital exhibit-based materials they make use of, as well as observe what kinds of materials they frequently acquire and adopt in their practice. This field study will result in a definition of user requirements that will help steer the design of the digital library. Moreover, this study will help identify educator-friendly user interface designs (Shneiderman, Byrd, and Croft, 1998; Fox et al., 1993).

On completion of the user study, we will identify, collect, and annotate digital assets from the Exploratorium’s existing digital assets based on educator behaviors, feedback, and preferences. We will work with Exploratorium departments to identify and select digital materials to catalog. Our criteria for selecting digital assets to include will be based on our current criteria (e.g., copyright is owned by the Exploratorium or we have the right to reproduce and distribute the asset), IMLS frameworks (IMLS, 2001). It will be based on information gathered from the field study of teachers and several educationally centered criteria: how often it is currently requested by teachers (popularity), level of adoption by teachers already (adoptability), whether the content can be matched to concepts and topics in State and National Science Education standards, the pedagogical stance that is supported (e.g., problem-based, collaborative team-based, discovery, inquiry-based, hands-on, self-guided, skill-based, mentored), whether materials embody or
include learner assessment and accountability (assessment-driven), and other key educational criteria. We will also pay particular attention to materials that are valued because of their highly time-sensitive nature (e.g., addresses a current scientific controversy or discovery), materials that have been teacher-tested over many years, and those assets that have historical significance.

Work package 1 will consist of a set of digital assets ready for cataloging.

**Work Package 2: Metadata for digital exhibit-based science resources**

In an IMLS-supported Exploratorium Digital Asset Management Project (EDAM) (Grant No. 10025), we have digitized and cataloged about 8,000 (with 2,000 on-going) Exploratorium exhibit-based science resources over the past two years. We have developed an institutional-wide system for managing digital assets including an establishing working documents for digital rights and intellectual property management of assets. Building on prior work, we will continue to organize, digitally archive, evaluate, and make available to museum audiences the Exploratorium materials.

In this project, we propose to further develop our digital assets infrastructure by adding capabilities to Exploratorium metadata to include pedagogical descriptors. We plan to examine closely current standards for Learning Object Metadata (IEEE, 2001), and recommend metadata and meta-descriptors that are specific or unique to the way the Exploratorium constructs and supports new science education resources and activities, adding inquiry-based pedagogical identifiers if required.

Because management, migration, and transport of digital objects requires a standard method of encoding metadata for digital objects, we will investigate and refine an existing standard to adopt and ensure that the metadata submitted with a collection is encoded in that standard. Exploratorium metadata could contribute to the limited ways in which educational learning objects are currently indexed and searched. To understand what/how/which metatags and descriptors need to be created, we will draw on an existing online collection.

To ensure there are automated ways to encode metadata for objects, digital management software will provide a cost-effective process for defining an object’s structure and in collecting its metadata. Additionally, the assets will go through a three-tiered inspection process as they are cataloged. That process will be based on the current approach established in the Exploratorium Digital Assets Management (EDAM). Actual cataloging of the resources will be accomplished using the Web-based cataloging tool developed by the SMETE Digital Library (Agogino et al., 2001; Dong and Agogino, 2001), existing metadata from EDAM, and educational descriptors as described above. The SMETE cataloging tool has the capability to write out item-level metadata in both DC and IEEE LOM format that conforms to preferred metadata element sets recommended by the NSDL Core Integration.

Work Package 2 will consist of a collection of completed item-level metadata ready for ingestion into a digital library.
Work Package 3: Exploratorium Online digital library at www.exploratorium.edu/library

Educators

PORTAL LAYER
Web browser on PC or Personal Digital Assistant

NSDL SERVICES
interoperability via OAI

harvested metadata

USER SERVICES
Search tools
Personalization
User profiles
Thesauri
Usage tracking
Annotations

META-DATA LAYER
Curation
Cataloging
Archiving

Oracle DB/MySQL
CantoCumulus5
FileMaker

EDAM
Pathways
Exhibit
X-reference

Imaging Station
ExoNET

Figure 6: Exploratorium Online Digital Library System Architecture

As our third work package, we will develop the Exploratorium Online Digital library which will build a system architecture (see Figure 6) for the current digital collections and digital assets from Exploratorium projects in collaboration with services offered by the SMETE Digital Library.

