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TECHNICAL REPORT

Steps Toward a Formative Evaluation of NSDL

Tora K. Bikson • Nidhi Kalra • Lionel A. Galway • Grace Agnew

Sponsored by the National Science Foundation



Transportation, Space, and Technology

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

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PREFACE

Like other National Science Foundation (NSF) programs, the National Science Digital Library/Distributed Learning (NSDL) program seeks to support individual projects that have strong scientific merit. Unlike other projects, however, the NSDL also seeks to develop distributed, self-sustaining communities of users of and contributors to shared collections of digital teaching and learning resources and tools. Substantial resources have been invested in a technical and social infrastructure to realize these goals.

NSF has structured the evaluation of this program in a phased approach. A prior phase of the evaluation, focused on documenting program inputs, was conducted internally and made available to the authors of this report. This technical report documents the methods, findings, and conclusions of a second phase of evaluation conducted by a research team from the RAND Corporation. The objectives of RAND's second-phase NSDL evaluation were to provide a preliminary assessment of the program based largely on existing information resources and results of the initial evaluation effort; to design a robust formative evaluation for a subsequent phase, refining research questions and methods; and to conduct limited field studies to pilot test instruments and procedures that could be used in a third phase of the program evaluation. RAND's interim evaluation of the NSDL is formative, in the sense that it focuses on processes and outputs in the program's logic model, and gives considerable attention to evaluating the model itself rather than program outcomes. Findings identify antecedents potentially supportive of the overall aim of the NSDL to facilitate improvements in teaching and learning in science, technology, engineering, and mathematics (STEM) disciplines.

This report was prepared under the assumption that the NSDL program would continue and that its output, as well as findings from the third phase of evaluation, would chiefly serve to inform NSF decisionmakers about ways to strengthen and improve the program going forward. Subsequently, NSF announced its decision not to fund the NSDL program beyond the 2012 fiscal year. In light of that announcement, RAND has decided to make this interim report—initially intended primarily for internal use by NSF decisionmakers—more broadly available. At the same time, we have refocused the final phase of evaluation to emphasize lessons learned that could be useful to other programs, both within and outside NSF.

We believe that the findings from this interim evaluation could be of interest to other programs in NSF and to other funding sources (e.g., programs within the U.S. Department of Education, private nonprofit institutions that support education research and development (R&D), state departments of education seeking to implement new STEM standards), as well as to the digital library community.

The RAND Transportation, Space, and Technology Program

This research was conducted in the Transportation, Space, and Technology (TST) program within RAND Infrastructure, Safety, and Environment (ISE). The mission of ISE is to improve the development, operation, use, and protection of society's essential physical assets and natural resources and to enhance the related social assets of safety and security of individuals in transit and in their workplaces and communities. The TST research portfolio encompasses policy areas including transportation systems, space exploration, information and telecommunication technologies, nano- and biotechnologies, and other aspects of science and technology policy.

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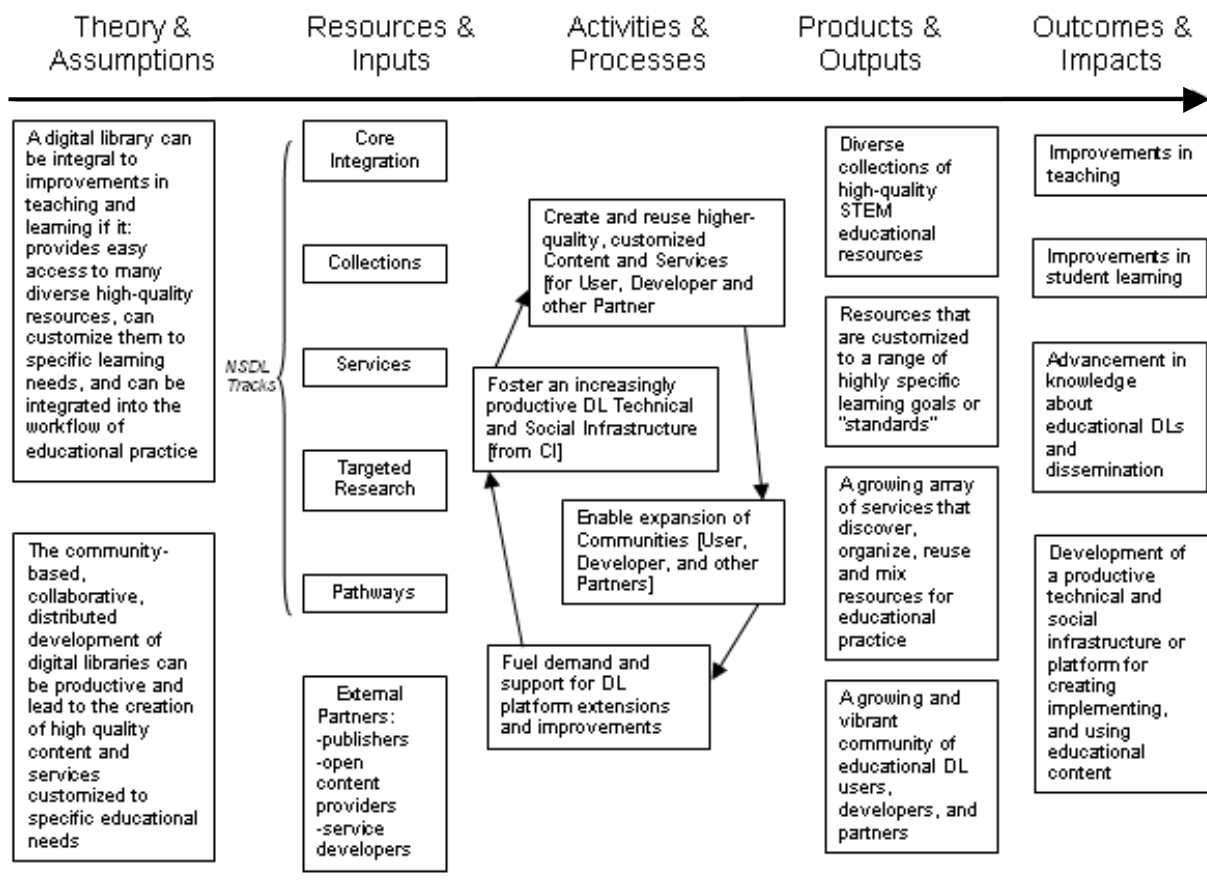
SUMMARY

The NSF's NSDL program turned ten years old in 2010. This technical report presents results of a preliminary program evaluation carried out by RAND in response to a request for proposals developed by NSF. These results represent the second phase of NSF's multistage evaluation plan. We organized our work around three principal evaluation goals:

- Provide an initial evaluation of the NSDL based on existing information resources, including results of a prior phase of evaluation.
- Conduct limited primary data collection studies to pilot test instruments and approaches and complement findings from extant information.
- Design a robust formative evaluation for a future phase of effort, refining research questions and methods.

BACKGROUND AND APPROACH

The NSDL program started in 2000 in NSF's Directorate for Education and Human Resources (EHR). Between then and 2010, it awarded more than 250 grants in several program tracks: Collections of digital contents (this track was discontinued in 2004); Pathways to assist in locating and using extant digital resources and tools (this track was initiated in 2004); Services; Targeted Research; and a Core Integration component, funded through a long-term cooperative agreement to establish and maintain an organizational and technical infrastructure to coordinate and support interactions among the projects in the other tracks. Early in Fiscal Year 2009, coinciding with the emergence of the program's emphasis on distributed learning, the Core Integration effort was divided into two separate projects, one a Resource Center and the other providing Technical Network Services.



SOURCE: McArthur, D., *NSDL Evaluation: Phase 1*, Washington, D.C.: National Science Foundation, 2008.

NOTE: DL = digital library. CI = Core Integration.

Figure S.1 NSDL Program Logic Model

Over this time period, the NSDL program logic model (see Figure S.1) changed little, except for the division of the Core Integration component (under resources & inputs) into the separate projects noted above. However, they share the same set of responsibilities as were formerly carried out by the Core Integration team. We therefore took that model as the starting point for our research.

RESEARCH PROCEDURES

Research procedures for this preliminary study were organized to follow its main evaluation goals. We began by addressing what can be learned from existing information in three key areas: the *digital resources developed*, the *avenues for accessing*

them, and the *expected outcomes for their use*. Specifically, we addressed these main research questions in response to the first aim:

- What is the state of health of the resource collections?
- What evidence do current web metrics provide about activities undertaken by users to find and access those resources?
- Are there early signs of positive effects from use of NSDL resources among science teachers or learners?

For this purpose, we assessed all current collections, examined the websites of the NSDL portal and several pathways, as well as support for moving between and among them, and reviewed project abstracts, reports, and research papers.

When we had initial answers to these questions from extant information, we then designed and carried out some primary data collection efforts to supplement the findings and to provide a better base for a future evaluation. In particular, we conducted pilot trials aimed at *assessing the metadata* intended to assist users in finding, identifying, selecting, and obtaining sought resources and at *exploring the usability* of available resources for accomplishing selected routine tasks in science teaching. Finally, we conducted a *minicase study of one full instantiation of the NSDL model*—a demonstration of curriculum customization to meet the needs of earth science teachers using resources from the Digital Library for Earth System Education (DLESE).

We then synthesized the findings from these exercises to yield results and recommendations, both for what NSF and the NSDL should do now, as well as for the design of a full formative evaluation. In the next section, we summarize key findings and recommendations and suggest a design for the anticipated future evaluation of the NSDL.

FINDINGS AND RECOMMENDATIONS

State of Health of the Resource Collections

The project relied on existing data derivable from NSDL sites to evaluate the authoritativeness, usability, and integration of the resources they make available. For this purpose, we cataloged and analyzed measurable characteristics representing attributes of interest for assessing their state of health. The three-tiered sample included 50 still-viable collections (of 71 funded by NSF), the 14 functioning pathways, and

nsdl.org as a one-stop shop for finding NSDL resources. Here, we highlight key findings and recommendations for future improvements.

Authoritativeness. Currency of the collections is questionable. Of the 50 collections, 14 of them (over a quarter) are not current, yet 13 of these are still available for search and retrieval via the NSDL. However, stability of the collections themselves is noteworthy, with 95 percent or more of records sampled from collections and pathways being still available. Evidence of scientific authoritativeness of the resources is weaker than would be desired. Just over half of the Pathways and just under half of all collections have published peer review practices. Further, only 40 percent of collections have evidence of professional oversight, compared with 86 percent of Pathways.

Metadata Usability. Metadata are generally problematic across resources—just over a third of pathways and just over a tenth of collections have good metadata. Sample searches often turn up heterogeneous resources (e.g., activities, articles, historic images) in a single display because results are subject matter-based and not use-based. When resources are found, metadata do not provide users with clear information about what can be done with them. The majority of pathways and collections provide some kind of copyright guidance, but it is inconsistent and usually hard to interpret. Privacy policies are available in the majority of pathways but in less than half of the collections.

Integration. Nsdl.org is not an integrated one-stop shop—it does not appear to be substantially greater than the sum of its parts. Further, there is no real evidence of pathway collaboration across the NSDL—no common elements of look, feel, and service characterize them, while the NSDL is mainly acknowledged as a funding source. Moving from pathway to pathway creates a sense of dislocation and of starting over.

Recommendations to NSF and the NSDL. Noncurrent resource collections should be identified and removed. For viable collections, it is important to promote regular checking to find and fix broken links. Additionally, policies and practices that evidence authoritativeness (peer reviews, professional oversight) should be encouraged and promulgated. With respect to usability, we recommend that the NSDL resource team and pathways researchers work with educator audiences to develop common metadata elements and vocabularies for core filtering elements that would address the workflow needs of STEM teachers.

NSF and the NSDL, in consultation with pathways leaders, should consider focusing nsdl.org on a social networking service model. For instance, the NSDL resource team could provide centralized statistics and surveys; users might “join” pathways and

manage their memberships; centralized folders and workspaces might be offered for each user; and users should have ways to share the resources they have created or customized, as well as to learn which resources are most frequently accessed by other users like themselves. More generally, multiple avenues should be pursued to realize the aim of having the NSDL be more than just the sum of its parts.

Recommendations for a Future Phase of Evaluation. In our judgment, evaluation of the state of health of the resource collections is largely complete on the basis of work done for the second phase effort. For a third phase of evaluation, we recommend two types of initiatives.

First, it would be desirable to revisit the pathways and collections periodically (e.g., at six-month intervals) to assess the extent to which selected noteworthy shortfalls are being remedied. On a more ambitious note, metadata evaluation should be undertaken to identify and address educators' needs for more context-friendly and useful core filtering elements. For this purpose, we would recommend an extension of the metadata pilot evaluation reported here. Extensions could include cognitive walk-throughs with representative users and experimental trials with added "educator schema" filtering elements.

Evaluative Evidence from Web Metrics

A second evaluation effort turned on exploring web metrics to see what evidence they might provide for addressing questions about the composition and growth of user communities, users becoming reusers and resource contributors, "cross-pollination" among pathways, and other aims envisioned in the NSDL program's logic model. For this purpose, we interviewed researchers responsible for nsdl.org web metrics. Additionally, we interviewed web metric staff at five pathways selected for their reputation using web metrics. We supplemented these interviews with a review of web metrics literature. Main findings and recommendations follow.

Nsdl.org and Web Metrics. The primary uses of web metrics at the top-level site are for overall traffic monitoring and for site modification and redesign. It is not presently feasible for nsdl.org to develop a clear understanding of its users because it lacks effective ways of getting data about them. The only avenue for learning more about its user community appears to be responses to brief pop-up online surveys, of unknown quality and representativeness. Presently, there is also not an ability to classify and characterize users by general site usage patterns, although this is a desired future goal for web metrics. Additionally lacking are comprehensive data about the pattern of

traffic into and out of nsdl.org. Thus, nsdl.org now has little knowledge about the demographic characteristics of its user community, nor a general understanding of its usage patterns.

Pathways and Web Metrics. Like nsdl.org, pathways chiefly use web metrics for monitoring overall traffic and for site redesign purposes. Like nsdl.org, all but one rely on pop-up surveys. Similarly, pathways undertake only very limited assessments of users' site usage patterns. Additionally, they do not know whether specific other pathways, or nsdl.org, or still other sites are the main sources or the main destinations of their users.

There is little communication about web metrics between pathways and nsdl.org, and no mandated reporting of web statistics either to the Resource Center or to Technical Network Services (TNS). There had been some attempt at standardization of web data using Omniture, but, presently, some pathways have moved to Google Analytics because it is available at no cost. In any case, the net result is that no summaries are available from pathways related to overall traffic flow, sources of users, and the like to help inform the present evaluation.

Recommendations to NSF and the NSDL. Standardized, basic web metrics should be selected and shared by nsdl.org and the pathways. Additionally, there should be mandated reporting of some web metrics (e.g., overall traffic flow, immediate sources and destinations of users) at designated intervals. Further, NSF and the NSDL should plan for future usage data collection when new technologies (e.g., social media) are likely to play a greater role in nsdl.org and the pathways. Some current web metrics might not be applicable to these technologies, although the new media are likely to become important in the growth and vitality of user communities.

Recommendations for a Future Evaluation. Recommendations for a future evaluation are dependent, in part, on the ability to obtain standardized web metrics from nsdl.org and the pathways as recommended earlier. To examine whether emergent user communities are exhibiting vitality, growth, and connectivity, as anticipated by the program's logic model, it would be desirable at minimum to measure basic traffic volumes over time, plus the sources and destinations of site visitors. These data would be useful for constructing a map of traffic relationships between nsdl.org, the pathways, and other key sites.

It is also important to measure the extent of use of private spaces by users to retain and tailor materials to their own needs and the rate or volume of contributions by users to shared spaces, for sites that offer these services. Such measures would shed light on

whether customized or customizable resources were being developed to meet particular teaching or learning goals, as the logic model predicts.

A last recommendation would be to pursue user classification by site usage patterns to provide a richer picture of users. Specifically, in given sites, it might be possible to carry out experiments where user computers—with users' consent—are instrumented for more detailed data collection and analysis.

Signs of Teaching or Learning Effects

The prior evaluation phase sought early signs that use of NSDL resources might improve teaching or learning in the STEM disciplines. We started by examining abstracts for the 250+ NSDL-funded projects and then reviewing, in detail, project reports and research papers from those that directly involved teachers or learners. Such a case survey was expected to yield a taxonomy of project features, as well as emerging themes or promising trends related to teaching or learning. Additionally, the review could be suggestive of hypotheses for further testing in a future evaluation while identifying exemplary cases for site visits. Chief findings and recommendations follow.

Body of Teaching or Learning Research. Among all the projects funded by the NSDL during its decade-long lifetime, at most about a dozen touch in some way on teaching or learning. Each of the studies addresses a different tool or resource, and each uses a different context and different procedures. These great variations in a very small body of work preclude categorizing project features or approaches.

Additionally, the methods typically employed by the projects are not ones that support inferences about teaching or learning effects. Experimental or quasi-experimental methods are largely absent. Assessments rely in the main on teachers' self-reported behavior changes or intentions to change. Consequently, a systematic case survey was not feasible for the second phase of evaluation. However, examination of this body of work surfaced some research sites that might be good candidates for case study. It also contributed to the design of a pilot usability study with a small sample of current and prospective STEM teachers.

Recommendations to NSF and the NSDL. The NSDL program should be strengthened by allocating more funding for targeted research to explore and evaluate teaching and learning effects associated with the use of NSDL resources. Teaching and learning support have been key aspects of the program's logic model from the start, even at the "products & outputs" stage, as well as part of the expected longer-term outcomes and broader impacts. In particular, it is critical to direct more research toward

understanding and facilitating the transition from NSDL “activities & processes” to education-specific “products & outputs.”

Recommendations for a Future Evaluation. A future phase of evaluation should routinely examine all forthcoming project reports (those produced since the review done for this report) to look for indicators of teaching or learning effects. However, because of the length of time that would likely be needed to elicit such effects, we would not expect to find major new contributions to the existing body of work. Consequently, we recommend continuing in two evaluative directions related to teaching and learning effects; both approaches have been piloted in the present study.

First, we recommend extending and replicating a resource usability study with a sample of current or future science educators large enough to yield statistically significant results. The study should investigate the relative advantages of orienting pathways by grade level versus subject matter or remaining generic. Results of such an experiment should valuably complement the suggested metadata evaluation and help inform efforts to shape and enhance the NSDL to better meet the needs of STEM teachers and learners.

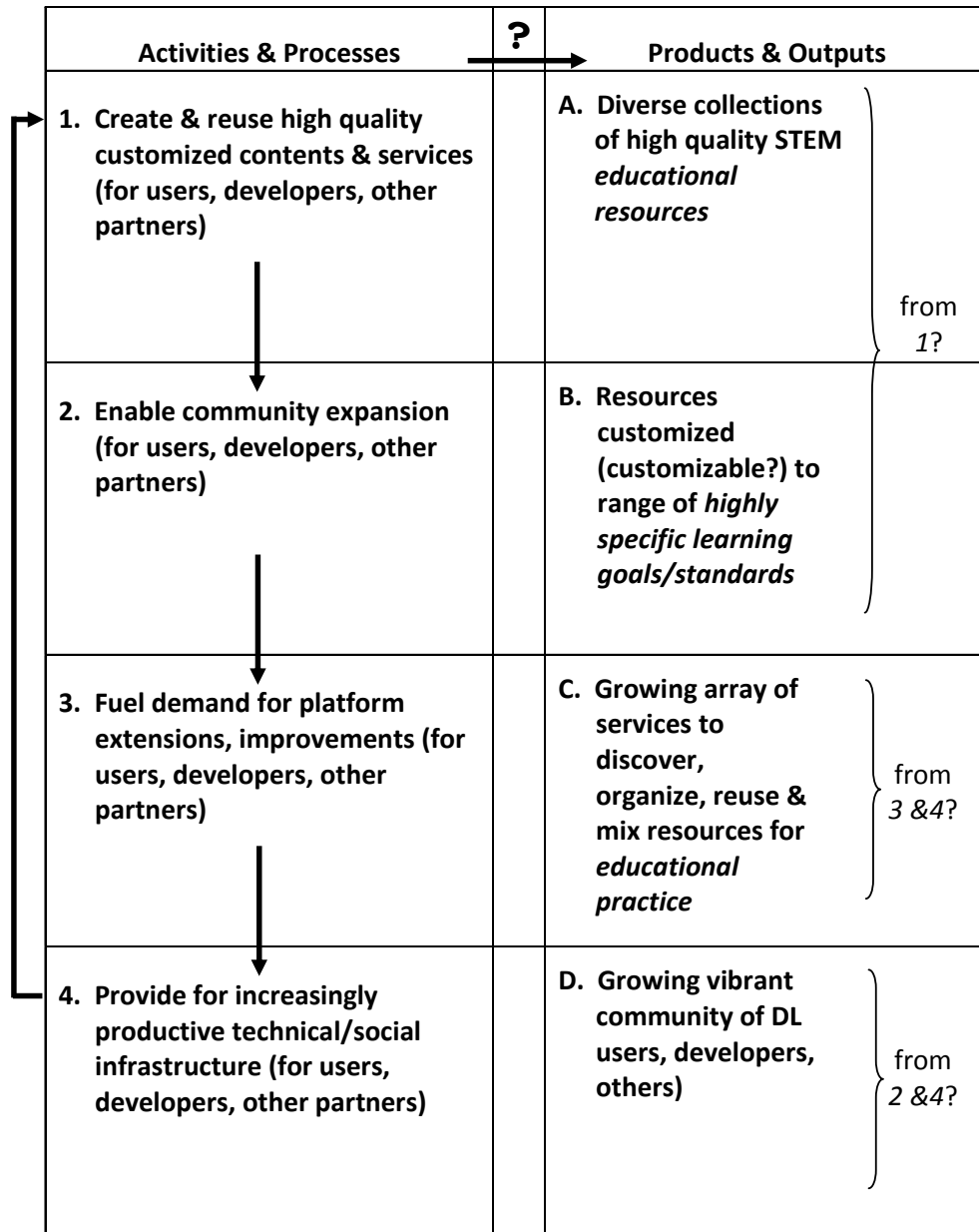
A second direction involves full case studies of projects that are currently putting NSDL resources into teachers’ hands for ongoing classroom use. One such case is the Denver Public Schools Curriculum Customization Service project, which was the focus of the minicase study reported here. Another attempt to instantiate the NSDL program model is represented by the Robert Noyce Scholarship project, which takes a quite different approach to attempting to introduce digital resources into STEM teaching and learning. A future evaluation should document and compare alternative avenues for bridging the gap between digital libraries and distributed learning.

Suggested Overall Design for a Future Evaluation

Earlier, we identified some specific research recommendations for inclusion in a further, more complete formative evaluation of the NSDL program. Here, we suggest an overall design for the third-phase program evaluation.

Conceptual Framework for a Full Formative Evaluation. We suggest beginning again with a focus on the intermediate components of the logic model— activities & processes, and products & outputs—for two principal reasons. First, the present evaluation makes clear that it is still too early to look for longer-term summative outcomes and impacts. NSDL resources are only just beginning to find their way into contexts of use, so significant effects of the NSDL on STEM teaching and learning in U.S.

education still lie in the future. Second, it is appropriate to look more closely at whether and how the activities & processes specified in the logic model are leading to envisioned products & outputs, especially as they are expected to facilitate the transition from digital library resources to distributed learning uses (see Figure S.2).



NOTE: Emphases are ours.

Figure S.2 Proposed Logic Model Components for Future Evaluation

In Figure S.2, arrows among the four types of activities & processes called out in the logic model indicate that they are supposed to be mutually influential; they are intended to give rise to a virtuous circle in which valued NSDL contents and services engender growing use, which generates demand for improvements, which, in turn, leads to an increasingly productive social and technical infrastructure in which initial resources are reused, customized, and supplemented. We have added hypothetical links, with question marks, between the two intermediate components of the logic model. The initial account of the logic model assumes, but does not explain how, the activities & processes set out in the left half of the figure will result in the four types of products & outputs on the right—especially the products & outputs that will constitute high quality educational resources (A) customized to a range of highly specific learning goals (B) and will yield a growing array of services for finding and organizing these resources to meet educational practice needs (C). A future evaluation, although still formative in nature, should investigate, assess, and, ideally, make recommendations for strengthening transitions between activities & processes and the educationally relevant products & outputs set out in the logic model.

Sociotechnical Systems Research Foundation. A sociotechnical systems-theoretic foundation guided our approach to the current evaluation and should continue to provide a research base for a future evaluation phase. The NSDL is envisioned as a complex, interconnected sociotechnical community (see, for example, the fourth activities & processes box in Figure S.2).

From the standpoint of sociotechnical systems theory as it applies to understanding the adoption of new technologies, successful outcomes can be viewed as a function of properties of the technologies, the contexts of use, and the implementation processes by which the former are integrated into the latter. Implementation is construed as the series of decisions made and actions taken once an organization makes the go-ahead decision to adopt a new technology. Sociotechnical systems theory sees implementation processes as aiming at the joint optimization of the capabilities of the social and technical constituents of the system. In this process, the technologies are modified to better fit the aims and capacities of the user context; concurrently, users' behaviors and environments will need to change (via, e.g., training, revisions of practice) to take advantage of the affordances of the new technologies. The guiding implementation assumption is that, like the terms of a simultaneous equation, social and technical challenges cannot be separately resolved. Implementation process characteristics are expected to be the strongest predictors of successful technological

innovation in social contexts (e.g., see the review in Bikson and Eveland, 1991). This theoretic lens guided the minicase study reported in Chapter Six.

A future evaluation should look for evidence that NSDL resources can be or are being customized for use in educational contexts (see Figure S.2, elements B and C under “Products & Outputs”). User involvement (or *demand-side input*) is a strong factor in optimizing a technology to suit the needs of a particular adopting context.

“Nested” Design and Methods

We suggest a four-tiered evaluation design, but we have put “nested” in quotes because, although the envisioned levels are interdependent in varied ways, the proposed design is not truly nested. What follows is a brief account of each level of the hierarchical sociotechnical system design approach (see Figure S.3).

<p>NSDL: the program and the site (N=1)</p> <p>PATHWAYS: exhaustive sample (N=14-17), plus selected tools and services</p> <p>COLLECTIONS: extensive sample of collections hosted by pathways, plus a sample of resources made accessible via pathways or nsdl.org</p> <p>USERS: survey of teachers who have had NSDL-related professional development; full-case studies of sites where teachers are known to be using NSDL resources (e.g., in classrooms); experimental trials with prospective users</p>
--

Figure S.3 Proposed Hierarchical Approach for Future Evaluation Research

The top level is the NSDL itself, including both the program and the nsdl.org site, the top social and technical dimensions of the sociotechnical system. At this level, there is an N = 1, susceptible only to a case study approach. Interviews with key stakeholders within and outside NSF and the NSDL would be the main method of choice, supplemented by a review of current integration efforts and an examination of web metrics focused on overall volumes, as well as source and destination traffic patterns.

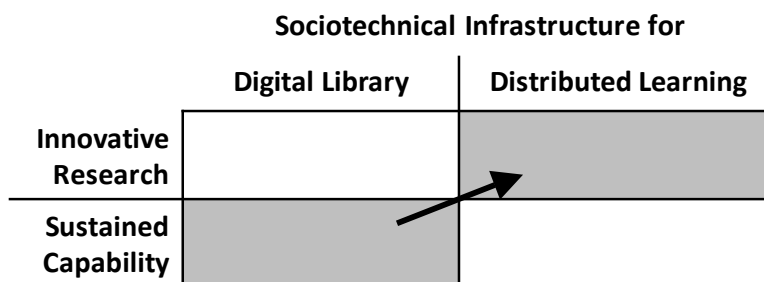
Next is the level of pathways, for which an exhaustive sample is appropriate, given their small number. Here, we suggest semistructured interviews with pathway project leaders and (if different) those in charge of web metrics. Additionally, we propose an examination of web metrics, including volumes and source/destination patterns. We also suggest an examination of the level of use of personal spaces, where

offered. At both this and the top levels, it should be possible to learn whether there are growing and contributing user communities.

Resource collections constitute the third level, where current NSF-funded collections are expected to number about 50. The evaluation of collections is already largely complete. The future evaluation effort should therefore be limited to follow-up checks to determine the extent to which policy recommendations from the this preliminary evaluation have been or are being implemented.

The lowest level, comprising users, merits the greatest attention in a third phase of evaluation. Here, the methods should attempt to elicit evaluative information about the transition to educational uses of NSDL resources for teaching and learning. For this purpose, we recommend a survey of teachers who have completed courses on how to use the available resources for STEM teaching. Additionally, for the user level, we would suggest building on the trials piloted and discussed in this report. In particular, a more in-depth metadata assessment and an expanded resource usability study would help determine whether high-quality STEM educational resources could be discovered, organized, used, mixed, and reused to meet educators' needs. Further, it would be desirable to carry out full-size case studies of projects that are making concentrated efforts to put NSDL-based STEM resources into teachers' hands for classroom use. For this purpose, the Denver Public Schools Curriculum Customization Service effort and the Noyce scholars program would merit study, along with any other such projects that emerge in the coming year.

Evaluation Focus. As an evolving, complex, distributed sociotechnical system, the NSDL program has multiple "personas." It is an interconnected library of digital resources that should provide a platform for enabling advances in STEM teaching and learning. Like other NSF programs, it is charged with stimulating innovative research, but it must also be concerned about the sustainability of the systems that can support such an endeavor. Figure S.4 displays these varied personas in a matrix.



NOTE: The shaded areas represent the evaluation domains we suggest for future evaluation emphasis.

Figure S.4 Evaluation Foci: Alternative Options

Each quadrant of the matrix represents a plausible domain within which formative evaluation results might be sought. For instance, when the *L* in *NSDL* means *library* (as in previous proposal solicitations and implicit in the activities & processes component of the logic model), evaluation might focus on the extent to which the program yields cutting-edge methods and tools for understanding and advancing library science for STEM resources in the ever-changing digital era. Or evaluation might focus on how well efforts are working to sustain and improve the resources the distributed library makes available for future research and development, much like a distributed “facility” — comparable, say, to geoscience facilities funded by NSF.

On the other hand, when *L* primarily means *learning*, as seems implicit in the products & outputs component of the logic model, as well as in the changed title of the 2010 NSDL call for proposals, the target of evaluation might shift to education-related results. If so, a future evaluation might focus on advances in research on how and why digital resources can markedly improve teaching and learning in the STEM disciplines. Alternatively, it could emphasize how sustainable those instructional improvements are after the initial period of research funding ends.

These options are not mutually exclusive in principle. In practice, they might not all be feasible to include in a future formative evaluation design, given limited resources. The shaded areas in Figure S.4 represent the evaluation domains we suggest for emphasis in a future evaluation phase. The Innovative research in digital library science (top left quadrant, unshaded) could reasonably be supported by other funding programs within and outside NSF. We would encourage NSF to make available and publicize its NSDL resources for research purposes beyond the NSDL program itself

while not including this domain as a focus of the proposed next phase of evaluation. However, both to support digital library science research and to enable advances in research on educational uses of digital STEM resources, it is critical to sustain the developed contents and services. We therefore recommend that a future formative evaluation examine progress toward sustaining the distributed digital library infrastructure (bottom left quadrant, shaded).

On the other hand, the study reported here indicates that efforts to put digital STEM education resources into classroom contexts have only just begun and are too few in number to justify an evaluation of their sustainability (in Figure S.4, bottom right quadrant, unshaded); rather, that should be the aim of a future summative evaluation. In the meantime, a future formative evaluation should pursue and examine factors that affect or could affect the adoption, implementation, use, and usability of the developed digital library infrastructure to meet the needs of STEM educators (top right quadrant, shaded). In these ways, the future evaluation efforts can inform and assist the anticipated transition from digital libraries to distributed learning. The NSDL should move aggressively to orient its program resources toward understanding how STEM education can be improved given a supportive high-quality digital teaching and learning infrastructure.

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We are also deeply indebted to the many representatives of the Denver Public Schools Curriculum Customization Project who took part in this project. We especially thank the Denver Public School District's science curriculum coordinators and earth science teachers who generously shared their time, insights and experiences with us. We are extremely grateful as well to representatives of the Curriculum Customization Service at the University of Colorado at Boulder's Institute of Cognitive Science and at Digital Learning Sciences in the University Corporation for Atmospheric Research (UCAR) for participating in our case study, providing us with an in-depth understanding of what digital curriculum customization entails. Warmest thanks go to Holly Devaul, Manager of Educational Programs and Services at UCAR, for organizing and seamlessly handling a myriad of logistical tasks in advance of and during our site visit.

Further, we could not have carried out this study without the help and cooperation of a great many people who have played significant roles in developing and sustaining the National Science Digital Library/Distributed Learning (NSDL) enterprise and who shared their knowledge with us. Representatives of the NSDL Resource Center and Technical Network Services met with us in person and responded as well to the many questions put to them by email. We also learned a great deal from discussions with a number of Pathways leaders and Principal Investigators.

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Services at the Florida Center for Library Automation, for her insightful comments and suggestions.

ABBREVIATIONS

3-D	three dimensional
ACM	Association for Computing Machinery
AMSER	Applied Math and Science Education Repository
BEN	BiosciEdNet
CCS	Curriculum Customization Service
ChemEd DL	Chemical Education Digital Library
CI	Core Integration
CIO	chief information officer
CITIDEL	Computing and Information Technology Interactive Digital Educational Library
CLEAN	Climate Literacy and Energy Awareness Network
CSERD	Computational Science Education Reference Desk
CSULB	California State University, Long Beach
CU-Boulder	University of Colorado Boulder
DDS	Digital Discovery System
DL	digital library
DLESE	Digital Library for Earth System Education
DPS	Denver Public Schools
DRC	Digital Library for Earth System Education Reviewed Collection
EHR	Directorate for Education and Human Resources
FAQ	frequently asked question
FISO	find, identify, select, and obtain
FY	fiscal year
GRAPE	Getting Reviewers Accustomed to the Process of Evaluation
GSE	Graduate School of Education
HEAL	Health Education Assets Library
IEEE	Institute of Electrical and Electronics Engineers

IFLA	International Federation of Library Associations and Institutions
IP	Internet protocol
IRB	institutional review board
ISE	RAND Infrastructure, Safety, and Environment
IsoveraDL	Isovera Digital Library
JiTDL	Just-in-Time Teaching Digital Library
KMODDL	Kinematic Models for Design Digital Library
MAA	Mathematical Association of America
MERLOT	Multimedia Educational Resource for Learning and Online Teaching
MIC	Moving Image Collections
MLIS	master of library and information science
MSP2	Middle School Portal: Math and Science Pathways
NAEP	National Assessment of Educational Progress
NSDL	National Science Digital Library
NISO	National Information Standards Organization
NSF	National Science Foundation
OAI-PMH	Open Archives Initiative Protocol for Metadata Harvesting
PALMM	Publication of Archival, Library and Museum Materials
PBS	Public Broadcasting Service
PD	professional development
PDF	Portable Document Format
PI	principal investigator
R&D	research and development
RC	resource center
RDF	resource description framework
RSS	Resource Description Framework Site Summary
SC&I	School of Communication and Information
SMILE	Science and Math Informal Learning Educators
STEM	science, technology, engineering, and mathematics
TAB	teacher advisory board

TIMSS	Trends in International Mathematics and Science Study
TNS	Technical Network Services
TST	Transportation, Space, and Technology
UCAR	University Corporation for Atmospheric Research
XML	extensible markup language

CHAPTER ONE. INTRODUCTION

The National Science Foundation's (NSF's) National Science Digital Library/Distributed Learning (NSDL) program turned ten years old in 2010.¹ This technical report presents results of a preliminary program evaluation carried out by RAND in response to a request for proposals developed by NSF. We organized our work around three principal goals:

- Provide an initial evaluation of the NSDL based on existing information resources, including results of a prior phase of evaluation (the first phase).
- Conduct limited primary data collection studies to pilot test instruments and approaches and complement findings from extant information.
- Design a robust formative evaluation for a future phase of effort (a third phase), refining research questions and methods.

The results reported here thus constitute an interim phase (a second phase) of an anticipated multistage program evaluation. The evaluation was carried out over a year, from May 2009 to May 2010.

BACKGROUND AND APPROACH

The NSDL program started in 2000 in NSF's Directorate of Education and Human Resources (EHR). Between then and 2010, it awarded more than 250 grants in several program tracks:

¹ Late in fiscal year (FY) 2000, the program came into being with the name *National Science, Mathematics, Engineering, and Technology Education Digital Library*, with the abbreviation *NSDL* (in which *S* itself stood for another abbreviation, *SMET*). Several years later, the order of terms in the full name was changed to *Science, Technology, Engineering, and Mathematics*, or *STEM*, but the *NSDL* abbreviation was retained. In FY 2009, the program name underwent another, more notable change: *NSDL* became an abbreviation for *National STEM Digital Library/Distributed Learning* program, concurrent with an increased emphasis on the link to science learning.

Collections. These projects sought to develop, organize, and manage sets of digital contents related to science, technology, engineering, and mathematics (STEM) learning within a coherent theme; the Collections track was discontinued in 2004.

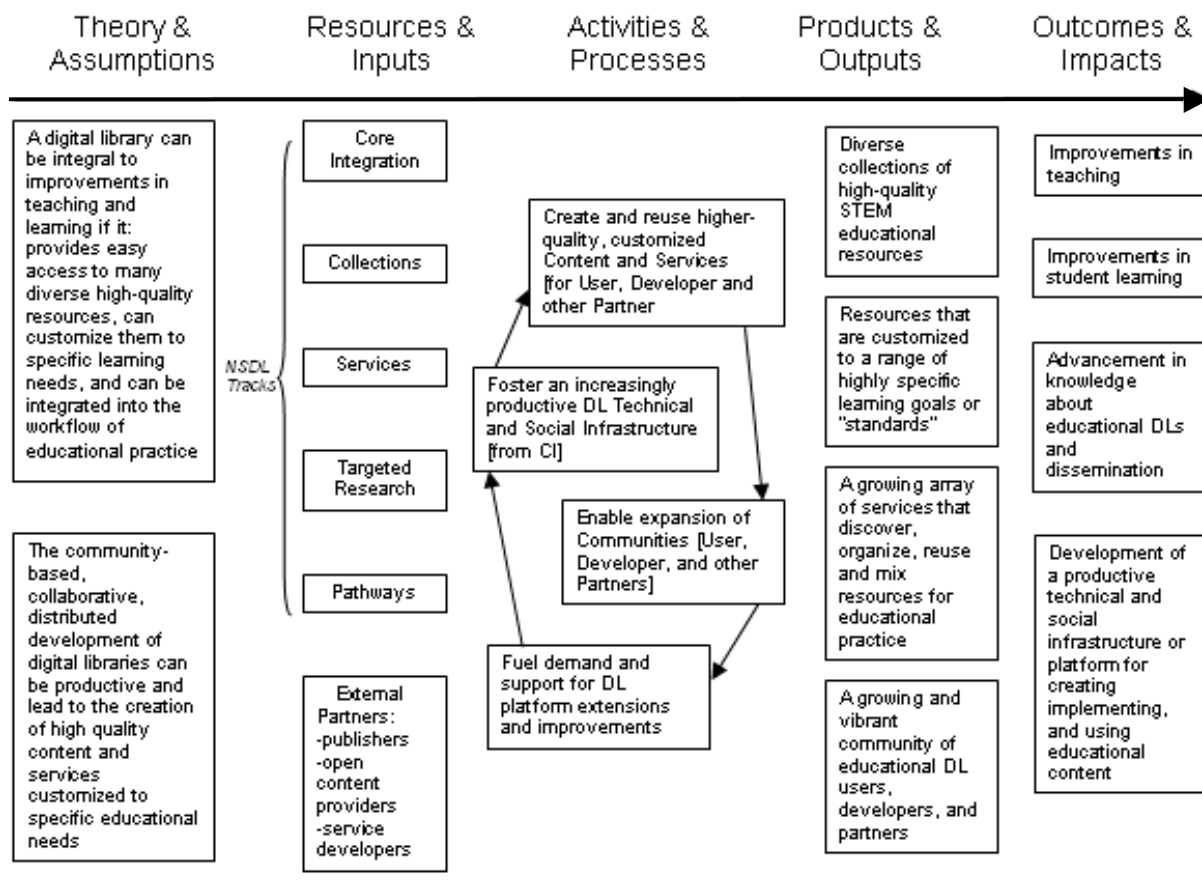
Pathways. Replacing the Collections track, the Pathways track introduced in 2004 funded projects that were intended to provide stewardship for STEM education contents and services needed by a broad community of teachers and learners, helping them to locate and use extant digital resources. In FY 2008, what was termed a *Pathways II* component was added to this track to help ensure the continued expansion and stability of the early Pathways efforts that were beginning to mature.

Services. From the outset, projects in this track aimed to increase the reach, value, and impact of digital library materials. Such projects tended to fall into two categories, a distinction reflected in program solicitations starting about FY 2004. First, usage development workshops undertook outreach, training, and professional development to engage STEM educators and help them learn to make effective use of NSDL resources. Other projects in the services track undertook to develop tools or services that would operate on or interact with the NSDL's digital resources to make them more readily usable by or useful to science educators, other resource developers, or both.

Targeted Research. Projects in this relatively small track were envisioned to accomplish applied research objectives that would have an immediate facilitative effect on activities done in other tracks.

Core Integration. Core Integration efforts provided the central functionality for NSDL, construed both as an organization uniting a community of projects within the program and as a technical infrastructure (including nsdl.org, the main portal) supporting the network of collections, services, and other digital resources. In FY 2008, the Core Integration project was divided into two complementary endeavors: an NSDL Resource Center would be responsible for the social and community development aspects of NSDL, and Technical Network Services would be responsible for the technical infrastructure, most notably to include hosting the nsdl.org portal and ensuring its continued development and maintenance.²

² For a rich history of the evaluation of the NSDL program, see Zia, 2011.



SOURCE: McArthur, D., *NSDL Evaluation: Phase 1*, Washington, D.C.: National Science Foundation, 2008.

NOTE: DL = digital library. CI = Core Integration.

Figure 1.1 NSDL Program Logic Model

Over the ten-year period, the NSDL program logic model itself (see Figure 1.1) changed little, except for the division of the Core Integration component (under resources & inputs) into the separate projects noted earlier. However, they share the same set of responsibilities as were formerly carried out by the Core Integration team. We therefore took the original logic model as the starting point for our research.

The prior evaluation work was carried out by a program officer of NSF and was directed toward the documentation of program-supported resources & inputs to date (see Figure 1.1); that work was completed by the time this project began in May 2009 and made available to the research team. Building on earlier findings, the evaluation effort we undertook focused on the two subsequent components of the model: activities & processes, and products & outputs.

LOGIC MODEL AS FRAMEWORK

We took the program's logic model as the conceptual framework for the evaluation because the NSDL is supposed to be an interconnected whole that is greater than the sum of its parts. Like other NSF programs, the NSDL seeks to support individual projects that have strong scientific merit on their own. Unlike other programs, however, the NSDL also seeks to develop distributed, self-sustaining communities of users of and contributors to shared collections of digital teaching and learning resources and tools. Relationships among the envisioned activities, processes, products, and outputs are depicted in the program model. Substantial resources have been invested in a technical and social infrastructure to realize these linked aims. Thus, any evaluation of the NSDL needs to examine and be guided by the program's logic model.