Work Package 4: Interoperability with the NSDL
Cataloging item-level metadata using the SMETE cataloging tool has the added benefit of enabling immediate interoperability with the NSDL portals through metadata harvesting with OAI-PMH and the SMETE Search Service, a Web services approach to distributed federated search. Because the SMETE cataloging tool supports both Dublin Core and IEEE LOM, the item-level metadata is ready for harvesting using OAI-PMH by NSDL portals. The SMETE Digital Library OAI data provider is based on the OAI server software written by DLESE. Additionally, other portals and NSDL services that rely on distributed federated search to synchronously search digital library collections may use the SMETE Search Service, a Web service for searching all the collections hosted by the SMETE Digital Library at UC Berkeley.

Work package 4 will consist of interoperability services to be publicized to NSDL collections and services through the NSDL Community portal.
In delivering the work packages, the project will
- Establish a collection of interactive museum exhibit-based digital resources that educate users on science concepts, scientific principles, and approaches to science education and professional development.
- Create descriptive metadata and guidelines for cataloging museum exhibit-based digital resources for educational purposes.
- Establish internal work practices at the Exploratorium on digital object management to authenticate the object’s origin by the date it was created, its content file format, scanning resolution used, rights information, etc. that could be used as a case of “best practices.” This follows the guidelines established by the IMLS.

In making Exploratorium resources available through the NSDL, we teach informal science by having learners “see” the science in action and by reconstructing the exhibit that demonstrates the scientific principles and natural phenomena. Educators and lifelong learners will know how to construct and conduct their own scientific inquiry experiences.

Key Staff

This project will be conducted by the Exploratorium Digital Collections Working Group, a cross-departmental group led by Dr. Sherry Hsi (Director of New Media Research and Evaluation) and Dr. Rob Semper (Executive Associate Director) and managed by Kurt Feichtmeir, General Manager of Learning Tools. Rose Falanga, the Senior Librarian/Information Technology Specialist, and a group of catalogers will play a key role in creating indices and metatags, and coordinating the cataloging and collections effort.

This group meets on a regular basis and includes staff from the following divisions: Information Technology; Media (photography, video); Interactive Media (Web-based resources); Exhibit Services, (exhibit sales and distribution); Teacher Institute (teacher development/resources); Center for Public Exhibition (museum exhibit collection management and maintenance); Editorial and Graphics (content and design of print documents); Public Information; and Development and Marketing.

The core digital assets group work on a day-to-day basis with asset creators, media producers, and other museum staff. Programmers and digital library architects will be subcontracted from SMETE.ORG (Alice Agogino, Brandon Muramatsu, Eric Fixler).
Timeline

We anticipate this project will be completed in a two-year period with stages of iterative refinement and user feedback.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
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<tbody>
<tr>
<td>Conduct field study of science teachers and teacher educators (Months 1-3)</td>
<td>Convene virtual advisory board meeting (Month 15)</td>
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<tr>
<td>Identify, collect, annotate, and tag digital assets (Months 1-12)</td>
<td>Refine metadata, descriptors, and indices based on pilot data (Months 16-20)</td>
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<tr>
<td>Convene advisory board meeting (Month 6)</td>
<td>Attend conference (Month 18)</td>
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<tr>
<td>Develop museum metadata from existing databases and assets (Months 1-12)</td>
<td>Add refined searching and other SMETE tools (Months 15-24)</td>
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<td>Integrate SMETE search tools and technologies (Months 1-9)</td>
<td>Harvest Exploratorium metadata (Months 6-24)</td>
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<td>Pilot study with users (Months 9-11)</td>
<td>User Study of educator’s use (Month 18-20)</td>
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<tr>
<td>Attend conference (Month 12)</td>
<td>Online Survey of educator use (Month 15-20)</td>
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<td>OAI Data Provider for Exploratorium metadata (Months 3-24)</td>
<td>Data analyses (Month 21-22)</td>
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<tr>
<td>Harvest Exploratorium metadata (Months 6-24)</td>
<td>Refinements based on user study (ongoing)</td>
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<td>Data analysis of pilot data (Month 11-12)</td>
<td>Provide recommended guidelines for cataloging assets within established metadata element set standards (Months 23-24)</td>
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<td>Communicate findings (Month 24)</td>
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Dissemination