FORMATIVE EVALUATION EFFORT

We proposed to undertake a formative evaluation addressing two intermediate components of the logic model because we believe it is too soon to look for longer term outcomes and impacts in a summative evaluation. First, while the program has been operational for a decade, the NSDL as a social and technical system is still evolving. For example, when the program began, Google itself was still an NSF research project; so considerable effort was expended in the early years on building a technical platform that would broadly enable locating digital resources and facilitate their use. Similarly, it was viewed as necessary to encourage the development not only of high-quality resources, services and tools but also of user communities that would constitute and contribute to the system's vitality; but that was before the large scale emergence of social media that now easily connect people with common interests. For such reasons, it seems premature even now to expect to observe fully built and relatively stable social and technical infrastructures.

Second, although this is a long-term goal of the NSDL, we argued that it is also too early to expect to find large-scale effects on teaching and learning outcomes in the STEM disciplines as a function of dissemination and use of NSDL resources, services, and tools in U.S. schools. However, it is not too soon to look for promising indicators of such results in the future. For instance, we would expect to find research projects experimenting with ways to engage classroom teachers in the use of the NSDL's digital STEM contents or exploring the efficacy of such contents in interactive learning

processes. At this stage, then, a formative evaluation looking for antecedents potentially predictive of the desired outcomes and impacts seemed most appropriate.

SOCIOTECHNICAL SYSTEMS FOUNDATION

Finally, a sociotechnical systems-theoretic foundation served as the research base for the evaluation reported here. It is clear throughout the NSDL logic model that digital libraries, as well as the distributed teaching and learning environments they are intended to enable and support, have both social and technical components and that these are taken to be highly interdependent. Sociotechnical systems theory seems well suited to account for how the social and technical sides of a complex system can be effectively integrated to yield complementary positive outcomes. Research carried out at RAND and elsewhere suggests the usefulness of a sociotechnical systems perspective for understanding how new technologies can be introduced into existing contexts of use to achieve the desired aims (see the review in Bikson and Eveland, 1991, as well as Bikson and Eveland, 1996, 1998; Bikson, Cohen, and Mankin, 1998; Mankin, Cohen, and Bikson, 1997).

RESEARCH PROCEDURES

Research procedures for this evaluation were organized to follow its goals. We began by addressing what can be learned from existing information in three key areas: the digital resources developed, the avenues for accessing them, and the expected outcomes from their use. Specifically, we addressed these main research questions in response to the first aim:

- What is the state of health of the resource collections?
- What evidence do current web metrics provide about activities undertaken by users to find and access those resources?
- Are there early signs of positive effects from use of NSDL resources among STEM teachers or learners?

For this purpose, we assessed all current collections, examined the websites of the NSDL portal and several pathways, as well as support for moving between and among them, and reviewed project abstracts, reports, and research papers.

When we had initial answers to these questions, we then designed and carried out some primary data collection efforts to supplement the findings and to provide a better

base for a future evaluation. In particular, we conducted pilot trials aimed at assessing the metadata intended to assist users in finding, identifying, selecting, and obtaining sought resources and at exploring the usability of available resources for accomplishing selected routine tasks in STEM teaching. Finally, we conducted a minicase study of one full instantiation of the NSDL model—a demonstration of curriculum customization to meet the needs of earth science teachers using resources from the Digital Library for Earth System Education (DLESE).

We then synthesized the findings from these exercises to yield results and recommendations, both for what NSF and the NSDL should do now and for the design of a full formative evaluation.

HOW THIS REPORT IS ORGANIZED

There are six substantive chapters, each addressing one of the key evaluation issues briefly noted in the previous section. Each chapter is intended to be self-standing. That is, because of their diverse foci, each chapter has its own rationale and methods section, as well as an independent discussion of the conclusions and recommendations its findings support. When relevant, the chapters have appendixes that provide supporting material. The substantive chapters are organized as follows:

- Chapter Two provides an intensive assessment of the state of health of NSDL digital resources based on an exhaustive review of online material in NSF-supported collections and pathways.
- Chapter Three reviews the extant web metrics and their viability for addressing questions about the growth and interconnectedness of user communities and patterns of user behavior.
- Chapter Four undertakes an exhaustive review of NSDL project reports and project-generated publications to determine the extent to which early evidence of teaching or learning effects is available.
- Chapter Five reports results of a pilot trial aimed at assessing whether metadata associated with the NSDL and selected pathways are useful for finding, identifying, selecting, and obtaining sought resources.

- Chapter Six presents findings from a pilot trial to explore and compare the usability of digital resources for accomplishing standardized STEM teaching tasks given four different starting points: Google, nsdl.org, an NSDL pathway aimed at supporting middle school teachers (MSP2); and a discipline-specific NSDL pathway (DLESE).
- Chapter Seven presents a minicase study of the Denver Public Schools demonstration project using the Curriculum Customization Services to enable district-wide use of digital resources for all earth science classes.
- Chapter Eight then summarizes findings from these efforts, along with their chief conclusions, recommendations for NSF and the NSDL, and implications for designing the future evaluation. The chapter closes with a suggested design for the full formative evaluation.

Finally, several appendixes provide additional details about procedures and results presented in the main body of this report: Appendix A lists the funded collections; Appendix B lists the Pathways; Appendix C provides web metrics; Appendix D gives the NSDL teaching and learning product synopsis; Appendix E describes the NSDL teaching and learning study synopsis; Appendix F describes usability studies; and Appendix G provides a sample Find, Identify, Select, Obtain (FISO) instrument.

CHAPTER TWO. ANALYSIS OF NSDL COLLECTION HEALTH

INTRODUCTION

This chapter discusses the evaluation of the health and viability of the digital collections that are at the heart of the NSDL. The NSDL was developed to provide a central portal for educators and learners across all STEM disciplines and across all education levels to discover and use digital educational resources. It is a multilayered collection portal, representing different levels of commitment to a national digital library of science content, tools, and services to enhance teaching and learning in the STEM disciplines. Many of its collections were funded by NSF as part of annual solicitations for grant proposals to participate in the NSDL. Other collections were selected by the NSDL core team or by Pathways collection developers to support mathematics and science education through inclusion in NSDL or Pathways collections.

We focused intentionally on collections and Pathways funded by the NSF as part of the competitive proposal process, since this is an evaluation of the NSDL as an NSF initiative. Also, these collections are expected to conform to expectations for official NSDL collections, such as sharing metadata records with the Core Integration team. Independent collections that are selected for use within the NSDL or its Pathways are under no similar obligation, so it is not reasonable to hold them to a similar level of quality and viability in an NSDL evaluation. We structured collection health evaluation around three layers of collection effort: individually funded collections, Pathways, and the NSDL portal.

The first layer consists of the individually funded collections that represent the initial offerings of the NSDL. To identify these collections, we worked from a spreadsheet supplied by NSF of funded projects, of which 71 were determined either to be collection projects or to have a significant collection component. The next collection layer evaluated was the Pathways, which provide stewardship for a broad subject area or a target audience and which can include individually funded NSDL collections as components within a Pathway. As of this writing, the NSDL lists 17 Pathways. Three of these represent recently awarded grants whose pathways are not currently available and thus were not evaluated: Climate Literacy and Energy Awareness Network (CLEAN), Elementary Mathematics Pathway (MathPath), and Teach the Earth: the SERC Portal for Geoscience Educators. Finally, we evaluated the NSDL portal itself, primarily to determine whether it provides an integrative and comprehensive presence and one-stop

shop to the contents of the NSDL collections. Both Pathways and the NSDL portal were examined in terms of their role in integrating individual collections and collaborating among themselves to create an integrated brand identity for the NSDL.

The actual value of a collection naturally resides with the individual resources contained in the collection. The rubber truly meets the road for the value of a collection when educators can discover, select, retrieve, and use the individual resources appropriate to their information needs. However, this evaluation intentionally focuses on evaluation at the collection level for several reasons. Collections are the organizing paradigm of the NSDL. Grants are awarded for collection-level activity. Search, retrieval, and display at the NSDL and Pathways portals are managed by collection. The NSDL and most Pathways enable users to limit their search or browse by collection, and, in many cases, the collection name or icon is prominently displayed in resource result lists.

Evaluation at the resource level also serves a different purpose, with different goals and different methodologies from those of the evaluation of collections. Evaluation at the resource level requires a thorough grounding and, preferably, significant expertise on the subject matter of the resource and the information needs of the audience and should involve benchmarks for general-purpose or research-level collections in each topical area. In contrast, collection health speaks more generally to the viability, trustworthiness, and durability of the collection in the aggregate and, thus, to the usefulness and general appeal of the portal offering the digital collection. Collection-level evaluation can provide fruitful results in terms of trends, commonalities, and impacts that have much to say about the quality of the resources contained within the collections.

Collection evaluation for the NSDL has proven to be a moving target. The attrition rate for NSDL collections is considerably higher than that of the resources they contain. Of 71 collections identified in the NSDL project spreadsheet, 21 (or 30 percent) were unavailable at the time of evaluation. By contrast, a sampling of resource availability in each funded collection and Pathway yielded attrition rates of 5 percent and 4 percent, respectively. Two of the 21 disbanded collections were available in October 2009 but were no longer available in April 2010, when this evaluation concluded. The high attrition rate for NSDL collections is likely caused by many factors, but particularly the grant research system, which focuses on finite projects funded for a limited period and conducted by researchers who typically move on to other areas of inquiry at the conclusion of the grant. However, the dimensions of collection health that were studied

resulted in durable, extensible conclusions that can offer guidance for the NSDL and for similar collaborative collection portals in the digital space, regardless of the changing composition of the collections comprising the portal.

METHODOLOGY

How can collection health be evaluated? This study proposed two important dimensions of collection health and viability: *authoritativeness* and *usability*. *Authoritativeness* focuses on the reliability of the collection. Can users trust the accuracy and completeness of the information included in the collection? *Usability* answers another important question: Will the resources users discover be useful in their educational contexts? Both of these broad attributes—authoritativeness and usability—contribute to a worthwhile experience for the target audience of educators and learners so that members of that audience will return to the collection portal for future information needs. Both evaluative concepts are in frequent use, particularly for digital collections (Blandford and Buchanan, 2003; Hall, Naughton, and Lin, undated; Xie, 2006, 2008; Kimbrough, Padmanabhan, and Zheng, 2000; Lim and Ko, 2005; Nicholson, 2003), in which the volatility and complexity of the digital space require explicit demonstrations that resources can be trusted and are simple and intuitive to use. How do we measure the health and viability of collections with respect to authoritativeness and usefulness?

To develop our evaluation rubrics, we looked to library science, an area of study that has a long history of developing principles and practices for collection development and maintenance. The primary and secondary audiences of the NSDL—educators and learners—may not be familiar with the concepts of collection management and may not think about resources the way a librarian might. Although the educator would not recognize the term *deaccessioning* or even fully understand its more common term, *weeding*, the fact that collection owners have, and follow, a policy and process for removing resources that are no longer authoritative or usable will result in collections that educators feel they can trust and a portal to which educators return for their pedagogical information needs. A collection with many broken links or that references dated theories will lose an educator’s trust immediately and might never receive a second visit. Principle 3 of the NISO *Framework of Guidance for Building Good Digital Collections* states that “a good collection is curated, which is to say, its resources are actively managed during their entire lifecycle” (National Information Standards Organization [NISO], 2007, p. 4).

The NSDL is repurposing its mission from being a digital library with its emphasis on collections of “stuff” to a learning portal with a focus on services that support educators in their pedagogical workflows. However, resources remain a key entity in the model of service to the educator. An educational portal will not support and satisfy educators unless it provides a healthy collection as its underpinning. The key is to practice solid collection management strategies without imposing them on the user, who should instead simply benefit from the resulting healthy collection. Libraries have learned this lesson and have evolved from collections of preserved artifacts to portals for user-centered learning. Our collection evaluation model looks at both dimensions of a trustworthy collection—authoritativeness and usability, from the perspective of library science principles and practices. Each of these dimensions is evaluated and discussed, for funded collections and for Pathways.

AUTHORITATIVENESS

A collection can be considered authoritative if it contains current and accurate resources that are well-maintained. Authoritativeness is ascribed by the collection audience to the resources within the collection and to the creators or curators of the collection (Xie, 2006, 2008). Resources from trusted information providers are assumed to be authoritative because of the standards and practices of evaluation and review associated with those providers. In this section, we examine multiple criteria that aggregate to achieve the quality of authoritativeness for a digital collection.

Currency

A very basic and obvious criterion for an authoritative digital collection is currency. Is the collection, and the portal hosting it, up to date and currently maintained? Just as a deserted house creates a sense of neglect and disrepair, an unmaintained website and collection that is not current creates an immediate negative impression on its potential audience. It is difficult to think of any STEM subject that does not require currency for collection authoritativeness. While provable facts may not change, concepts and interpretations surrounding facts do change over time. Pluto can be proven to exist in largely unchanged form, but any resource presenting it as the ninth planet is conceptually inaccurate. Even resources that are digital reproductions of ancient artifacts require up to date tools, such as 3-D image viewers, for display and manipulation, as well as activities that reflect current pedagogical practices or relate the artifacts to contemporary counterparts. Digital resources that do require tools for

viewing and manipulation, such as Macromedia Flash® viewers, need to keep those tools up to date so that potential users aren't "locked out" from utilizing the collection because their browsers cannot interface with the viewing tools.

Currency Measure. NSDL-funded collections and Pathways were examined to see whether the hosted collection, the site hosting the collection, or the tools and services provided were current as of 2009. For many Pathways, it is difficult to determine which collections they host, so evaluating the currency of their supported collections was not useful. The NSDL portal is a "collection of collections" and, as such, was largely rated by the continued listing of unavailable or outdated collections in the overall NSDL union catalog. The results are displayed in Table 2.1. Results for each individual collection are available in Appendix A. As Table 2.1 indicates, 20 percent of available funded collections are not current. Twenty funded collections that are inactive or no longer current are still available for search and retrieval in the NSDL. It is recommended that the NSDL use the collections summary spreadsheet available as a supplement to Appendix A to evaluate and remove outdated and unavailable collections from its metadata catalog and that a similar process be followed, on at least a semiannual basis, to weed out collections that are no longer active.

Table 2.1 Results of Currency of NSDL–Funded Collections and Pathways

	Funded Collections (n = 71)	In NSDL Portal (n = 47)	Pathways (n = 14)	In NSDL portal (n = 14)
Current	30	27	13	13
Not current	14	13		
Unknown	6		1	1
Inactive	21	7		

Collection Development Policies

The first collections principle in the NISO *Framework* states, "A good digital collection is created according to an explicit collection development policy" (NISO, 2007). Collection development policies serve two key purposes. To begin with a mission statement, description of target audience(s) served and a description of collection scope provide many different audiences, from the end user audience of educators and students to potential collection collaborators, with basic and valuable information about the relevance of the collection to their needs. Mission, audience, and scope can also be used by intelligent tools and services to prioritize collection results in a federated search

or to respond to “How do I...” natural language queries that can guide a user to the collection most appropriate to their needs. Mission, audience, and scope also serve the critical purpose of focusing the efforts of the collection builders to avoid mission creep and to ensure that any changes to these key areas are made intentionally by the collection builders and documented for the benefit of collection users. It is important that a collection accurately reflect its stated mission, audience, and scope and that any exceptions, such as the inclusion of K–12 resources in a portal with a stated audience of higher education, are explained to the users so that users do not make assumptions about the size of the K–12 collection in comparison to resources for higher education. Studies by Xie (2006, 2008) have documented that users value such elements as scope and mission. DLESE requires every participating collection to write a scope statement and provides comprehensive guidance on its construction, which can serve as a model for other Pathways (DLESE, 2006).

Collection Development Policy Measures. Core components of a collection development policy can generally be divided into qualitative and quantitative components (Arizona State Library, undated). Qualitative components include a statement of the *mission* or purpose the collection is intended to fulfill, the *audience* the collection is intended to serve, and the *scope* of the collection—collectively, the range of formats, genres, and subject areas that the collection will cover. These are qualitative aspects of a collection because they are nonnumeric measures of the collection portal’s informational role—telling the audience what to expect from the collection and providing a broad benchmark for judging whether the collection fulfills its promises. Quantitative components provide measurable strategies for ensuring a collection that can meet the promises inherent in the qualitative components. There are many quantitative components that could be considered, including usage statistics. Usage statistics apply equally to search engine and service usability and are discussed elsewhere in this report. Specific to collections are accessioning and deaccessioning policies (see NISO, 2007). Does the collection have published criteria for selecting resources for the collection, as well as published criteria for removing resources that are no longer useful or at least no longer available? These are treated as quantitative measures because, presumably, resources that are managed in conformance with both policies can be counted and measured against the overall collection. While there are other components of a complete collection development policy, we selected these as being most critical for digital collections and also most accessible for understanding and implementing by collection developers who are largely not from the library science field.

We searched the websites of each funded collection and Pathway, looking for evidence of both qualitative and quantitative collection development components. Even when these were labeled differently or combined—for example, when scope was included in the mission statement—the collection was credited with possessing the component. We did not contact collections to determine if collection development policies were available offline. Availability on the website, where the target audience and potential contributors can readily discover them, is important for all components. Some collections represent well-defined collections from a single and trusted source that are simply being made digitally available, such as the Kinematic Models for Design Digital Library (KMODDL), which consists of digital facsimiles from a 19th-century mechanical models collection. Even these collections, however, should have collection development policies, since digital information is not static and, at some point, will include outdated or unavailable resources that should be removed.

Table 2.2 shows the qualitative collection development components. These include the presence of a collection development policy itself, as well as mission, scope, and audience.

Table 2.2 Qualitative Collection Development Components

Collection Development Component	Funded Collections (n = 50)	Pathways (n = 14)
Collection development policy	10	4
Mission	45	14
Scope	43	8
Audience	39	11

Given that many NSDL collections were developed by scientists and educators, it is not surprising that few collections (20 percent of funded collections and 29 percent of Pathways) include published collection development policies. A clearly defined mission is common to projects generally and not just to collections, so it is equally unsurprising that 90 percent of funded collections and 100 percent of Pathways include a published mission statement. Eighty-six percent of funded collections include collection scope, but the Pathways are surprisingly low, with 57 percent of collections containing a discoverable statement of scope. This could reflect the stewardship role of Pathways, which often do not have direct control of the collections they host and often aim for a broad and comprehensive array of collections at the expense of well-defined collection

boundaries. Given the importance in the educational arena of resources appropriate to the audience learning level, it is surprising that all collections do not identify their target audience. Seventy-eight percent of funded collections and 79 percent of Pathways collections identify their target audiences. We would expect all collections to provide the level of guidance to potential users and collaborators that these core components of a collection development policy comprise.

The NSDL provides collection level metadata for each collection, which include intended audience and scope of collection (formats, types, and subjects of resources). However, it is difficult to keep this information as up to date as individual collection websites. Standardized placement of collection policy elements, such as mission, scope, and audience on Pathways websites, as well as core services, such as simple search, can create an integrated presence across Pathways and provide users with intuitive guidance and instant familiarity for navigating and browsing Pathways collections. The Pathways should consider constructing a core design template that provides a basic level of consistency across collections without sacrificing individual creativity and content.

Table 2.3 contains the quantitative measures—accessioning (adding) and deaccessioning (weeding) criteria and policies. Again, we were very expansive in our evaluation, accepting any published guidance for adding or removing resources from the collection. Very few collections had published criteria, policies, or even statements of support for selection and deselection criteria. These criteria should be discoverable at the website but are not as critical to publicize on a top-level page to potential users. However, educators who want assurances that a collection is carefully selected and that currency and appropriateness of resources are maintained will want to be able to find this information at the website. What is most surprising is how few Pathways include policies or criteria for adding or removing resources. Managing collection resources for appropriateness and viability is a critical part of collection stewardship and guidance that Pathways are tasked with providing.

Table 2.3 Quantitative Components of Collection Development

Component	Funded Collections (n = 50)	Pathways (n=14)
Accessioning	19	4
Deaccessioning	7	2

Table 2.3 shows that 38 percent of funded collections have published accessioning criteria, contrasted with 14 percent with deaccessioning criteria. Only 29 percent of Pathways have published accessioning guidelines, and only 14 percent have deaccessioning criteria. The NSDL has a published collection development policy that provides useful examples and guidance for all core components. It should be broadly promoted for adaptation and use by the Pathways collections, at a minimum (NSDL, 2010).

Resource Attrition Rate

As discussed earlier, the continued availability of resources discovered through browsing or searching the collection website is a key factor in the trust that users feel in the collection. Resource availability is an ongoing and significant concern for digital collections. Studies have found availability attrition rates ranging from 30 to 50 percent for web resources cited in scholarly publications (Koehler, 2004) and, for educational resources used in science pedagogy, from 11 to 17.5 percent (Markwell and Brooks, 2002). A sampling of search results for NSDL collections conducted as part of this assessment found collections that are significantly more durable. For funded collections, 10 of 259 sampled resources, or 4 percent of the sample, and 14 of 281 (or 5 percent of) sampled resources in Pathways were not available when searched. These low resource attrition rates are an obvious and significant strength of the NSDL. More information about the items searched for each collection is provided in Appendixes A and B.

Peer Review and Professional Oversight

Users attribute authoritativeness to the collections but also to the collection developers. Peer review, involving an assessment of accuracy, quality, and value by peers with expertise in the topic, has long been acknowledged in scholarly publishing as the “gold standard” to ensure that available resources are useful and even innovative and important. In the K–12 community, the branding provided by professional

associations and respected information providers in the education arena, such as the Public Broadcasting Service (PBS), is an equally important indicator of an authoritative collection. User comments and ratings serve a different purpose than peer review. Peer review is intended to vet resources for inclusion in a collection. For this reason, peer reviewers are generally selected for expertise in an area. Comments and ratings are offered after the fact of collection inclusion, are offered by members of the user community with a range of expertise, and are primarily intended to reflect on the resource's usability or to add value by sharing experiences and recommendations for using the resource. The ability to comment and rate resources is considered a usability, rather than an authoritativeness, measure and is assessed later in this chapter.

Measures of Peer Review and Professional Oversight

We examined the websites for evidence of peer review, which could include a published peer review process, the designation of one or more collections within a portal as peer-reviewed, particularly if these collections are favored for searching and display, or an editor or editorial board tasked with providing this professional review. Some collections offer very nuanced peer review. The Computational Science Education Reference Desk Pathway (CSERD) combines both peer review and usability in a three-step review process—verification, validation, and accreditation—that evaluates the resource at each stage of its life cycle. As the CSERD website notes,

verification, validation, and accreditation reviews are a more structured way of reviewing the information on CSERD. This type of review proves most helpful when examining the “usability” of an item. Someone looking through can clearly see any errors, problems, drawbacks, or strong points of the material. The reason this can be done so clearly is [that] the information input in these reviews is all formatted to allow for quick, efficient, and yet in-depth reviews. (CSERD, undated)

DLESE includes both peer-reviewed and non-peer-reviewed resources. Peer-reviewed resources are collated into the *DLESE* Reviewed Collection (DRC) and always appear first in result lists for search queries. Other NSDL collections offer excellent published guidelines for resource review, which serve the double purpose of providing both published accessioning standards and guidance for potential peer reviewers. The Multimedia Educational Resource for Learning and Online Teaching (MERLOT) portal offers three-hour online training for potential reviewers, known as “GRAPE Camp” (for Getting Reviewers Accustomed to the Process of Evaluation). These collections represent

different models for collections wanting to offer rigorous review practices and to promote peer-reviewed resources to their users.

Professional oversight could be evidenced in several ways, including sponsorship or participation by one or more national organizations or the presence of an advisory board of recognized experts in the field. Results are shown in Table 2.4 and, for individual collections, in Appendixes A and B.

Table 2.4 Peer Review and Professional Oversight

Oversight Type	Funded Collections (n = 50)	Pathways (n = 14)
Peer review	24	9
Professional oversight	20	12

Given the high academic involvement in the development of most collections, the low level of evident peer review and professional oversight in a sponsoring or advisory capacity is somewhat puzzling. Only 48 percent of funded collections and 64 percent of Pathways contain peer-reviewed resources. Forty percent of funded collections and 86 percent of Pathways have professional oversight. Some collections were developed by experts in the field or from known resources or contributors. Examples include *www.eSkeletons.org: An Interactive Digital Library of Human and Primate Anatomy* and *Teachers' Domain*, a collection of PBS resources. However, even these collections can benefit from professional oversight for advice in such areas as resource presentation and resource display tools. Pathways must occupy a position of authority within the community of collections for which they provide stewardship. Competitive proposals for Pathways are often evaluated in part through evidence of sponsorship by significant associations in the field and evidence of oversight through the presence of an advisory board. Not surprisingly, the percentage of Pathways collections with professional oversight is fairly high (86 percent).

USABILITY

A collection can contain the most authoritative resources in a field of study, but, if the resources are not used, all the effort involved in creating the collection is wasted. Authoritativeness can lead a user to a collection, but usability will ensure that users find what they need and return to the collection to meet future information needs. Usability is based on clarity of presentation, simplicity of navigation, and ease of use for tools and

services to utilize the collection, but it is also tied to the user’s ability to find and select resources appropriate to a workflow need. Can users find an activity that explains mathematical probability that sixth grade students can perform in small groups? Can they find a good simulation of a volcano that explains to fourth grade students exactly what happened in Iceland to generate a thick cloud of ash? How collections guide users efficiently and effectively to the resources most responsive to their information needs is the essence of collection usability. Dimensions of collection usability that we selected for evaluation are discussed in turn.

Search Strategy Supported

The first dimension of usability is the ability to find resources in a manner of the user’s choosing. Broadly speaking, there are three general methods for finding resources—the *simple*, or “Google” search, in which users enter keywords in a box with little or no guidance; *advanced search*, in which the user filters the search results in advance according to preselected criteria, such as education level or physical format of the resource; and *browse*, in which the user browses all the resources belonging to specified resource categories. These are often subject areas, such as browsing all resources in chemistry; education level, such as browsing all resources for grades 3–5; and, for Pathways and the NSDL portal in particular, browsing by participating collection.

Search Strategy Supported Measures. Funded collections and Pathways were examined for the search strategies supported. There is significant overlap with the evaluation of the NSDL technical infrastructure, which is discussed in depth elsewhere in this report, so, for collection health evaluation, we focused only on available search options and not how effective they were. Many, but not all, collections offer at least two searching strategies, as displayed in Table 2.5, and several offer all three.

Table 2.5 Search Strategies Supported

Search Strategy	Funded Collections (n = 50)	Pathways (n = 14)
Simple search	32	14
Advanced search	25	11
Browse	44	12

Advanced search, supported by 50 percent of funded collections and 79 percent of Pathways, is the least common search. It is surprising that common search strategies are not offered by all collections, except that all Pathways offer simple search as described in the previous section.

Equally important to the type of search is how quickly the search option can be found. Most people visit a collection portal to find a resource quickly and then move on to employ the resource in their work. Part of Google's popularity lies in the single-minded simplicity of its web presence. The search screen is featured prominently and can be quickly accessed and used. Some collections were particularly problematic in their approach. Most collections provide a simple search directly on the home page. The MathDL Pathway places a search of the NSDL and of its collection partners on the front-page toolbar. The simple search for the MathDL collection is on the "About MathDL" page, which is two clicks away from the home page. The Middle School Portal features a simple search screen prominently on the top task bar of the home page. However, this search box searches the website rather than the collection, and this distinction is not intuitive for the general user. Placing search or browse prominently on the home page so that users can quickly and easily access resources is a basic but very important way to increase the usability of a collection. Placing search in the same place on the home page of each Pathway collection can help to build both an identity for the NSDL and a feeling of seamless navigation across Pathways.

Some collections offer additional search strategies. The Marine Mammal Commission Digital Library of International Environmental and Ecosystem Policy Documents offers a search, with patent pending, called *integration*. Unfortunately, we were not able to determine what this search is intended to accomplish, and the collection does not appear to be maintained or to offer useful guidance on applying the search. The Harvard-Smithsonian Center for Astrophysics's Digital Video Library offers a nuanced browse by educational standards and instructional strategies.

The Pathway MatDL uses the Fez application that provides a user interface for the open source Fedora Commons repository software. Fez was developed by the University of Queensland in Australia (University of Queensland, 2007). Many of the search filters from the original Fez implementation are still available in MatDL, which must be confusing for site users. For example, clicking "by Subject" under the "Browse" options takes the user to a link for the Australian Picture Thesaurus, which is not only irrelevant to materials science but is also a broken link. The "Help" button on the top

task bar takes the user to a list of frequently asked questions (FAQs) for the University of Queensland eSpace institutional repository.

Metadata Implementation

Search strategies are only as effective as the information supporting them. Although most, if not all, search strategies support keyword searching, the reality is that keyword searching has distinct limitations. To begin with, educational resources tend to be very diverse and to cover a range of genre and formats. A lesson plan and an interactive digital activity might incorporate the same keywords but are not the same thing, although the activity can be used within the lesson plan. A video simulation of a pulley might have no keywords against which to search.

Metadata afford structured information about a resource that provides *consistent description* to enable users to filter, compare, and select resources based on criteria important to them. Good metadata also provide *context*, to enable users to match resources to his or her particular workflow need. Educators bring questions to the discovery process that metadata should attempt to answer. For example, a sixth-grade teacher might be looking for a small-group activity that enables students to learn fractions. Metadata can enable the teacher to filter his or her search by education level (sixth grade), type of resource (educational activity), and topic (fractions).

How can metadata be implemented to support both consistency and context? Creating good, effective metadata can be a very time-consuming process. Balancing the metadata needs of users and resources against the level of effort required to create good metadata is a conundrum that the library world, which has been cataloging resources since the earliest libraries, has yet to solve. However, there are recognized strategies and principles that reflect useful and viable metadata practices that support the targeted audience and beyond that have been usefully employed by a broad variety of digital libraries. Strategies employed in the digital collections environment include the following:

- *Use of a metadata standard.* Conformance to a standard, such as Dublin Core® or Learning Object Metadata, brings consistency to metadata and enables the collection managers to benefit from the work and tools of others and to share their metadata with other collections. The NSDL requires support for its customized use (application profile) of Dublin Core, called nCore, which is then harvested using the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) for concatenation in the NSDL union catalog. Collections developing their own

metadata schema should employ the same strategies, such as creating a registry documenting the metadata, as are employed by metadata standards bodies.

- *User-friendly display.* Metadata should present information to end users in friendly, consistent displays that are jargon free and that reflect user workflow needs. Metadata that conform to a standard often have prescribed elements, such as “creator” or “typicalLearningTime.” Such metadata are generally expressed in a schema that is documented in an extensible markup language (XML) or resource description framework (RDF). Data elements are often expressed in conventions that support robust machine processing, such as the elimination of spacing and punctuation between words in a metadata element name. Effective use of metadata makes a distinction between the metadata that are created, validated, and stored and the metadata that are displayed to end users, which should represent terms and concepts familiar to those users. Displays should also reflect the evaluative processes of the user, displaying the most important selection information in short displays, with the option to see expanded information about the resource in a full display.
- *Coordination with the search process.* Metadata must also support the search process effectively. When users are offered the option to browse or search a collection, the unspoken understanding is that all resources have been structured such that a search on resources for a fifth-grade audience will retrieve all resources intended for a fifth-grade audience. It is also expected that searching on the entire range of education levels will provide all resources, structured by the different education levels. This will occur only if education level is a *mandatory* data element in the metadata, meaning that all resources are cataloged with a completed education-level metadata element. It is useful also to align metadata and the search process such that any term used within a filtering element displays for selection by the user only if at least one metadata record contains that term. This is recommended rather than required but does ensure that users are not frustrated by too many searches that produce no resources.

Metadata Implementation Measure. There are many dimensions to effective metadata and tremendous variety and creativity in how metadata can be implemented. Metadata are generally very specific to the audience, the subject matter, and the type of resource. In some cases, the metadata are embedded in the structured resources supported by the collection. Examples include the Earth Exploration Toolbox, in which the structured chapter sections do double duty as metadata. Similarly, the Tree of Life Web Project has structured templates for branches and leaves that supply metadata for browsing the hierarchical taxonomy of species available at the site.

Every resource can benefit from structured descriptions, so first we looked for evidence that any metadata strategy was implemented in the collection. We then evaluated metadata for each funded collection by looking for documentation and evidence of a metadata standard used, integration with the search strategy, and effective metadata displays. Because of the great variety of metadata strategies, a side-by-side comparison of metadata was not useful. Also, since the most effective metadata are aligned with the needs of the resources and the audience, measures such as “completeness” are very relative. For a collection aimed at busy middle school educators, less is often more, and the metadata cannot be usefully compared to those employed at a site focused on experimental data for reuse by researchers. We decided to assign a rating of *good* for metadata that are consistently described and applied, integrate well with the search strategy, and have a clean, jargon-free display that support the target audience.³ A rating of *acceptable* indicates that the metadata meet minimum requirements but lack robustness in one or more of these areas. A rating of *poor* indicates that metadata either are not available or fail to meet minimum expectations for a robust metadata implementation. Results for both funded collections and Pathways are provided in Table 2.6. Ratings for individual Pathways and Collections are provided in Appendixes A and B.

Table 2.6 Metadata Implementation and Rating

Implementation Rating	Funded Collections (n = 50)	Pathways (n = 14)
Metadata implemented	38	14
Good metadata	6	6
Acceptable metadata	23	7
Poor/nonexistent metadata	19	1

Not surprisingly, all Pathways include a discoverable metadata implementation. Pathways, which are aggregating multiple collections in support of a specific subject domain, type of resource, or audience, understand the value of structured information for integrating these resources into a congruent whole. Many Pathways are union

³ The paucity of sites with “good” metadata ratings led us to give greater attention to assessing metadata quality in a primary data collection effort described in Chapter Five.

catalogs of metadata rather than hosts for the actual resources, so the metadata implementation is the collection.

The DLESE Pathway was an early adopter of rigorous, effective metadata practices, adapting and using the Institute of Electrical and Electronics Engineers (IEEE) Learning Object Metadata standard. DLESE offers both training and tools for creating metadata to the NSDL community generally. Such collections as Health Education Assets Library (HEAL) and Starting Point: Teaching Entry Level Geoscience, have successfully adapted and used the DLESE metadata schema and tools. Educational standards are particularly useful for public school educators. Many collections offer metadata for national standards relevant to each resource. Teachers' Domain is particularly noteworthy for customizing standards to the state that the user identified during the registration process. TeachEngineering provides an excellent site that offers searching by a range of national engineering standards, as well as by individual state standards.

Funded collections and Pathways that were rated particularly well for metadata are those that reflected the educational context and terminology of their audience. The Science and Math Informal Learning Educators (SMILE) Pathway has a clean, effective display that answers many of the questions a busy educator would want to know about a resource before selecting it to view. A link to the resource and a description of what the resource contains and a cumulative rating score are prominent in the display, but other useful information, such as age range, materials needed, cost of materials, preparation time involved, and learning styles supported, as well as subject areas, collection owner, and related resources, are all provided in a friendly, jargon-free display. An example of SMILE metadata is provided in Figure 2.1. Note that the ability to log in (top screen) and provide feedback (bottom screen) is prominent in the display without interfering with the educator's ability to focus on the resource description itself.

Experimenting with Naked Eggs

howtosmile.org/record/487

State Abbreviations RAND Intranet Bulletin WorldCat allbooks Advanced Search ROBIN Share on Facebook Other Bookmarks

HOWTOSMILE.ORG
ALL THE BEST SCIENCE & MATH ACTIVITIES

Search

Activities Users

Home About Participate Help Blog Register

Sign In

Username or email:*

Password:*


Create new account
Forgot Password?

User Lists

This activity is part of these lists

- Edible Activities by namedina
- Water Quality Fun Activities by TruDunham
- Chemistry Activities by Ray Ferrer
- Summer 2010

Experimenting with Naked Eggs




★★★★★

Description

In this activity about osmosis, learners use a naked egg (one with a dissolved eggshell) to learn about selectively permeable membranes. This is a great activity to easily show the qualities of different solutions and their effect on cell membranes. Can the effects be reversed? Try it and find out! Activity also contains a recipe for 'naked eggs.'

Source Institution



Keywords

egg eggshell membranes
selective permeability osmosis
hypotonic hypertonic
selectively permeable

Quick Guide

Preparation Time:	4 to 24 hours
Learning Time:	10 to 30 minutes
Estimated materials cost:	1 cent - \$1 per student
Age Range:	Ages 11 - 18
Resource Types:	Activity Experiment/Lab Activity
Language:	English

Materials List (per student)

Experimenting with Naked Eggs

howtosmile.org/record/487

State Abbreviations RAND Intranet Bulletin WorldCat allbooks Advanced Search ROBIN Share on Facebook Other Bookmarks

Summer 2010 by semery

Afterschool activities by twambeke

1 of 2 >>

Related Videos

There are no videos for the resource. Be the first to add a video.

+ Add your own Video

Materials List (per student)

- At least 2 naked eggs
- Containers large enough to hold a single egg and some liquid (coffee mugs or tumblers work fine)
- Corn syrup
- Water
- A big spoon

Subjects

Informal Category

Food and Cooking

Subjects

- Life Sciences
 - Cells
 - Cell Structure and Function
- Physical Sciences
 - Chemistry
 - Solutions

Audience

To use this activity learners need to

see

Learning styles supported

Involves hands-on or lab activities

Other

Components that are part of this resource

Making Naked Eggs

NOTE: The bottom screen shot is what the user would see upon scrolling down from the top screen shot. The metadata are visible on the same page, simply by scrolling.

Figure 2.1 SMILE Pathway Metadata Example

Among funded collections, Starting Point: Teaching Entry Level Geoscience provides equally effective metadata that address educators' pressing workflow questions, as demonstrated by Figure 2.2.

The screenshot shows a web browser window with the URL serc.carleton.edu/sp/library/roleplaying/examples/tide.html. The page title is "Changing With the Tide". The main content area includes a "Summary" section stating: "This lesson plan is written around a brief role-play in which students learn about and act out the behavior of plants and animals in a salt marsh habitat as the tides change. An unusual feature of salt marshes is the dramatic daily change in stresses and interactions that the organisms face." Below this is a "Learning Goals" section with four bullet points: "Describe three different aspects or life forms of the salt marsh.", "Compare and contrast the low and high marsh.", "Explain what happens in different areas of the marsh at low and high tide.", and "Explain the roles different organisms (or other elements) play in the salt marsh by acting out a salt marsh scene." The "Context for Use" section states: "The full exercise is estimated to take 1-2 hours, but the role-playing segment, transferred to a university marine biology or oceanography classroom, should take about 15 minutes. It is a good exercise to break up a lecture because it gets students out of their chairs (very important for those after-lunch classes). It might make a good introduction to a field lab involving a salt marsh." The "Description and Teaching Materials" section begins with: "The [Changing with the Tide \(more info\)](#) lesson plan on the web contains all of the necessary materials, including some links, except for index cards. The instructor can copy and paste the roles from the lesson plan onto the". A red arrow points to the link "The Changing with the Tide (more info)".

Figure 2.2 Starting Point Metadata Example

Note that the peer review status of the resource is highlighted at the beginning of the metadata record. The primary – and significant – drawback for an otherwise excellent, comprehensive record is that the link to the resource itself is buried in the metadata description, as the red arrow (inserted by authors) in Figure 2.2 indicates, perhaps to force a user to read the entire description. It is always best to leave navigation decisions to the user and rely on the usefulness and brevity of the metadata to encourage users to read the entire description.

Metadata that were either acceptable or poor generally reflected the jargon and machine-processing artifacts of the underlying metadata, all of which should be hidden or transformed into context-appropriate descriptions for end users.

The CSERD Pathway had acceptable metadata elements that provide sufficient information for a user to make a resource selection but received a poor rating because

most sampled records lacked information in many important categories, such as education level—categories, it should be noted, that are supported for both browsing and filtering. Figure 2.3 illustrates the problem that results when metadata elements, particularly those used for browsing and filtering the collection, are not mandatory.

The screenshot shows a web browser window with the URL www.shodor.org/refdesk/Catalog/Item/247/summary. The page title is 'Martindale's 'The Reference Desk''. The browser's address bar shows the URL, and the page content includes a navigation menu with 'User Home', 'Catalog', 'Resources', and 'Help'. Below the navigation menu, there are tabs for 'Summary', 'Read Reviews', and 'Add Reviews'. The main content area displays the following metadata:

Title	Martindale's 'The Reference Desk'
Url	http://www.martindalecenter.com/
Creator	Jim Martindale
Contributor	None listed
Publisher	None listed
Description	On line reference desk covering a wide variety of topics in science and liberal arts.
Format	HTML
Language	EN
Subject	Space, Astronomy, Physics, Education, Computational Science, Ecology, Biology, Animals, Insects, and Pets, Computer Science, Mathematics, Information Technology, Engineering, Chemistry, Psychology, Science and Technology Policy, Social Science, Oceanography, Paleontology, Meteorology, Medicine, Life Sciences, Hydrology, Humanities, Government, Geology and Geophysics, Geography, General Education, Forensics, Energy, Earth Sciences, Disabilities, Complex Systems, Cognitive Science, Aviation and Aeronautics, Atmospheric Science, Artificial Life, Anthropology and Archaeology, Agriculture, Acoustics
Keyword	Astronomy, Physics, Mathematics, Engineering, Chemistry, Bioscience, Reference, materials science, Geoscience, Calculators
Audience	Researcher, Educator, Learner/Student
Education Level	Higher Education, Middle School, Grade 9, Grade 8, Grade 7, High School, Grade 12, Grade 11, Grade 10, Graduate/Professional
Type	Search Engine/Collection

Figure 2.3 CSERD Metadata Example

One of the funded collections, the Computing and Information Technology Interactive Digital Educational Library (CITIDEL) collection, offers unvarnished metadata in which the XML data labels are reproduced faithfully. As Figure 2.4 illustrates, the data elements are not even reordered for the end user audience. Administrative dates (date accessioned, date available, and date issued) appear first, while title is second to last in the display.

The screenshot shows the CITIDEL website interface. The browser address bar displays the URL: www.citidel.org/handle/10117/85457mode=full&submit_simple=Show+full+item+record. The page header includes the CITIDEL logo and the text "Computing and Information Technology Interactive Digital Educational Library".

On the left side, there is a search bar and navigation links: Home, Browse (Communities & Collections, Titles, Authors, Subjects, By Date), Sign on to (Receive email updates, My CITIDEL authorized users, Edit Profile), Help, and About DSpace.

The main content area displays the following metadata:

Please use this identifier to cite or link to this item: <http://hdl.handle.net/10117/8545>

Full metadata record

DC Field	Value	Language
dc.date.accessioned	2009-07-15T16:25:06Z	-
dc.date.available	2009-07-15T16:25:06Z	-
dc.date.issued	2009-07-15T16:25:06Z	-
dc.identifier.uri	http://hdl.handle.net/10117/8545	-
dc.format.extent	10367 bytes	-
dc.format.mimetype	application/msword	-
dc.subject	ACMCCS98::Computing Milieux::HISTORY OF COMPUTING	en
dc.title	Women in Games	en

Appears in Collections: [Related other sites](#)

Files in This Item:

File	Description	Size	Format
womeningames.docx		10Kb	Microsoft Word View/Open

Figure 2.4 CITIDEL Metadata Example

Equally problematic is the repository artifact, “Files in This Item,” indicated in Figure 2.4 by the red arrow (inserted by the authors). This artifact is apparently necessitated by the metadata infrastructure. DSpace is an object-based repository architecture and requires an object data stream, along with metadata, to create a repository package. In this case, DSpace is used to store metadata for resources hosted elsewhere. In order to supply the objects required by DSpace, “artificial” objects are created that provide links to the actual resource. This very cumbersome methodology requires the user to click “View/Open” link beside the file name (a Microsoft® Word document, indicated by the red arrow in Figure 2.4). Clicking this link takes the user to a document containing nothing but the link to the described resource, as illustrated in Figure 2.5.