We plan to share both formative and summative results on a regular basis. We intend on presenting our work at conferences attended by science educators, technology specialists, and museum administrators: ASTC, IMLS Web-Wise Annual Conference, NSTA, the National Educational Computing Conference (NECC), and Museums Computer Network (MCN).

Formative results and user study outcomes will also be shared with museum, library, academic researcher, and education communities via a project Web site linked to the Exploratorium Web site. All project-related materials such as surveys, research procedures, user requirements, and training materials will be distributed via the Web site.

We will market the availability of the Exploratorium Online digital library using existing email lists from Exploratorium member communities, educator list-serves, and monthly newsletters. As part of services and community outreach currently handled by the Exploratorium Learning Studio, we will add and refine existing training in how to use the digital library. The Exploratorium will disseminate via our memberships with the Internet2 Consortium and the New Media Consortium (a collaboration of colleges, high-tech companies, universities, and museums), and its Learning Object Initiative.

In the last quarter, we will publish a final report that articulates “effective practices” and lessons learned. We will disseminate this report through our partner network (ExNET), national conferences, the Exploratorium Web site, and other mechanisms.
Evaluation

Project evaluation will include process evaluation (formative) and outcome-based evaluation (summative). Data will be collected by Exploratorium researchers and project staff led by Dr. Sherry Hsi, the Director of New Media Research, with guidance from advisors Prof. Christopher Hoadley and Prof. Mimi Recker. Process evaluation will measure performance against our stated goals and objectives and will align with planned user studies.

Process evaluation will be assessed by the following approaches:
- Feedback solicited and documented during two advisory board meetings
- Evaluative comments received during presentation and review at NSDL meetings
- In-depth interviews and videotaped usability testing with educators from pilot and formal user studies
- Online surveys provided by educators when they access the digital library test interface
- Feedback received at conferences and presentations for museum, science teacher, and education communities

Outcomes-based evaluation will provide:
- A research-informed model of teacher use of digital library and media consumption patterns
- Preferred keywords, metatags, and query mechanism by science educators to search for digital exhibit-based museum-produced content
- Results from user studies on which user interfaces and search configurations were successful and less successful for enabling users to access and reuse digital assets from the Exploratorium Online
- Implementation of a unified search mechanism that conducts distributed searches across Exploratorium assets
- Information about a partner museum’s use and how they adapt Exploratorium metadata
- Formal user study data about online audiences and their feedback about the access and capabilities of the digital library

1. Convene Meetings with Advisory Board
In the first two quarters, the advisory board will convene at the Exploratorium (See section on Advisors). The purpose is not only to seek expert advice, but also share an understanding of a unique social, cultural context. We will look at how digital exhibit-based content is created, and ways exhibits and exhibit resources are used for teaching and informal science learning. In the second year, we will convene a second advisory board meeting, as a virtual meeting using teleconference and/or real-time collaborative conference technologies (e.g., TAPPED-IN, MSNetMeeting)