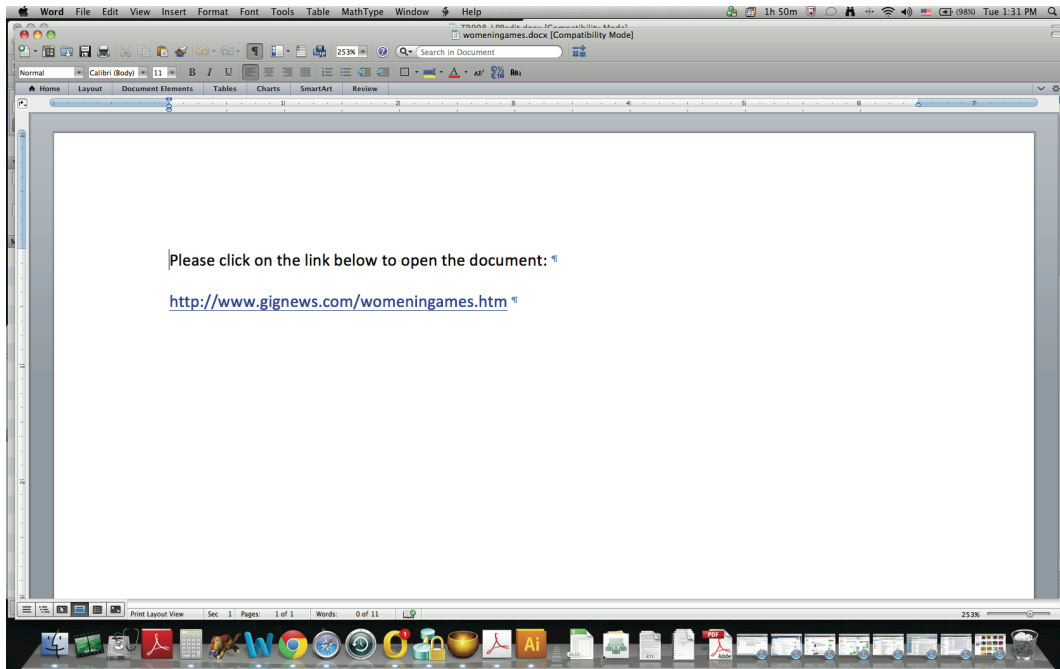


Figure 2.5 CITIDEL “Resource” Example

User Policies

Copyright and privacy policies are very important for providing guidance to users and contributors about their rights and responsibilities for using the collection site and its resources. The creator of a resource, as rights holder, has the right to allow viewing, copying, reproduction, and modification of a resource he or she has created for the term of copyright, which is currently 70 years past the year of death of the creator. Resource users need to know what rights they have to use the resource (e.g., can I view in the classroom? reproduce in a homework sheet? modify the content to fit my teaching context?). Given the high profile litigation for digital resources, such as music files and Google Books, educators are well aware of copyright as a limiting force for resource use. When we showed some mathematics resources to middle-school math teachers, their responses were phrased as questions (“Can I use this resource to do that?”) rather than declaratives (“I can use this resource to do that”). A clear copyright strategy can clarify any restrictions in a friendly and understandable manner so that resource users can reuse resources with confidence and, in fact, can feel free to reproduce and modify resources to suit their educational needs.

Privacy issues are equally important for collection users. Many collections provide tools for personal collection management and opportunities to interact publicly with the resources and other resource users through resource ratings and comments or contributions to blogs or discussion forums. Users need to know that their privacy is respected through a posted privacy policy that identifies whether cookies are used, what personal information is collected, whether they have access to that personal information, and how long that information is kept. A published privacy policy is essential to establishing a relationship of trust with collection users, particularly those who are entrusting personally identifiable information to the site through registration. There are two aspects to privacy that need to be addressed: (1) the capture and use of personally identifiable information and (2) privacy of collection visitors' resource use. The U.S. government has issued fair information-practice principles (see Federal Trade Commission, 2007) that should govern the privacy practices of digital collection portals. These include notice to users and user awareness of personal data collection practices, users' ability to consent or opt out, the ability to access their own personal data, and a guarantee that personal data are kept secure from others (Federal Trade Commission, 2007).

User Policy Measures. We searched the collection sites of funded collections and Pathways for evidence of a copyright policy or, at a minimum, that copyright information about resources is provided to users. We also looked for a published privacy policy. For copyright, we looked for evidence of copyright for both contributors and users of resources. Many collections have policies linked from a bottom task bar or in a "policy" section of a website, providing terms of use for both collection and website, as well as a privacy policy. Some collections document copyright status or permissions for use for individual resources in a rights element in the metadata record. Licenses for use can also be provided that display with web-based resources and give the user guidance on the way the resource can be reused. Creative Commons licensing is becoming the de facto standard in the digital collections space for brokering rights between creators and users in a friendly, effective manner, so we looked for evidence that Creative Commons licensing was in use by funded collections or Pathways.

Another important aspect of copyright is providing guidance for contributors, who might want to know whether they can continue to exploit their own works in other ways once they have been contributed to the portal or who might want to set the permissions and restrictions for their own works. Very few portals provided licensing guidance to contributors, even those that actively solicit contributions to the portal.

Metadata creation and organization are also governed by copyright, and a nuanced and complete copyright policy will address metadata also, but we focused our evaluation on the resources as being most relevant to the target audience of STEM educators. Evidence of user policies is provided in Table 2.7.

Table 2.7 Evidence of User Policies

Evidence	Funded Collections (n = 50)	Pathways (n = 14)
Copyright policy	31	12
Copyright policy for contributors	6	2
Copyright policy for users	28	12
Creative Commons license	8	1
Privacy policy	20	10

Sixty-two percent of funded collections and 86 percent of Pathways provide some level of copyright guidance. Three of the funded collections that provide copyright guidance do not provide user permissions guidance. In these cases, the collection usually just acknowledges that resources are copyright protected and might identify the copyright holder. Copyright for contributors is a small percentage for both funded collections (12 percent) and Pathways (14 percent), but not all collections invite resource contribution. Creative Commons licensing has not gained much traction in either funded collections or Pathways. Only 26 percent of funded collections with a copyright strategy use Creative Commons licensing. Only the SMILE Pathway uses a Creative Commons license.

It is very important that copyright permissions, particularly user permissions, are clear and understandable; otherwise, they raise more questions than they answer and could result in the audience being afraid to use resources in the collection. MatDL includes a metadata element, “copyright,” that can have the values “on” or “off,” but there is no explanation of what these values mean. Among funded collections, the Tree of Life Web Project, which actively encourages both contribution and use, has a very simple but complete copyright policy that discusses ownership of each part of the collection, including user-contributed resources, and gives guidance on seeking permission for reuse. The policy also discusses fair use and provides a link to guidance on applying fair use to the reuse of Tree of Life Web Project resources. This policy can give guidance to other collections with multiple contributors and can be implemented

equally after the fact, as well as at the beginning of collection building (Tree of Life Web Project, undated). Among Pathways, Teachers' Domain provides very complete permissions that are very closely aligned to Creative Commons permissions and that give clear guidance to educators about how they can reuse the resource (Teachers' Domain, undated). Users can also filter searches by permitted use, which includes view, download, download and share, and download, share, and remix. We did a blank search limited to "download, share, and remix" and found a large number of available resources for reuse. The SMILE Pathway provides a collection-level Creative Commons license that is a simple and effective strategy to apply or to retrofit after the fact for other collections.

A few collections provide access to data gathered from human subjects—most notably the Online Psychology Laboratory, which encourages students to participate in human subjects research data analysis. It was surprising not to see guidance on the rights of human subjects in the research process, particularly the role of the Institutional Review Board (IRB), since protection of human subjects is integral to human subjects data gathering and analysis.

Added Value and Personal Services

A last aspect of usability to consider is the added value provided to collections by the tools and services that actively engage users with the collection and the site. These services include commenting on or rating resources, asking questions or exchanging ideas through blogs and wikis, organizing resources into personal folders, and sharing resources with others through email or social networking sites (e.g., Facebook or Twitter). Added value can also include tools and services for creating personal learning objects, creating metadata, or implementing a repository. Some sites host private collections for users engaged in teaching or research. Just-in-Time Teaching Digital Library (JiTDDL) hosts teaching assignments and student responses for educators. Many sites offer newsletters, online journals, or RDF Site Summary (RSS) feeds of recommended resources. The Middle School Portal offers a complete social networking site using Ning software, where educators can come together to share issues and concerns and explore topics of interest together. Other sites offer training, awards, and other professional opportunities to users. Some sites offer scholarships or awards, such as the BiosciEdNet (BEN) Pathway's BEN Scholars and the MathDL Pathway's Mathematical Association of America (MAA) Journal Writing Awards.

Added value services that involve user engagement with the collection frequently require registration. Registration enables users to manage the resources they select from the collection and to gain recognition for comments or reviews attached to resources. Registration also provides collection managers with a useful way to track use and to engage in more nuanced needs assessment with active participants. However, requiring registration could impede an integrated NSDL and work against multidisciplinary pedagogy, since users must organize and manage their personally selected resources in separate collection folders and, in some cases, must register before they can access a resource they discovered through a federated collections search.

Registration and Personal Services Measures

Most collections offer added value in terms of useful information, tools, and services. These are often specific to the target audience or the nature of the collection. For our evaluation, we looked specifically at common services that enable user engagement with the collection—the ability to comment or rate resources and the ability to save resources into a personal folder or workspace. We also looked at registration and whether registration was required or optional. Finally, we looked at whether sites requesting registration, whether required or optional, had published privacy policies. Registration and Personal Services are shown in Table 2.8.

Table 2.8 Registration and Personal Services

Registration or Service	Funded Collections (n = 50)	Pathways (n = 14)
User registration available	23	13
User registration required	2	1
Privacy policy available	13	9
Ability to comment/rate resources	12	11
Personal workspace/folder available	10	7

A significant percentage of funded collections (46 percent) and Pathways (92 percent) offer added value services through registration, although only a very small percentage of those (9 percent of funded collections and 8 percent of Pathways) require registration. All sites that offer added value through registration should have prominently published privacy policies. Currently, only 56 percent of funded collections

with registration and 69 percent of Pathways with registration have published privacy policies. Results for individual collections are available in Appendixes A and B.

It should be noted that we were unable to log into the funded collection Physics Classroom, which requires being part of a formal class to participate. We based our understanding of this collection on the information published in the open areas of the site. Teachers' Domain, the only Pathway to require registration to use the site, also requires identification with a school as part of registration. We were uncomfortable with making up an affiliation with a local school, particularly because it was not clear how that information might be used. We also wondered how home schools and independent learning environments could make use of this Pathway. We found an answer in the FAQs that we could simply select the nearest available school. We suggest that this information be included on the registration page, or at least prominently linked from that page.

Pathways Integration and Collaboration

In addition to the dimensions of authoritativeness and usability that were discussed earlier, we also looked at the stewardship and integrative role that Pathways play in the NSDL collection community, as well as their role in creating a distinctive NSDL presence or brand.

Pathways Integration and Collaboration Measures. We searched the Pathways websites for NSDL branding to document the relationship of the Pathway to the NSDL and to determine if a recognizable identity is created for the NSDL through its Pathways collections. We also looked for the ability to search the NSDL, or other Pathways, either independently or as a federated search, from each Pathway site. We looked for tools or services developed by the Pathways that were offered to other collections for their use, as well as evidence that Pathways were reusing tools developed by the NSDL or by other Pathways. We looked for funded collections or other Pathways collections that are incorporated in the collection of the Pathway. It is difficult to identify which collections, if any, are included in some Pathways, so it is possible that there is more integration of funded collections than is currently apparent. Finally, we looked for evidence of collaboration among Pathways, in which a Pathway might, for example, be listed as a partner, participate in other Pathways on advisory boards, and the like. Collaboration among Pathways might not be documented on the website, and we did not contact Pathways collections directly. However, successful branding of nsdl.org as a portal, and of the Pathways as stewards of the NSDL collectively, requires that this evidence be

readily available. As Table 2.9 indicates, the only consistent branding across Pathways is the clickable NSDL logo, sometimes accompanied by text explaining the role of the Pathway in the NSDL. Pathway partnerships documented on one Pathway website are generally not reciprocated with acknowledgment on the other.

Table 2.9 Pathways Collaboration and Integration

Pathway Title	Number of Funded Collections Included	NSDL Logo Present	Searching of NSDL Possible	Collaboration with Other Pathways	Searching of Partner Pathways Possible	Tools Offered or Used
AMSER	7	Yes	No	DLESE, ComPADRE, MatDL	Yes	No
BEN	0	Yes	No	No	No	IsoveraDL repository software
ChemEd DL	2	Yes	No	No	No	No
ComPADRE	3	Yes	Yes	No	No	No
CSERD	0	Yes	No	No	No	No
DLESE	4	Yes	No	No	No	Metadata schema, tools, DDS repository service
Ensemble	1	Yes	No	No	No	Walden's Paths
Engineering Pathway	2	Yes	No	No	No	No
MatDL	0	Yes	No	No	No	No
MathDL	5	Yes	Yes	Middle School Portal	Yes	No
MSP2^a	-	Yes	No	No	No	NSDL Wiki
SMILE	1	Yes	No	ComPADRE, Engineering Pathway, MSP2	No	No
Teachers' Domain	0	Yes	Yes	DLESE	No	No
Teaching with Data^a	-	Yes	No	No	No	No

NOTE: AMSER = Applied Math and Science Education Repository. IsoveraDL = Isovera Digital Library. ChemEd DL = Chemical Education Digital Library. DDS = Digital Discovery System. ^a A list of included collections is not provided on the Pathway's website, thus, it's indeterminable whether NSDL-funded collections are included or not.

NSDL PORTAL COLLECTIONS INTEGRATION

The NSDL portal (nsdl.org) plays many roles in the NSDL initiative, including providing infrastructure, core services, and guidance for Pathways and other participating collections. The NSDL portal's influence and presence stretch across all viable funded collections and Pathways. Answering the question, "is the NSDL portal

greater than the sum of its parts?" is thus complex and difficult. With respect to collections, the NSDL concatenates and searches metadata from Pathways and NSDL collections and clearly has the intent to serve as a one-stop shop for users wanting a single portal or multidisciplinary approach to the distributed NSDL collection ecosystem. This overarching role is clearly related to collection health and seemed the most pressing and obvious to explore in this evaluation.

NSDL Portal Collections Integration Measures. To evaluate the NSDL portal as a one-stop shop, we looked at three basic measures that demonstrate the effectiveness of a central, or union, catalog of resources. This central catalog can be created by collecting (harvesting) metadata from participating collections on a regular basis into a centralized catalog or by searching across multiple catalogs using a federated search engine, or by a hybrid of the two approaches. Each methodology has both benefits and drawbacks. The significant drawback of a union catalog is currency. Unless collection records are harvested at least as frequently as daily, the union catalog will be out of date. Harvesting not only provides catalog records for new resources but also, presumably, notifies the union catalog of resources that are no longer available, thus cutting down on the number of broken links discovered. Federated searching provides greater currency but little opportunity to normalize catalog record displays. Federated searching also requires some level of mapping for indexed metadata fields, which tends to eliminate nuanced, sophisticated searching and can result in resources that are not responsive to the search terms entered. We realize that the NSDL is moving to a federated searching approach at least for Pathways. However, it is not clear whether the changeover from union catalog to federated search is complete. The evaluative measures we employed work for either strategy, however, including a hybrid approach combining harvesting and concatenation with federated searching. We looked at two basic measures for search and retrieval:

- Are resources indexed in funded collection and Pathway sites also available via the NSDL portal? (That is, is there resource overlap?)
- When resources are available in more than one collection, or are collected at different time intervals, does the NSDL eliminate duplicate records in displays? (That is, is the NSDL removing duplicates, or deduping?)

We sampled approximately six resources in each funded collection and 20 resources in each Pathway for availability in nsdl.org. Some resources were no longer

available in the original collection and were not counted in the results, although we did search for them in nsdl.org and generally found them present, with broken links. Of 253 resources searched and found in funded collections, 139 are also available at the NSDL portal. This represents an overlap of only 55 percent, which is significantly low for a central portal that aspires to offer a one-stop shop for the wide range of distributed NSDL resources. The NSDL contains 184 of 267 (or 69 percent of) the available Pathways resources searched. Given the commitment for collaboration and integration with Pathways, this is also a low amount of overlap. Information about resource overlap by individual funded collection or Pathway can be found in Appendixes A and B.

Pathways usually integrate resources from multiple collections. Therefore, it can be expected that individual resources in Pathways may also be found in relevant funded collections and even other Pathways, with the result that there could be many metadata records across nsdl.org for a single resource. Successful union catalogs are able to match records on such criteria as creator, title, and identifier or URL so that a single, composite record appears for resources that have more than one metadata record. This can be done against a static union catalog or on the fly for federated searching. The NSDL portal creates composite records for duplicate resources, with multiple collection logos indicating the various collections in which the resource can be found. However, 45 of the 184 (24 percent) sampled Pathways resources available in the NSDL had one or more duplicate records. Duplicate records can be confusing to users and can result in users missing records for resources that might be more appropriate for their needs but that appear further down in the search results than the user is willing to look, as Figure 2.6 illustrates. Information on individual titles searched by Pathway can be found in Appendix B.

The screenshot shows a search results page on NSDL.org. The search query is "are we alone" and 1576 results are displayed. The results list is as follows:

Title/Description	Education Level
<p>Are We Alone? http://www.teachersdomain.org/resources/ess05/sci/ess/eiu/alone/index.html This video segment adapted from NOVA features a variety of scientific perspectives on the age old question, "Are we alone in the universe?" Animations make vivid the improbability that we could intercept a radio wave signaling extra terrestrial intelligence. <i>Resource Types: Audio/Visual</i> <i>Pathways: Teachers' Domain:Digital Media Resources Pathway</i></p>	Middle School High School
<p>Are We Alone? http://www.teachersdomain.org/6-8/sci/life/div/alone/index.html This video segment adapted from NOVA features a variety of scientific perspectives on the age old question, "Are we alone in the universe?" Animations make vivid the improbability that we could intercept a radio wave signaling extra terrestrial intelligence. <i>Resource Types: Audio/Visual</i> <i>Pathways: Teachers' Domain:Digital Media Resources Pathway</i></p>	Middle School
<p>Are We Alone? http://www.teachersdomain.org/6-8/sci/ess/eiu/alone/index.html This video segment adapted from NOVA features a variety of scientific perspectives on the age old question, "Are we alone in the universe?" Animations make vivid the improbability that we could intercept a radio wave signaling extra terrestrial intelligence. <i>Resource Types: Audio/Visual</i> <i>Pathways: Teachers' Domain:Digital Media Resources Pathway</i></p>	Middle School
<p>Are We Alone? http://www.teachersdomain.org/9-12/sci/ess/eiu/alone/index.html This video segment adapted from NOVA features a variety of scientific perspectives on the age old question, "Are we alone in the universe?" Animations make vivid the improbability that we could intercept a radio wave signaling extra terrestrial intelligence.</p>	High School

Figure 2.6 Duplicate Metadata Records in Results List

The NSDL portal has great potential to serve an integrative role for Pathways and other NSDL creations, but the one-stop shop union catalog role is currently not successful and should be reevaluated by the Resource Center (RC), the Technical Network Services (TNS) team, and Pathways.

Performing this evaluation required multiple visits to funded collections and NSDL Pathways, often one right after the other. The feeling in each instance was of “starting over” and learning an entirely new portal and collection management strategy. The strong impression created was of largely independent collections with very little relation to each other and a fairly minimal relationship to the NSDL, whose logo or name generally appears in the sponsorship or funder task bar at the bottom of the page and often appears to carry no more significance than that of a funding sponsor.

There was very little sense of common purpose or of even a minimal common identity across collection sites. It was evident that the concept of an integrated constellation of collections does not currently exist in any meaningful way. Adding some common elements and common approaches to collection provision, such as search boxes that appear in the same place on each site and offer a similar searching experience when appropriate, and that guide the user to relevant complementary collections would go a long way toward building a common identity. An aspirant collaborative collection to emulate for successful branding is the Publication of Archival, Library and Museum Materials (PALMM) in Florida. PALMM is “not a digital collection itself but rather an umbrella identity for a group of digital collections” (Caplan, 2002, p. 58). PALMM achieves its brand in part because “the current guidelines define screen layout so that the websites for all digital collections have a common look and feel, and more substantively, so that navigation is predictable and consistent” (Caplan, 2002, p. 58). As noted in the previous section, Pathways would benefit from a common placement of standard elements, such as mission, scope, audience, and simple search screen, as well as logo placement for the NSDL and links to other Pathways. Adopting a core design template, which still allows creativity and differentiation among Pathways, would help create NSDL brand familiarity for users.

It is also critical to build connections explicitly across Pathways that explain to users how collections complement each other and to seamlessly hand off searches from one Pathway to another as search queries change or if too few resources are retrieved. The NSDL core team could profitably invest time and effort in building a “guided path” across Pathways and collections that could suggest and search appropriate Pathways based on a user’s information need. As a fairly easy first step, search results that retrieve fewer than a preset number of resources in a topic can be encouraged to search a complementary Pathway, and an automatic search transfer or at least the link to a federated search of that Pathway should be available in the current search screen. Building these linkages is critical to leverage the various strengths of individual Pathways, to avoid collection duplication across Pathways, to support multidisciplinary searches, and to ensure that the brand identity persists, even if the central NSDL portal should disappear or change significantly. A common search strategy at each Pathway that enables Pathways to leverage each other’s complementary strengths would greatly assist in building an NSDL brand identity.

Searching the central portal and even some of the individual Pathways reveals another significant problem: the extreme heterogeneity of the collections. A search for

astronomy could result in a scholarly article, followed by an historical image, followed by an interactive virtual telescope activity. The results are often bewildering to even an experienced user. The NSDL core team is aware of this problem and has taken important steps to address it with a collection weeding project, in which collections that are no longer relevant to the repurposed mission to serve primarily K–12 education are being evaluated and weeded. A complementary approach would be to use metadata in a more rigorous manner to enable educators to apply consistent metadata elements in both simple and advanced searching that lead more readily to a consistent display of resources specific to a workflow need. There might be times when a fourth-grade educator will want an interactive digital lesson, an historical image, or a scholarly article. The issue is to ensure that a search retrieves results appropriate to the educational task. Developing common filtering data elements and testing them against Pathways collections in order to build consistent results is a good first step. Our metadata study, discussed in Chapter 5, indicates that educators are willing to limit even simple Google-style searches by grade level and type of resource. This type of search limiting or filtering is already offered by the NSDL portal and by all Pathways at some level. A significant problem, however, is that Pathways do not consistently use the same concepts for filtering and never use the same terminology.

Three standard filtering metadata elements for an educational audience that are in use in some form for most Pathways are

- *resource type*, or *genre*, which can be defined as a construct or category of resource that is readily understood by the target audience, such as “lesson plan” or “instructional activity”
- *audience*, which is generally interpreted to be instructional level (e.g., grade) but can also be interpreted as “role” (e.g., educator), or both.
- *format*, which represents the physical format of the resource and can be general (e.g., video) or specific (e.g., MPEG-4).

We analyzed the filtering elements offered by each Pathway and by the NSDL portal. It was difficult to separate genre and format for many Pathways. The conceptual or content type (*genre*) is frequently mixed with the physical type (*format*). This intermingling is acknowledged in Table 2.10. The filtering indicated no exact overlap in terminology used across any of the collections surveyed. Filtering elements and vocabularies used by individual Pathways are provided in Appendix B.

Table 2.10 Search Filtering Metadata Elements Applied

Pathway	Filtering by Genre	Filtering by Format	Filtering by Genre/Format Combined	Filtering by Audience
AMSER	√	√		√
BEN			√	√
ChemEd DL			√	√
ComPADRE			√	√
CSERD			√	√
DLESE	√	√		√
Ensemble	√			
Engineering Pathway	√	√		√
MatDL	√			
MathDL	√	√		
MSP2	√			
SMILE			√	√
Teachers' Domain			√	√
Teaching with Data			√	√
NSDL portal		√		√

Many collections offer vocabularies that are highly specific to their portal, such as the resource types in the Engineering Pathway, which are geared to their portal areas: “community,” “reference,” and “teaching.” MatDL offers technical jargon that seems an artifact of its repository software for its mix of type and format vocabulary, e.g., “Generic Document Version Dublin Core 1.0.” Surprisingly, there was no significant overlap in terminology used for the filtering element *audience*. Some portals broke this into “role” and “educational level,” and others broke this element into broad and specific education levels.

Some portals offer a very effective filtering strategy with robust vocabularies geared to their audience, a prominent search strategy and effective use of filtering metadata at both the simple and advanced search levels. Two portals that do a very good job with search filtering metadata are DLESE and the Engineering Pathway. The

Engineering Pathway did particularly well with audience filtering. For the simple search, grade ranges are provided. From the “Advanced Search” option in the left navigation bar of the “Advanced Search” screen, users can select “K–12 Search,” “Higher Education Search,” or “Geocentric Search” (see Figure 2.7). The K–12 search enables limiting by individual grade or by specific upper and lower grade ranges. This was praised by some educators participating in the metadata analysis discussed in Chapter Five.

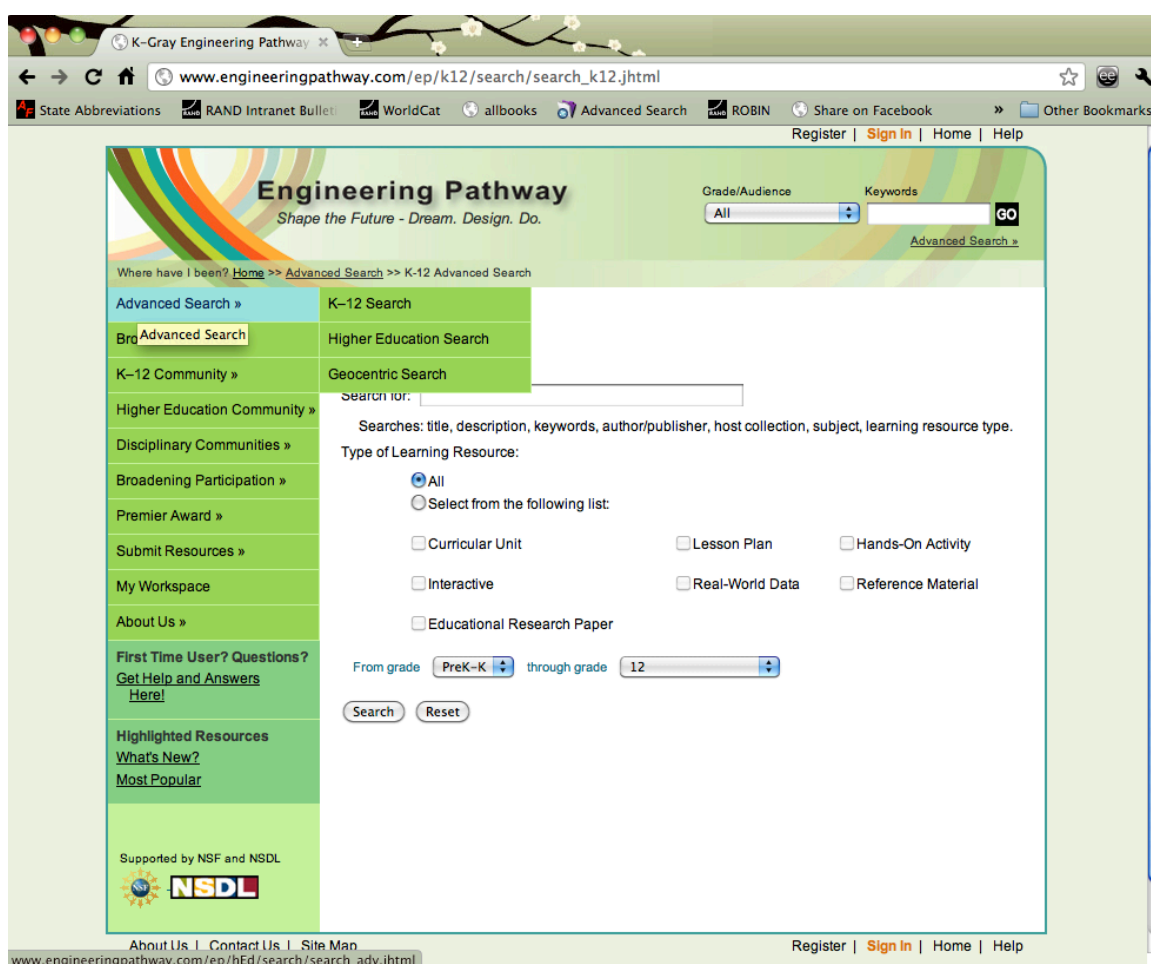


Figure 2.7 Engineering Pathway K–12 Advanced Search Screen

RECOMMENDATIONS

Core Recommendations

As the preceding sections have demonstrated, there are some basic strategies that the NSDL and Pathways could employ to improve collection health. These are listed here with the primary party responsible in parentheses:

- Remove collections that have not been modified, at least at the website level, in the past two years. Appendix A can assist with this. (NSDL and Pathways)
- Ensure that all Pathways collections include mission, scope, and audience for their collection in a prominent location. Placing these elements, clearly labeled, in the same places on each Pathways website can assist with branding and inter-Pathway navigation for users. These elements should be identical to those provided in collection metadata at the NSDL portal. (NSDL and Pathways)
- Provide a collection development policy that includes, in a prominent location, policies for adding and weeding resources. (Pathways)
- Check links at least three times a week, and delete metadata for any broken links that persist through three checks. (NSDL and Pathways)
- Place a simple search box prominently on the front page of the collection portal. This advertises that the portal is a collection portal and enables the user to accomplish the primary service of the portal immediately, if desired. Placing the search box in the same location for each Pathway will aid with branding and inter-Pathway navigation. Consider supporting filtering by education level even for simple search because educators are the primary audience. (Pathways)
- Document metadata practices, and ensure that the metadata either conform to a metadata standard or at least are robustly and consistently applied. Ensure that displays are free of jargon and metadata artifacts and that the labels represent the terminology of the primary audience. Ensure that elements used to filter an advanced search or as categories in a browse are present in all records. (Pathways)
- In a prominent place on the website, provide terms of use that explain resource ownership and reuse to end users. Placing the policy in the same place, with the same title, on each portal, aids in branding and inter-Pathway navigation. (Pathways)
- In a prominent place on the website, provide a privacy policy that explains how personally identifiable information is safeguarded and how information use is kept confidential. Placing the policy in the same place, with the same

title, on each portal, aids in branding and inter-Pathway navigation.
(Pathways)

- Enable searching of other Pathways and of nsdl.org from each Pathway portal. Place in the same location on each Pathway to assist with inter-Pathway navigation. (Pathways)

Developing the NSDL Brand

If the NSDL is to persist, it must develop a brand among the educator community as a trusted and useful source for digital information. The concept of brand identity is important for an information portal, such as nsdl.org, because users will base impressions of the collection on the totality of the experience visiting the website and discovering and using resources. A brand is the mental image that an audience has of an organization, product, or service. In an article for *Library Journal*, Dempsey notes, “Good brand management is the crux of the business model, driving the strategy behind the experience you provide the customer” (2004). Branding is important in the digital space because there is little or no human intervention to explain or convince educators to visit and use a collection portal. A collections brand that simultaneously projects both authoritativeness and usefulness is critical to penetrating the pedagogical marketplace, in which so many competing avenues for educational content exist. A brand identity for the NSDL is complicated by the fact that Pathways and other NSDL projects are reviewed and awarded grants independently.

The diverse collections of NSDL Pathways and individual collections could be harmonized considerably by applying standard vocabularies for metadata filtering elements: resource type, resource format, and education level (audience). These vocabularies could be developed with educators and could reflect their workflow and professional terminologies. Text processing and language analysis techniques could be used on available metadata and refined through full-text analysis automatically to assign these elements to individual metadata records. This effort will aid considerably in building a useful and integrated NSDL collection that can respond effectively to a busy educator’s workflow needs.

Other issues that can work against a seamless user experience in the NSDL are resource rights and authentication. Some resources in the NSDL require subscriptions for access. Other resources have varying rights for reuse, particularly for remixing or adapting into educational products, such as homework sheets. Creative Commons, the nonprofit licensing agency, provides simple legal licenses and understandable, graphical

symbols to provide guidance for users of resources. A Creative Commons license can be assigned to all resources in a collection or individually assigned by each creator to each resource. Creative Commons provides open source web tools that can be used to assign licenses upon submission to the digital collection. A common platform, in which users do not have to learn new concepts or terminologies for resource permissions, not only helps to create a brand but ensures that moving from Pathway to Pathway will consistently produce usable resources, which is critical if the NSDL is to persist over time.

The necessity to register at many sites in order to take full advantage of the services offered is another significant hurdle. It was very difficult during this evaluation to keep track of the user ID and password, even when the same values were used for many different collections. The NSDL could usefully provide a fairly lightweight but secure identity mechanism using a web-based solution, such as OpenID, and provide aggregated usage statistics, as well as survey data, to individual Pathways and collections to support greater understanding of who the NSDL's users are and how they can be helped to navigate across the rich collections contained therein.

Beyond rights and identity management, the NSDL portal could play a significant role in creating seamless navigation and personal services across collections. The NSDL portal could be a service and collaboration portal that would enable users to join Pathways and other collections from the central site and to gather resources selected from many different Pathways into a single workspace. Users could manage their subscriptions to different Pathways, as well as to services, such as blogs and forums, from the central site, which could also suggest new Pathways sites users might want to join. The NSDL core team could also offer common usage and evaluative services to Pathways, which could ensure that users do not receive pop-up surveys from multiple collections in a given time period. Moving from a centralized collections portal to a social networking service platform would enable the NSDL to focus on improved navigation and personalization and to avoid creating a false impression of being a one-stop comprehensive shop.

Next Steps for a Future Evaluation

We suggest that the core need for collections that are independently managed and heterogeneous in nature is to add consistency of collection management and use to ensure a quality experience at any NSDL Pathway and to develop an NSDL brand for Pathways that is unmistakable and yet lightweight enough to sustain over time, even if

the NSDL portal itself should cease to exist. Practical strategies and exemplars to follow have already been provided in this report. The collections have been available for a long enough time, and the metrics for evaluating them are fairly common and easily understood, so we do not believe that a third-phase evaluation of collection health is needed. A future evaluation should instead focus on evaluating collection usability and responsiveness to educator workflow tasks through the surrogate that provides standardization and consistency for resources: the metadata implementation. This is discussed in Chapter Five, "Metadata Assessment."

CHAPTER THREE. WEB METRICS IN THE EVALUATION OF THE NSDL

It is important for the NSDL as an institution (the interrelated social and technical systems that constitute the NSDL main website, the Pathways, and the collections) to measure the use of the sites and to understand whether users can find, obtain, and get value from the resources that they seek. Because the NSDL's constituent sites are dispersed among different organization and because users are diverse and widely distributed, the only feasible method of constructing a big picture view of the NSDL is by utilizing web metrics based on data collected by the servers and browsers that request and provide NSDL resources to users.

Appendix C provides an overview of web metrics and descriptions of how they are utilized by organizations to learn how their websites are being used. In this chapter, we describe how web metrics are currently being used by the NSDL, based on interviews with personnel working on the main NSDL site and with personnel at five selected Pathways. We close with a discussion of how web metrics can be used in the next phase of evaluation.

USING WEB METRICS

There are two aspects of using web metrics to manage and improve a website. First, data must be collected from the interaction between user browser and site server. As described more fully in Appendix C, web servers providing objects to a user's browser automatically log each object provided, along with other data, such as the time, user address, and type of browser. The second and more challenging step is to analyze these large data sets. For our purposes here, it is sufficient to say that there are two varieties of web metrics that are of use both in the commercial world and for NSDL.

The first category comprises overall traffic. Examples include page views, where visitors land on the website, and where they come from: a portal (such as nsdl.org), a search engine such as Google, or typing in a URL or using a bookmark. If the user has come via a search engine, the search terms used are also generally available. Other measures, such as time on a page or from which page the user exits the site, are also informative. Additional perspective is gained by tracking trends in these metrics over time and comparing the numbers with the growth in web traffic.

The second type of web metric is much more complex to analyze: These constitute data derived from the actual paths of individual users through a website. They include

all of the first variety but supplement overall traffic information with a page-by-page description of what pages the users visited, how long they stayed, and what web objects they clicked on. These data can be used to determine website features that confuse users and make them leave the site, and can help segment the user population into different groups by their behavior. This information can be used, in turn, for customized responses to particular types of users and for automatic navigation systems customized to user types. However, as noted in Appendix C, this type of analysis is a current research topic, and methodology is not standardized.

In order to assess current use of web metrics at both the NSDL portal and the Pathways, we conducted two sets of interviews:

1. We interviewed people at the NSDL Resource Center (RC) and Technical Network Services (TNS) who are responsible for web metric use for the portal site. Their focus is on measuring the use and usability of the NSDL portal site nsdl.org: how many users come to the NSDL, and how well do they find and use collections maintained by the NSDL itself?
2. The use of web metrics to track and evaluate usage at the NSDL Pathways is critical because the Pathways have become a primary focus of the NSDL and therefore a major locus of user activity. Therefore, we elected to interview principal investigators (PIs) and other knowledgeable contacts at five Pathways to discuss their use of web metrics.

WEB METRICS AT THE NSDL

The web metrics discussed with the NSDL RC and TNS interviewees are measurements of the NSDL's main website.⁴ Our interviews revealed that the primary goals for web metrics analysis here are to confirm that users are finding the portal and to evaluate their use of it to find and access the external collections, particularly the Pathways.⁵ The metrics used by the NSDL portal measure total visitors, the pages

⁴ The operations and usage of the Pathways and other collections are of interest to the NSDL, but the collection of web metrics by the external sites is the responsibility of those sites themselves.

⁵ Although the search engine of the portal is considered to be a primary source of user pointers to external sites, as of our interviews, the NSDL had not completely instrumented its search facility. Although the NSDL portal tracked search terms entered into its search engine and analyzed the terms for potential metadata, it did not yet

visited, entry and exit pages, and, by using sequential reports, the time trends for each. NsdL.org also links to commercial websites, and the traffic and direction metrics are of interest to these sites as well so that they can quantify the user traffic that originates from the NSDL.

The metrics are used both to demonstrate current usage and to guide redesign of the site. For the present evaluation, we did not assemble historical information on usage, although that should be part of a more comprehensive future evaluation. The interviewees noted that web metrics did play an important role in some aspects of site redesign. One specific example was the placing of a link behind a page object that users habitually clicked; this location was identified by “heat maps,” which highlight the areas where high numbers of clicks are made.

As in the commercial world, information from raw measures of user behavior will be limited if users cannot be “identified,” e.g., linking the users with demographic information of interest to the site or determining return users. This information can allow the site’s managers to understand why different users behave differently.⁶ It would therefore be very helpful to attach demographic information of various kinds to the metrics currently recorded in order to relate types of usage (and usage issues) to different segments of the user community, e.g., repeat users versus newcomers. However, obtaining this kind of information is very sensitive politically and socially. Linking users’ access to library materials without their express permission is generally not allowed by professional ethics of librarians and, in many cases, is not allowed by

collect information on how far down the list of search results a user looked nor whether a user clicked on a result. This is an area related to usability assessment and is discussed elsewhere in the report.

⁶ This is why commercial firms try to link user behavior to user demographics using registrations, or *cookies*. Cookies are small files left on a user’s computer that will tell a website if the user (or the computer) has visited before. They sometimes also yield more historical detail about a user’s actions. They are at the center of controversies about computer privacy. Until recently, U.S. government agencies were prohibited from using cookies in most circumstances. This policy was under reexamination, partially because other, similar technologies are becoming available on which decisions also have to be made. See U.S. Public Policy Council of the Association for Computing Machinery (USACM) (2009) for a summary and ACM comments on the policy options. In mid-2010, the Office of Management and Budget released memos advising federal agencies that certain kinds of tracking could be done, subject to privacy restrictions. See Sunstein (2010). Libraries have objected to the use of cookies, on general principles of privacy.

law. Registration, which could collect basic demographic information, is not considered a viable option for nsdl.org because of the perceived barrier it places to initial usage. An alternative method of gathering some demographic information is the use of pop-up surveys displayed by the site when a user leaves a page. In such surveys, users are asked a very small number of questions to allow coarse classification of their usage pattern (e.g., teacher vs. student). Response rates to pop-up surveys are likely to be low and potentially biased for some populations of users.

As discussed in Appendix C, the most sophisticated form of web metric is the analysis of the “user path” through the website: the sequence of pages users visit and the links they click. User paths can be examined at several different levels of detail, ranging from measuring path lengths to a target page, on up to segmenting users by the characteristics of their paths to gain insights into each user’s goals. The interviewees agreed that user path analysis was a goal for them but that very little along these lines has yet been done. As described in Appendix C, clickstream analysis, as this type of analysis is called, is currently a research topic, but the NSDL does not, at present, make any use of these methods.

Finally, the interviewees noted that the NSDL web metrics working group had produced a draft proposal on a broad set of metric issues, including web metrics but going beyond them to examining the impact of the NSDL and its collections on teaching practice and student learning (NSDL, 2009).⁷ They also pointed out that the NSDL itself is moving beyond being just a portal and collection repository and is beginning to use such social media as Twitter, Facebook, and YouTube to build awareness of the NSDL and make resources available to a wider audience. Metrics for these efforts will need to be a part of future NSDL evaluations of impact and usability but have been little studied to date.

WEB METRICS IN THE PATHWAYS

At the level of Pathways, our purpose in the study reported here was to gain insights into what web metrics could potentially provide in a future evaluation. It was neither possible nor necessary to study web metric usage at all Pathways for this

⁷ Presented at the 2009 NSDL annual meeting in Washington, D.C.

purpose. Instead, we sought to study sites that had a reputation for using web metrics extensively.⁸ We ultimately selected five Pathways for interviews:

- MatDL (materials science)
- ComPADRE (physics)
- Teachers' Domain (broad science for K–12)
- SMILE (the Exploratorium in San Francisco, California)⁹
- Ensemble (computer science Pathway under construction, in beta version as of this writing).

This was not designed to be a representative survey; after discussions with NSDL community members, the five Pathways were selected specifically because they were sites with a reputation for using web metrics extensively.

These five exemplify the diversity of the NSDL Pathways and the communities they aim to serve. MatDL focuses mainly on undergraduate education; Teachers' Domain is for K–12 teachers; ComPADRE and Ensemble are K–undergrad; and SMILE, as associated with a public science museum, is for all learners of every age (“K through gray”). Some of them own and manage almost all of the collections they make available to users, while others link to outside collections as well and function as portals. It is important to note that all Pathways have limited resources for management and maintenance.¹⁰ For an overview of some of these Pathways, see Khoo et al. (2008).

The primary use of web metrics for all five Pathways was to measure overall user traffic. Each of the four fully launched Pathways felt the need to demonstrate that it was reaching a substantial audience and that user numbers were growing commensurate with the maturity of the site and overall web usage. All of the sites used the same basic measures: visitors, time on site, popular pages, and the pages from which users came. Older sites (i.e., those funded earlier in the program) are additionally concerned with

⁸ During each interview, we asked for the interviewees' suggestions of sites that used web metrics well. We contacted some of these additional sites informally (e.g., at the NSDL annual meeting in November 2009), and these conversations also informed our treatment of web metrics.

⁹ SMILE is a Pathway, while the Exploratorium both hosts a funded digital collection and is a partner in the SMILE Pathway.