2. Conduct User Studies
After the unified search is put into place with basic capability, we will conduct a two-tiered iterative study that will involve an early pilot study, redesign, and a formal user study to evaluate usability, accessibility, and applicability among different teachers and teacher educators. Our study will group participants into audience types (elementary, middle, high, as well as group them by level of technology fluency (novice, intermediate, expert) and experience in science teaching. We will test the Exploratorium Online interface and accessibility with a range of science teachers (N=30). The pilot study will take place at the end of the first year, and the formal study will take place in the second year after refinements to the user interface, search tools, and metadata have been refined.
Rather than rely solely on self-reports, we will observe educators as they perform structured and unstructured tasks with the digital library and Exploratorium digital assets. These tasks will be designed to elicit the patterns of behavior and possible bottlenecks in usability such as navigation, search, access, and reuse of digital assets. Participants will be interviewed, observed and videotaped while using the user interface to provide specific feedback on the design of the search capabilities, the quality of materials found, pedagogical appropriateness, and other educationally centered criteria. Participants (N=20) will also include asset creators and partner museum staff who are users of the digital collection to understand how they shape the production of assets to fit categories that are important to teachers.

Given the 17 million unique visits annually (Semper and Wanner, 2000), an online survey will also be created to study the general public and educators who visit and access the Exploratorium online. We will also collect preliminary information with regard to the kinds of services needed and preferred by educators. We will work closely with a staff science teacher and representative teachers to receive continuous feedback for improvement.

3. Refine the Search, Indices, Guideslines, etc. Based on User Tests
Educator feedback via online surveys, lab-based usability tests, and interviews will help determine necessary refinements to the design and directions for future development with our digital library.

Sustainability

The Exploratorium has an on-going commitment to provide human resources to support its existing digitization, cataloging, and library services for its audiences. The curation and persistence of Exploratorium digital library and assets will continue to be supported by the Digital Collections Working Group at the Exploratorium to train and support individuals and departments to submit materials into our digital library with existing support from sources like IMLS, foundations, and the museum. Because we assume that the Exploratorium is not unlike other science centers with departments that seek local control and management of the assets they personally generate, we will continue to coordinate and manage the use and collection of digital assets drawn from the constellation of databases that exist in addition to institute asset description and documentation.

This project is the second phase of the longer-term implementation of an institution-wide plan that will continue with institutional support. Cost savings resulting from the unification of formerly separate staff roles and decentralized collections will help build human capacity to support the Exploratorium Online infrastructure and future services. The Exploratorium is exploring the potential for fee-based services and benefits connected to Exploratorium membership, subscription models, licensing fees to publishers and online course providers, and other revenue-generating streams.

In collaboration with the SMETE Open Federation as well as linkages to other NSDL education efforts such as the planned “Information Architect” project at Utah State, the California Digital Library Project, and the Harvard-Smithsonian Center for Astrophysics, we will maintain currency in information regarding near future learning technology developments.
Advisors

In creating a design for the Exploratorium Online, this project will address a variety of needs such as the audience, intended usage, technology design, sustainability, and scalability. Our advisory board will guide the direction of the digital library and specify the requirements that the library must meet. In addition, advisors will monitor the progress of the project and serve as a source of formative evaluation. Advisors are drawn from areas representing potential constituents of this project.

NSDL Integration Issues
   Prof. Alice Agogino, SMETE Education Digital Library

Libraries
   Dr. Daniel Greenstein, California Digital Library Project

Information Science / Digital Library
   Prof. Mimi Recker, Dept. of Instructional Technology, Utah State University

National Science Education Standards / Digital Library
   Dr. Matthew Schneps, Harvard-Smithsonian Center for Astrophysics

Science Teacher, Curriculum Developer, Learning Standards
   Laura Baumgartner, Science Teacher, Bellevue High School

Teacher Educator / Professional Development of Teachers
   Dr. Candace Brown, Institute for Inquiry, Exploratorium

Education Research
   Prof. Christopher Hoadley, College of Education, I. S. and T, Penn State University

Museum Partner
   Chip Lindsey, Fort-Worth Museum of Science and History