¹⁰ For example, the Pathways that are hosted by academic institutions typically have as PIs faculty members who work part time on the Pathway, plus graduate student assistants who help, as do some staff (again, many part time).

user experience measures, which are now on a par with overall traffic measurements. In studying user behavior, the measures typically include general paths, path length, and heat maps of user actions on web pages. Most of these results have remained internal to the site management, except for a set of papers about Teachers' Domain (Donahue, 2006a, 2006b, 2006c, 2006d, 2006e).¹¹

All of the five Pathways expressed strong interest in moving to a user-behavior level of analysis;¹² however, the NSDL and its pathways face high obstacles in acquiring any external information on users. Of the five Pathways we interviewed, only Teachers' Domain requires registration to use the site, and the registration process asks some basic demographic questions. MatDL, ComPADRE, and Ensemble offer voluntary registration but do not require it; anecdotally, most users of these sites do not register. The Exploratorium, with its website associated with the public science museum of the same name, does not require or even offer registration. Although the internet address of the user's computer can identify coarse locations, such as state or country, it cannot be used to identify specific computers because the addresses are dynamically assigned each time a computer enters the web. As noted in the earlier section on nsdl.org, one alternative is to ask a departing user to answer a very short pop-up questionnaire, which several Pathways have done.

One issue that stood out is that there seems to be little regular communication of web metric statistics between the NSDL and these five Pathways. Although there is an expectation that the Pathways will report usage statistics, there is currently no standardized report,¹³ and the interviewees noted that the sites rarely had a dedicated staff member doing web metric work. Grantees are required to report on their project to NSF, but such reports are limited to the project and tend to be used for best practices, not ongoing usage trends. The NSDL staff noted that, because of the range of project types and the different ages of the sites, it is very important to keep context in mind when interpreting web metrics for external sites.

¹¹ As of this writing, these papers are available from Michael Khoo's website at Drexel University (Khoo, undated).

¹² Donahue (2006e) explores some of the uses of pathways to determine problems that users are having doing tasks, such as registering.

¹³ Standardizing metrics for the NSDL itself has been an ongoing challenge.

Some of this inconsistency in traffic measurement and reporting methods is attributed to variation in data processing (especially early in the history of the NSDL),¹⁴ part seems to be due to lack of a formal program, and part to lack of resources at the Pathways. The use of Omniture software to collect web usage data was seen several years ago as a good initiative,¹⁵ but the Pathways are moving to the use of Google Analytics for web metrics because the basic service is free.

Given the evolution of the NSDL to a central portal with specialized Pathways, it is necessary to collect a consistent set of information on usage and movement between the NSDL and the Pathways. The NSDL Metrics Working Group has suggested the same idea in its draft report (NSDL, 2009), and the Pathway personnel we interviewed agree. However, with the Pathways facing limited resources, the NSDL itself is a more feasible place to centralize this activity. Internal web metrics for the Pathways could be facilitated by NSDL standardization and technical support. As we discuss in the recommendations for the future evaluation, the collection and analysis of comprehensive Pathway web metrics should be a central part of developing an overall evaluation of the NSDL.

RECOMMENDATIONS FOR FUTURE EVALUATION

Using Web Metrics

As we have noted repeatedly in this report, the NSDL central website, its Pathways, and the collections linked to them form a complex, ever-changing community with a broad and diverse composition and many different user communities. Although usability tests, surveys, and field experiments, such as the Denver Public Schools Curriculum Customization Project, provide valuable and detailed information on the experiences users have with the NSDL, such projects are too expensive and time-consuming to be used to evaluate the entire NSDL or even large portions of it. Web

¹⁴ As described in Appendix C, raw web usage data logs have to be processed extensively to eliminate spurious users and ensure correct counting of page views, among other things. Lack of consistent treatment of different situations at various Pathways and collections means that it is difficult to compare web metrics.

¹⁵ The NSDL paid for the sites to use the Omniture web metrics software about five years ago, but its in-depth adoption and use have been characterized as slow in general.

metrics are a relatively inexpensive method of getting a broad overview of the entire system and have the additional advantage that more detailed analysis can be focused on specific sites and collections as needed to help select areas for study with surveys, interviews, and possibly experiments.

Recommendation 1: Construct (and Keep Updated) a Map of the NSDL Community

It is first necessary to identify sites with different amounts of traffic and linkages and focus web metrics efforts on sites with important characteristics (e.g., high traffic, low traffic, specialized audience). To this end, we first recommend that the expectant future evaluation use NSDL and Pathway web data to build a detailed, NSDL-wide map of sites where users come from and the sites to which they go. For example, Google probably plays a large role in helping users to find material on the NSDL-related websites, but we do not know how it compares with other sites, such as the NSDL portal itself or other, competing search engines. This should be done for past years as well, if the data are available, but, in any case, a current picture should be constructed. Some of this type of analysis is being done already for some individual sites, but these analyses seem rarely to be drawn together in one place. Conceptually, the map would be a network of NSDL sites with links indicating the direct user traffic between them, as well as the traffic from external sites, such as Google.

This map can then be used to assist in implementing the evaluation design by identifying sites with different amounts of traffic and linkage and focusing more intensive data collection at sites of interest (e.g., high traffic, network centrality). The map should thus provide a context for the future evaluation.

Recommendation 2: Classify and Characterize Users

The most important data gap in the NSDL's use of web metrics is the lack of ability to characterize a user. Without some information on the different kinds of users and how their behavior differs, the raw page views and other statistics risk missing important issues for some of the key constituencies of the NSDL. As noted in Appendix C, it is possible to employ cluster analysis on user paths to segment users into different groups. This information can be used to infer user characteristics and aims, and it can be supplemented with information from pop-up surveys, rough location information, or

other collected data.¹⁶ For sites with registered users, the behavior of registered and unregistered users could be compared; this might allow classification of unregistered users or the determination that registered and unregistered users are different.

This is potentially a rich source of information on users, one that has not yet been tapped extensively by either the NSDL website or the Pathways. However, the clustering of user paths to identify user segments is presently a research topic in web marketing, computer science, and statistics, and there are few standard approaches that are widely accepted. It is also not known at this point whether sufficiently detailed data are currently kept by either the central NSDL website or the Pathways for such analyses.

Depending on the resources available, it might be possible to instrument web browsers for selected groups to collect detailed usage data that can be linked with specific users. This option raises privacy concerns for general use but potentially could be implemented as part of a more structured study that has users focused on specific tasks, such as constructing lesson plans for school use; that has obtained advance informed consent; and that puts strict privacy safeguards in place. As we have noted elsewhere, this is being done by the Denver Public Schools Curriculum Customization Project, and we anticipate that results from that effort will provide information and insight to a third evaluation phase.

Recommendation 3: Be Responsive to Adoption of New Technologies

A final point to consider in future evaluations is that new web technologies, services, and venues are appearing constantly that change the ways websites operate and what they do; they therefore require changes in the web metrics that are collected or can be collected.¹⁷ Forms of social networking, such as Facebook, could make specialized collaboration facilities on NSDL-related sites obsolete. New forms of electronic communication, such as Twitter, might require new methods to capture usage. This is especially vital because the NSDL itself is starting to use these venues for communicating with users. The third phase of evaluation should assess the NSDL efforts

¹⁶ For an example of this approach, see Recker, Xu, et al. (2009).

¹⁷ For example, when the NSDL was brought online in 2000, extremely powerful search engines, such as Google, were barely known. Some new methods of organizing pages on websites apparently cause current methods of logging page views to miss user views (interview with personnel at the Denver Public Schools Curriculum Customization Service, March 18, 2010.)

in these venues as well and define, collect, and analyze metrics and recommend ongoing data collection to ensure that the new media are evaluated as the NSDL evolves.

CHAPTER FOUR. TEACHING AND LEARNING EFFECTS

PURPOSE

Although NSDL resources and tools are still under development, and those that have been developed have yet to be widely diffused, we thought it likely that some projects have brought NSDL resources to teachers and students, at least in limited trials. For projects that have attempted to influence teaching practices or learning processes in STEM classrooms, we sought to identify any early evidence of positive effects on outcomes. Specifically, we asked the following questions:

- Are there improvements in teaching practices or teacher content knowledge? For example, could educators teach more, more rapidly, or more effectively? Were they able to customize learning content to specific cognitive needs of students? Could they customize teaching to their school context and curriculum objectives? Were they able not only to find appropriate content in NSDL collections but also to create and share modules?
- Are there indications of improvements in student learning? For example, did students learn more or more rapidly? Did they learn new concepts or perspectives? Were they able to learn using preferred approaches or styles?

Such evidence would provide insight into where NSDL tools and resources may be most successful in the classroom and would suggest how the NSDL program might adjust its efforts to maximize these outcomes.

METHODS

At the start of this project we recognized that, while the ideal method for identifying teaching and learning effects would be a meta-analysis of projects that meet typical inclusion criteria,¹⁸ an insufficient number of NSDL projects had undertaken either basic experimental research or field trials in realistic education settings, and few relied on standardized assessments. We instead anticipated conducting a case survey of

¹⁸ Inclusion criteria for meta-analyses typically include sufficient statistical power and standardized outcome measures.

projects that would yield a sense of the outcome themes. Appendixes D and E provide a brief review of the literature on case surveys.

Because this examination of teaching and learning effects is formative rather than summative, our case survey approach emphasized themes and indicators rather than conclusive measures of effect. We proposed a four step approach:

1. *Identify relevant projects.* The project catalog developed during the earlier evaluation includes more than 250 projects across various NSDL project tracks. However, our initial look at the catalog suggested that few projects actually have brought NSDL tools or resources to teachers and students to provide evidence of any type of teaching or learning effects. Thus, we anticipated first identifying those projects that do fall into this category by carefully examining the catalog to screen for projects that directly involve teachers and students in some way. Then we would narrow this list further to a core set of projects that have some evaluation component, chiefly by examining the publications and reports these projects have produced.
2. *Review project data.* Next, we expected to build an inventory of the features and data related to each selected project from step 1, including but not limited to the following:
 - a. project objectives
 - b. teacher or student populations involved
 - c. STEM subjects addressed
 - d. NSDL resources employed
 - e. evaluation methods and instruments
 - f. project outcomes.

We intended to use existing project reports and publications because new data collection, apart from clarifying questions to project leaders, was beyond the scope of this task.

3. *Build a taxonomy, and report on themes.* Third, we sought to synthesize teaching and learning outcome themes by organizing this inventory of project data into a taxonomy that would allow us to identify salient project features, and then, by examining the results of project evaluations according to this taxonomy, to arrive at patterns or themes. In particular, we decided that teaching effects could include effects on the following:
 - a. teacher content knowledge, which, in the best case, would be measured by an instrument that was previously validated or that was mandated by the state for teacher licensure or certification

- b. teacher instructional practices, such as teachers' use of digital tools or NSDL resources in classrooms or changes in instruction techniques, strategies, or pedagogy
- c. teacher attitudes, which are less compelling indicators of teaching and learning outcomes, given that changes in attitude do not necessarily translate into changes in teaching or learning.

Such effects would ideally be supported by statistically significant changes linked to use of NSDL tools, resources, or professional development (PD).

Similarly, learning effects could include effects on the following:

- a. students' domain-specific achievement, which, in the best case, would be supported by statistically significant change linked to use of NSDL tools, resources, or PD as measured by a reliable and valid instrument
- b. student attitudes, which are less compelling indicators of learning outcomes, given that positive changes in attitude toward learning in a discipline do not necessarily translate into changes in learning behavior and outcomes.

With respect to teacher- and/or learner-oriented studies, we sought to locate either basic research on how varied types of digital materials might positively influence teaching or learning processes or well-constructed evaluations of the potentially promising educational effects of such materials during the development process or in use cases. Such a taxonomy of methods, measures, and outcomes is consistent with the literature on effects (Blank, De las Alas, and Smith, 2008), though we anticipated that there might be few studies that used "best case" measures.

4. *Identify procedures and projects for pilot trials or site visits.* Lastly, we anticipated that these themes would provide insight into the types of evaluation measures and primary data-gathering techniques that would further illuminate teaching, learning, and other effects of incorporating NSDL resources into instructional practice at varying education levels. This would help identify project sites at which these techniques could be piloted most effectively; it would also suggest promising sites for case studies offering lessons to be learned.

FINDINGS

As part of step 1, identifying relevant projects, we first reviewed a catalog of NSDL project awards to identify those that sought to bring NSDL tools and resources to teachers and classrooms, either in formal or informal settings. From the award abstracts,

we found that very few projects are strongly aimed at measuring effects, but several projects implied some component of teacher or student involvement. Specifically, we identified 20 projects that, based on their descriptions, seemed most likely to examine teaching or learning effects, 26 that seemed somewhat likely have some teaching or learning components, 17 that seemed quite unlikely candidates, and approximately 200 remaining projects that did not appear to evaluate such effects. We focused on the 20 projects that were deemed most likely to examine teaching or learning effects; they are described in Appendix D. After gathering and reviewing available project publications, we found that only seven of the 20 reported findings on teaching or learning effects. The other 13 were judged to have had no relevant results—either because we could not find or obtain publications or because the project did not, in fact, evaluate the effects of NSDL tools and resources as the abstract suggested, or else their results were still pending.

The seven projects that reported findings on teaching or learning produced a total of eight different studies of teaching and learning effects as described in their respective reports and publications (one project produced two studies). These eight studies are described in Appendix E. A review of these studies illuminates some interesting features about this relatively small body of work related to NSDL teaching and learning effects.

What Is Being Evaluated? NSDL tools and resources are generally brought to the classroom by teachers, and it is through changes in teachers' practices and behaviors that the NSDL might ultimately affect student attitudes and achievement. It is therefore perhaps not surprising that nearly all (seven of eight) of these studies sought to evaluate teachers' instructional practices and attitudes, while only half touched on aspects of student achievement. Interestingly, none of the studies evaluated teacher content knowledge, though this is one of the areas in which the NSDL might be most effective.

What Are the Studies' Contexts and Methods? The study contexts and methods varied widely. Except for the pair of evaluation studies conducted by the same project, no two studies used the same NSDL tools or resources. Four studies evaluated the effects of tools the projects had developed to help users access or organize websites and resources; three studies evaluated the effects of the projects' own websites and resources; and one evaluated NSDL resource use in general. Again, given that the model is for teachers to bring the tools and resources to students, five of the eight studies included some kind of teacher professional development (PD). This diversity demonstrates the breadth of NSDL tools and resources, but also makes it difficult to

aggregate and generalize findings to the potential effects of the NSDL as a whole on teaching or learning.

Six of the eight studies did not use research methods that support causal inferences about teaching or learning effects. In some cases, the evaluations were formative and part of pilot trials, although, in others, a quasi-experimental comparison group would have been appropriate. Similarly, most studies also had small sample sizes and interventions that were “low dose”—one day of professional development, a handful of resources used through the school year, and so on.

What Kinds of Data Were Collected? All six nonexperimental studies relied heavily on surveys and self-reported statements about instructional practices, attitudes, expected student achievement, and other effects. In some cases, these were the only data collected. Self-reported data are often unreliable (Cook and Campbell, 1979), making it difficult to make inferences from the results of the studies. Additionally, many of these surveys evaluated professional development sessions, so the surveys focus on *intended* rather than actual changes in teaching practices, and only in one study was there follow up to identify subsequent actual changes in self-reported teaching practices. Intentions are not necessarily strong predictors of actual changes or outcomes, so the actual effect on teaching practices is unknown.

All four studies of tools—a number that includes the two experimental studies—also gathered web metrics, software artifacts, and other computer-generated data to provide evidence of actual changes in teacher or student behavior. Finally, two studies—one experimental and one nonexperimental—used pre/post tests to measure student achievement, although, in both of these cases, the instruments might be overly aligned with the resources and tools used as interventions.

What Are the Findings? The findings reported in the different studies naturally varied and, on the surface, seem to suggest positive outcomes from NSDL tools and resources. In general, teachers and students both reported positive attitudes toward NSDL resources and tools; teachers also reported intentions to use these tools and mentioned positive outcomes with students. In cases in which student achievement was assessed, the tools and resources showed signs of improving student achievement by some measures.

However, there are three key features of this body of work that neither allow us to do a case survey of the projects and continue our assessment approach nor allow us to interpret the apparent findings of the various studies as indicators of teaching and learning effects from the NSDL:

1. The body of work is too small—eight studies in total stemming from seven different NSDL projects—to fairly serve as indicators for a program that has funded more than 250 projects.
2. The studies are too varied—each addresses a different tool or resource in a different context and using different methods—even to draw inferences about a particular aspect or subset of NSDL tools and resources.
3. The methods and measures used, although appropriate for pilot studies and formative evaluations, have many weaknesses that make them inappropriate for an overall analysis of effects on teaching or learning.

In sum, currently no empirically trustworthy indications of the teaching and learning effects of NSDL use are available.

CONCLUSIONS

In this phase of the project, we sought to evaluate projects that have attempted to influence teaching practices or learning processes in STEM classrooms, either directly or indirectly, and identify any early evidence of positive effects on outcomes. What we have found is that the projects with teaching and learning evaluation components are too few, too diverse in their contexts and methods, and not methodologically strong enough for us to draw these inferences and suggest directions of outcomes.

Our findings have several implications for the present evaluation, the future evaluation design, and for the NSDL as a whole:

1. Although we cannot yet answer the question “Does the NSDL positively affect teaching and learning when it is used?” we might instead ask and try to answer a different, more timely question: “Could the NSDL positively affect teaching and learning if it *were* to be used?” This question has led us to design and pilot a usability study to understand the potential utility and value of the NSDL for teachers. This pilot trial is described in Chapter Six. The results of such a study, when used in future research with a larger sample of participants, would provide insight into how the NSDL might need to change to become more valuable to teachers so that positive outcomes can be brought about.
2. Our literature review and subsequent communication with researchers suggested to us that use of the Curriculum Customization Service (CCS) in Denver Public Schools (DPS) is probably the most complete implementation of NSDL tools and resources to date. As a result, we conducted a minicase

study of the CCS project, which is described in Chapter Seven. Although the project is ongoing and the results are not yet available, a full case study of the DPS/CCS project would be a valuable addition to a third evaluation phase.

3. As noted, part of the absence of effects may be attributable to the fact that it might take several years to build NSDL tools and resources, before which they can obviously not be well evaluated. Nevertheless, our examination of the research tracks and interviews with PIs, coupled with this project review, tells us that there appears not to be a programmatic emphasis on bringing the NSDL into the classroom. The targeted research track has not been dedicated to understanding teacher and student engagement with STEM disciplines and associated NSDL resource use, and funding for evaluations appears to have been limited. Given that teaching and learning outcomes are key aspects of the teaching and learning effects in the NSDL logic model, this suggests that the NSDL program could be strengthened by directing more targeted research to achieving and evaluating these effects.

In sum, although the NSDL literature does not yet illuminate the effects on teaching and learning, it does suggest several steps that can be taken toward this goal.

CHAPTER FIVE. METADATA ASSESSMENT PROCEDURES AND ANALYSIS

PURPOSE

Metadata are very much a linchpin factor in collection health. Well-designed metadata will successfully respond to user needs by connecting users to resources that support a workflow need or critical task in an intuitive, largely transparent manner. Metadata accomplish this by bringing consistency and context to resource description to pull together useful resources in response to a query. A user might want an in-class activity (resource type) to teach sixth-grade students (education level) about offshore oil spills (subject). Resources are created independently and reflect the terminology and context of the individual creators. One creator may create an “interactive resource” and another may create a “fun in-class project.” Metadata pull both of these resources together for discovery by assigning a common term for resource type to both, such as “educational activity.” A search on “educational activity” will only be useful to the target audience, however, if the term is familiar to them and ideally is part of their every day workflow vocabulary. Well-designed metadata are thus very much a collaboration between the collection developers and the end user audience and should represent both concepts and vocabularies that are important to the workflow of the user.

We wanted to develop a comprehensive and nuanced evaluation strategy for metadata that could be tested in this phase of evaluation and then modified as needed and extended in a future phase. Key criteria for this evaluation were that it should have a user focus and should engage the target audience in evaluating metadata using a methodology that was meaningful to its members and reflective of their actual workflows. A primary audience for the NSDL comprises K–12 educators who are teaching one or more STEM courses. This is a very broad audience with different learning goals and objectives at each level of education. STEM subject areas are also very broad and range from the theoretical to the practical in each subject. The diversity of scope and audience within Pathways collections makes identifying a rubric for metadata evaluation very challenging. Fortunately, considerable work has taken place in the past decade on isolating core information tasks that are common to any user, topic, or information need.

The International Federation of Library Associations and Institutions (IFLA) appointed the Study Group on the Functional Requirements of Bibliographic Records,

which issued a groundbreaking and influential report in 1998 (IFLA, 2009). The report identified, among other things, four user tasks that metadata for any audience or purpose should support and dubbed them *FISO*:

- *Find*: Can users find resources that correspond to their search criteria?
- *Identify*: Can users identify what resources they have found from the metadata provided?
- *Select*: Can users select the resource most appropriate to their information task from two or more discovered resources?
- *Obtain*: Can users obtain the resource described by the metadata?

Educators look for resources that meet their workflow needs by engaging in these four tasks. Metadata should enable all four tasks equally in a manner that supports and represents the educational workflow context. We regarded support for the *FISO* user tasks as an important dimension of collection health that could be successfully evaluated for Pathways and for the NSDL portal. We developed a rubric and methodology that could actively engage educators in meaningful evaluation and dialog about the metadata supplied by Pathways and the NSDL portal. This rubric would not only answer questions about the usefulness of existing Pathways and NSDL metadata but also give guidance that the NSDL and others could use to develop an “educators” metadata standard that represents the workflow and practical information needs of K–12 STEM teachers.¹⁹

DESIGN OF THE ASSESSMENT

A primary concern for the development of the rubric was to provide recognizable scenarios that would engage end users with the metadata, in which the focus is placed on the scenario of use and not on the mechanics of the metadata. An instrument was

¹⁹ The development of this *FISO* rubric was influenced by the successful use of a *FISO* methodology to evaluate the Moving Image Collections (MIC) portal, an NSDL portal funded in 2002. Grace Agnew, a member of this evaluation team and a co-author of this report, was the principal investigator (PI) of that project and oversaw the work of graduate students Ying Zhang and Yuelin Li, who developed and implemented a successful *FISO* analysis of MIC metadata (Zhang and Li, 2008).

designed to provide study conditions that engage users in scenario-based information tasks intended to isolate the core FISO activities: find, identify, select, and obtain. Each instrument provides two scenarios relevant to teaching a specific subject, first for the NSDL portal and then for a Pathway collection. The scenarios and resources for both the NSDL and the selected Pathway are similar, involving comparable but not identical STEM topics while asking the same FISO-based questions. The NSDL portal and the Pathway scenarios thus enable us to determine whether incorrect answers to a metadata interpretation question likely result from educators' not understanding the question or from problems with the metadata or their presentation. In each case, the user first performs FISO tasks on the NSDL portal and then the Pathway. The Pathways selected for this test were Engineering Pathway, DLESE, BEN, and MathDL. We selected Pathways that are subject matter-based rather than based on audience (such as the Middle School Portal and SMILE) or specific to a resource type (such as Teaching with Data). The chosen Pathways are more comparable to one another and represent a fairly broad range of STEM topics (engineering, earth sciences, biology, and mathematics).

We used a web-based instrument (rather than in-person data collection) in order to reach participants in a range of relevant disciplines in the time available for the trial. We also wanted to learn whether a web-based instrument would be accepted and useful because an online procedure could potentially engage a more representative audience in a future evaluation of NSDL portal and Pathways metadata. We conducted the pilot trial at Rutgers University.

Instrument

Four instruments were developed, each consisting of four parts. The first part explains the purpose of the study, asks about course of study at Rutgers, and provides information about participants' rights in the study, particularly privacy of identity and confidentiality of answers. The second part engages participants in a FISO evaluation of the NSDL portal, while the third part engages them in a FISO evaluation of a selected Pathway. The final section asks participants to evaluate the instrument itself, particularly whether any part of the instrument was confusing, used unfamiliar jargon, or took too long to complete.

The heart of the instrument is the FISO analysis of the NSDL and Pathway collection search strategy and metadata. Each FISO section consists of four activities and associated questions:

- One activity involves four questions evaluating the ability to search for resources at the portal, based on a described scenario of use (**find**). Participants link to the relevant collection portal, search for a resource, and answer questions about the search process.
- Another activity concerns the ability to click a URL link and obtain the resource located by the participant at the portal (**obtain**).
- Three questions require identifying characteristics of a resource based on a scenario and a linked Portable Document Format (PDF) resource description (**identify**).
- Two questions require selecting the most appropriate resource from two resource descriptions provided, based on a described scenario of use and a linked PDF with two resource descriptions (**select**).

A sample instrument is presented in Appendix G. Results of the analysis are presented in the next section.

Participant Sample

Participants were solicited from relevant education and library science programs at Rutgers University. We solicited library science graduate students (candidates for master of library and information science [MLIS] degrees) from the Rutgers School of Communication and Information (SC&I) via a call for participants posted on the school's graduate student bulletin board. School media specialists, a key target audience for the NSDL and Pathways, are a growing cohort in the SC&I master's program and an important potential audience for the NSDL and Pathways.

Rutgers does not offer an undergraduate degree in education but instead offers an education minor in many science fields and a fifth-year education program for students majoring in such subjects as biology, chemistry, and mathematics that involves a student teaching practicum. Master's, Ph.D., and Ed.D. degrees are also offered in mathematics and the biological and physical sciences. We contacted Rutgers faculty teaching fifth-year and graduate programs for education in mathematics, biological, and physical sciences. Many students in these programs are already employed by schools but are working on either a media center degree or an advanced education degree, so responses reflect a mix of future and practicing educators.

As Table 5.1 indicates, 50 students began the study by answering initial questions in the introduction section, which asked them to identify their degree program and

advised them of their privacy rights as study participants. Thirty-seven students participated in the first study condition, evaluating the NSDL portal, representing a decrease of 26 percent. Participation in the second study condition, the evaluation of Pathway metadata, decreased a further 16 percent.

Table 5.1 Instrument Completion Rates

Completion Rate	Initial Participation	Completing NSDL Evaluation	Completing Pathway Evaluation	Completing Instrument Evaluation
Instrument 1 (NSDL and Engineering Pathway)	n = 26	20 (77%)	16 (61%)	17 (65%)
Instrument 2 (NSDL and DLESE)	n = 5	4 (80%)	2 (40%)	3 (60%)
Instrument 3 (NSDL and BEN)	n = 7	5 (71%)	4 (57%)	4 (57%)
Instrument 4 (NSDL and MathDL)	n = 12	8 (67%)	7 (58%)	7 (58%)
Totals	n = 50	37 (74%)	29 (58%)	31 (62%)

Instrument 1, which involved scenario-driven tasks using the NSDL portal and the Engineering Pathway, targeted graduate students in the Library and Information Science graduate program. The response rate was highest for this group, with 26 students, or 54 percent of all initial participants. Among this group, 16, or 55 percent, completed all sections of the instrument. In the other disciplines approached for this pilot study, both initial response rates and instrument completion rates were substantially lower, as Table 5.1 makes clear.

The attrition rate for study participants from one scenario to the next within a group is also a concern. A significant drop off rate occurs from those initially opening the instrument to those completing tasks to evaluate NSDL metadata to those completing tasks to evaluate Pathway metadata. The participation rate from the Pathway metadata evaluation to the instrument evaluation is fairly stable. There could be many reasons for such attrition. The procedures are fairly complex, requiring students to complete some basic tasks and to open multiple associated PDF files. Many

students may have found the requirements too much to undertake (the attrition rate reflects issues with study design that are addressed later in this chapter). What is noteworthy, however, is that the participants who completed all sections of the instrument provided fulsome, thoughtful answers.

ANALYSIS OF RESULTS

This analysis is divided by FISO category—find, identify, select, and obtain. The mechanics of participating in the study involved visiting the relevant portals via links provided in the online instrument, in order to search for resources, as well as opening PDF files provided on a private website that displayed metadata from each portal and then navigating between the web-based instrument and the PDF metadata records. Participants were advised to keep both the instrument and the PDF windows open and toggle between the two. They seemed to have little trouble with the process, according to comments in the evaluation section.

However, given the substantial attrition between the NSDL-based and Pathway-based FISO tasks, together with the very small numbers of respondents per Pathway, the numbers in the tables in the rest of this section should be interpreted as summaries of qualitative information rather than as quantitative findings.

Find and Obtain (NSDL portal). Participants were first asked to visit the NSDL portal and to find a resource based on a scenario of use. Scenarios of use identified the education level (eighth grade) and a subject specific to each instrument, such as “a web-based resource to illustrate plate tectonics” (instrument 1) or “a resource to explain probability to your students” (instrument 4). The use of the verb “illustrate” caused confusion for some participants, who limited resources to “images” in order to find an illustration. A link was provided to the NSDL portal and participants were asked either to provide the title or the URL of the resource that they found. Participants could elect to do either a simple (Google-style) search or an advanced search. The advanced search was defined as “fill[ing] in multiple text boxes and/or limit[ing] your search by categories” to help participants identify what type of search they completed.

Nineteen of 37 participants, or 51 percent of those answering the question, performed the simple search. Sixteen, or 43 percent, performed the advanced search. Two participants, or 5 percent, were not sure what type of search they performed. The results reveal equal comfort with simply entering keywords and limiting the search by one or more criteria.

Participants were asked in the next question whether they limited their search by criteria, such as educational audience. Although the NSDL offers a simple search screen on the top-level page, the ability to search by general, K–12, higher education, and research and specialized search is also offered. The K–12 search enables limiting by grade level and format. Advanced search offers additional search limit elements, such as collection. Twenty-one of 37 participants (57 percent) answering the question about this second search effort indicated that they did limit their search. Fifteen of 37 respondents (41 percent) did not limit their searches. One respondent was not sure whether he or she had limited the search or not. Thirteen of those who limited their searches identified education level or grades 6–8 as the filter. One person limited searching to the K–12 search portal. Five limited resources by format, four of whom limited by “images,” most likely in response to the unfortunate use of the verb “illustrate” in the scenario description. The results of both “search” questions illustrate a substantial degree of comfort with limiting searches, particularly by the critical filtering element, “education level.”

Twenty-seven of 37 respondents (73 percent) were able to open the resources they selected. Six respondents (16 percent) indicated that they could not open the resource, and three respondents (8 percent) indicated that the file was not found. Most of those who selected “no” indicated that the file was not found or that the Pathway collection containing the file was down. Two respondents who selected “yes” noted in comments that they went through several resources with broken links before finding an available resource. One respondent commented, “the NSDL needs to do some serious updating.” Another respondent who selected “no” noted that the site required registration to obtain the resource. Still another respondent commented that a link led to another link rather than to the resource, which was frustrating. The percentage of unavailable resources in this study, at 8 percent, is twice as high as the overall resource attrition rate found in the sample of resources searched in the NSDL, which was 4 percent (see Chapter Two). The results reported here, although from a small sample, tend to corroborate our finding that broken links are a concern for the NSDL.

The next question asked whether the search box was easy to find at the site. Thirty-six participants (97 percent) felt that the search box at the NSDL portal was easy to find. Only one respondent answered “no.” This respondent, an MLIS student, commented, “I had to decide whether to use ‘advanced search K–12’ or ‘resources for K–12 teachers.’” The final question evaluating “find” for the NSDL portal asked, “How easy is it to search for resources in the NSDL?” Results are shown in Table 5.2.

Table 5.2 NSDL Search Ease of Use

Degree of Ease	Number (n = 37)	Percentage
Easy	20	54
Somewhat easy	11	30
Difficult	1	3
Somewhat difficult	1	3
No opinion	3	8
Not sure	1	3

The largest percentage of respondents (84 percent) found searching the NSDL portal easy or somewhat easy. One respondent suggested that the ability to limit a search be offered at the top level, while another suggested that the most appropriate search for a given user should be provided based on recognition of a returning user, as long as cookies are not used. Perhaps the most striking response was that of a biology education student: “It was very easy to type the keywords and find some suitable sources, but when I went back and conducted an advanced search, which allows you to define your audience, it made finding useful sources even easier.”

Find/Obtain (Pathways).

Engineering Pathway. Fourteen respondents reported either URLs or titles for resources located at the Engineering Pathway. Sixteen respondents documented the type of search completed. Eleven (69 percent) performed the advanced search, and five (31 percent) performed the simple search. All 16 respondents indicated that they limited their searches by one or more criteria. Ten comments indicated limiting by grade range, and three comments indicated limiting by audience. The Engineering Pathway supports upper and lower grade range limiting, and there was evidence in the comments that respondents experimented with ranges to obtain results. One respondent commented that the ability to set ranges was better than using the preselected ranges of the NSDL. One respondent was quite critical, commenting, “I did start with a simple search and it was awful. Even the advanced search was difficult with none of the resource format types seeming to describe what I was looking for exactly. I had to open a separate list to read their definitions for different format types [because] it was unclear.” All 16 respondents found the search box easy to locate. Eleven respondents (69 percent) were able to open the targeted resource. Two respondents selected “no”; two respondents selected “not sure”; and one selected “file not found.” One respondent who answered “no” commented that he or she could not find an appropriate resource. As

with the NSDL portal, this indicates a significant issue with resource availability for the Engineering Pathway.

DLESE Pathway. Only two of four respondents in the NSDL/DLESE group searched for resources on the DLESE portal. One participant selected simple search, and one selected advanced search and limited search results by grade level. Both respondents were able to open the resource and found the search box easy to find.

BEN Pathway. Four respondents to the instrument that evaluated the NSDL and BEN searched for resources at the BEN portal. Two performed the simple search, and two performed the advanced search. Three respondents limited their search. Two commented that they limited their searches by education level, and one of those two also limited by “free resource.” All four were able to open the resource and responded that the search box was easy to find.

MathDL Pathway. Seven respondents to this instrument searched for resources at the MathDL portal. Six performed a simple search, and one performed an advanced search. Two of the seven limited their searches. Comments indicated limiting to grades 6–8, format text, and the Middle School Portal. Four of seven (57 percent) reported that the search box was easy to find; two were not sure; and one felt that it was not easy. The search box on the MathDL home page indicates a search of partner resources. The search MathDL box is found by clicking “About MathDL” on the left-hand task bar of the home page. One respondent noticed this and commented, “unclear whether the search box was only for ‘partner resources’ or for MathDL itself.” Six respondents were able to open the resources they found, while one was unsure. The latter respondent commented, “Clicking on the title gives a link to an abstract of the article. I am not sure where to go for the article. There was a link, which I followed to another web page, but I am not sure if that page is the article.”

Participants generally found Pathways easy to search, particularly DLESE and BEN. One respondent commented about the Engineering Pathway that “there were so many options that it was a bit overwhelming.” A respondent to the BEN scenario commented that “the audience filter was helpful as was the ability to search for free resources.” A respondent to the MathDL scenario commented, “I would *never* use an online source for a classroom.” Results for Pathways ease of search are shown in Table 5.3.

Table 5.3 Pathways Ease of Search Ratings

Pathway	Respondents	Somewhat			Somewhat Difficult	No Opinion
		Easy	Easy	Difficult		
Engineering Pathway	n = 14	5	4	2	3	
DLESE	n = 2	2				
BEN	n = 4	4				
MathDL	n = 7	3	3			1
Total	n = 27	14	7	2	3	1

As with the NSDL, the majority of respondents (21 of 27, or 78 percent) rated the search as easy or somewhat easy, although, for both Engineering Pathway and MathDL, dissatisfaction of some respondents is particularly evident from the comments.

Identify (NSDL and Pathways). Identification is a core information task that involves interpreting the metadata that results from a search. Can users identify critical information about a resource so that they understand its salient characteristics? This is an important precursor step to evaluating the resource for responsiveness to a user's information need. We provided a metadata example in PDF for a resource for the NSDL portal and a PDF of metadata record representing the same kind of resource, meeting the same scenario of need, for the Pathway collection. Topics varied by instrument and were selected to represent the subject matter strength of each Pathway. The scenario and questions for the NSDL portal and the Pathway collection were intentionally similar to isolate whether any problems of interpretation were the result of the metadata record or the participant's ability to interpret metadata. At least one participant indicated that having scenarios and questions that were so similar across the two sections of the instrument was confusing, however.²⁰ Three questions were asked about the resource. Correct responses ranged from 25 to 100 percent and are summarized in Table 5.4; number and percent of correct identification responses are shown in the right-hand half of the columns.

²⁰ It is important to underscore that keeping scenarios and task-based questions about them equivalent across the trial is critical to ensuring that the trial evaluates metadata usefulness rather than user competence. For instance, if participants can identify resources correctly using NSDL metadata but cannot do so using MathDL metadata, this provides evidence that the Pathway metadata are not as serviceable as the NSDL metadata in helping them accomplish a key FISO task.

Table 5.4 Correct Answers, Identifying Resources

Question	NSDL		Engineering Pathway		DLESE		BEN		MathDL	
	Q1	n = 36	25 (69%)	n = 16	10 (63%)	n = 2	2 (100%)	n = 3	3 (100%)	n = 7
Q2	n = 25	20 (80%)	n = 16	5 (31%)	n = 2	2 (100%)	n = 4	4 (100%)	n = 7	0 (0%)
Q3	n = 35	21 (60%)	n = 16	12 (75%)	n = 2	2 (100%)	n = 3	1 (25%)	n = 7	4 (57%)
Average		69%		56%		100%		75%		29%

Generally, participants were able successfully to identify characteristics of resources. Exceptions are highlighted in Table 5.4. Question 2 about the Engineering Pathway resource metadata asked whether a software or browser plug-in were needed to experience the resource. The description notes that a Shockwave[®]-based activity is included. This is buried in a paragraph-length description of the resource rather than in a metadata element that could be separately displayed for emphasis, which could explain why so few answered correctly. Users were asked to name the software application, if any, that was required for the resource. All five who answered correctly were able to name the application. One noted, “Shockwave, but the specs are archaic.” Question 3 in the BEN portal asked whether the resource “Cells I: Make a Model Cell” needed advance preparation by the teacher. The resource description indicates that students will select items to represent various cell structures and will justify their selections. This account suggests that teachers may have to prepare items in advance from which students can choose to accomplish that task. However, the survey participants were very confused by this description and variously stated, “Nothing needs prep—it sounds like the resource will include worksheets and such,” “No preparation materials listed here,” and “I couldn’t tell if the lesson plan includes pictures of animal and plant cells, or if the teacher will need to prepare pictures or microscope slides for the students.” Although the description sounds intriguing, it does not explicitly indicate what types of items will be needed to build a cell structure or who will be responsible for gathering the supplies. These are critical questions for a teacher, who would certainly consider preparation time, effort, and expense to be important evaluative characteristics of a resource.

The MathDL participants generally had more difficulty interpreting the metadata records. Their correct responses for the NSDL resource ranged from 57 percent to 86 percent. The typeface for MathDL metadata is smaller than the norm and did not reproduce well as a PDF. At least one participant complained about the PDF quality for

the resource metadata. For the first MathDL question, “What type of resource is this?” two participants answered “PDF,” which might have represented mistaking the surrogate metadata PDF display for the resource itself, since the resource type appears prominently in the metadata record. The second question asks whether a method for determining probability is provided in the description of the resource. In fact, the description states that three methods of determining probability are provided. No participant answered “yes.” In general, there is a pattern across all surveys for a higher percentage of incorrect answers for any information provided in a note or description field. It is clear that structured fields with succinct information are more likely to be noted and correctly interpreted by participants.

Select (NSDL and Pathways). Selection is an important user task for large portals containing large numbers of heterogeneous resources. Selection involves the ability to compare two or more resources to select the most appropriate resource for a user’s need. The selection task is the most contextual. One resource may be preferred over another because it is deemed to be qualitatively better than another—for example, a searcher might assume that a resource that has a high rating from many users is better than a resource with a lower cumulative rating. A user might also select one resource over another because the metadata indicate that it is more responsive to the user’s scenario of need. We attempted to assess the latter condition. The instrument provides a basic scenario of need and two resource-metadata records in a single PDF. Two resources with NSDL metadata are provided in the NSDL evaluation section, and two Pathway collection metadata records are provided in the Pathway evaluation section. The participant is asked to select the resource most responsive to the scenario of need and to provide an explanation for the selection. Results are provided in Table 5.5.

Table 5.5 Correct Resource Selection Based on Scenario

Scenario	Engineering				
	NSDL	Pathway	DLESE	BEN	MathDL
Sample size	n = 36	n = 16	n = 2	n = 4	n = 7
Correct answer	28 (78%)	14 (88%)	2 (100%)	4 (100%)	3 (43%)
Enough information provided?	29 (81%)	13 (81%)	2 (100%)	2 (50%)	2 (33%) ^a

^a Of the 7 in MathDL, one of the participants did not receive this question; total respondents for this cell = 6.

Comments from participants indicated a nuanced analysis of each resource that went beyond the fairly simple scenario provided for each resource selection question. Many educators provided rationales with a focus on the impact on or engagement of the student. Sample comments include the following:

As a teacher, I would use the resource that involves students as active participants in the learning, not mere observers of an animation.

Both seemed capable of teaching students about the DNA structure, but the “DNA Jewelry model” activity was much more interactive and would allow students to physically create a model of DNA to take around with them. It also lends better to group work, where students could offer creative ways to model DNA into jewelry and work together to create accurate models. This activity seemed a lot more engaging and fun.

The first source did not provide any information as to how the students will learn about DNA structure; it just said that they would.

I would pick this one because it requires students to determine probabilities. The other one seems to be only a demonstration that experimental approaches to probability will yield similar results to the theoretical models if a large number of trials are made.

Sounds like far more fun—I would bet the kids doing the Build an Earthquake City would remember that lab for far longer than the passive other choice.

The selection question seemed to spark more energy and more nuance in the educators, perhaps because it was the most similar to their real world workflows. Again, the MathDL participants had the most difficulty with their resources; only 43 percent selected the correct resource to respond to the scenario of need. The explanation of resource chosen was more nuanced than the fairly basic metadata provided by the MathDL Pathway and indicated that the participating educators were attempting to look beyond the fairly simple scenario and even simpler metadata displays. The same

educators selected the correct NSDL resource 71 percent of the time, which clearly indicated that the issue is that the MathDL metadata failed to provide sufficient information to make a selection and not that the educators lacked interpretive and evaluative skills. As one of the teachers noted about the metadata provided, “Poorly presented, hard to read, limited description.” By contrast, the educators commented on the NSDL selection between “The Casino Game” and “Cupcakes and Boxes,”

The cupcake activity is geared towards the high school audience. It requires the students to come to terms with dependent probabilities and deals with a famous paradox in probability. It would not be good for teaching eighth graders the basics of probability.

Another educator commented about the correct selection, “The Casino Game,” “School internet will probably block ‘The Casino Game’ either because of the name or the Java,” which is a useful reminder to resource creators to avoid unnecessarily controversial names or high bandwidth applications.

The final selection question—“was enough information provided to make a selection?”—elicited useful information in participant comments about additional metadata elements to display, including the name of the publisher, subject keywords, descriptions of activities, resources needed, how simulations work, and how they provide information. Several participants noted that they would never select a resource without trying it first, that the metadata description alone would not be enough. One educator reiterated, “I would *never* use the Internet to find a teaching resource.”

Several educators based their selection at least in part on the amount of description provided in metadata. Comments included the following: “There was adequate information on one source, the other may have also been appropriate but did not provide sufficient information to proceed with it,” and “Not as much information in the plate tectonics animation—the other one having more information was one reason to use that one.” It is clear that the educators took advantage of the metadata provided to help with decisionmaking. One comment about selecting between resources with NSDL metadata records, with italics added here for emphasis, demonstrates how different metadata elements are used by a thoughtful educator to support a selection:

At first glance, I leaned toward animations; the name Musical Plates, possibly because I am an active amateur musician, threw me off. The *additional resource* section made me step back. A more careful reading of *abstract* persuaded me this was a more thoroughly thought out program, and that animations had more entertainment value but less directed educational value.

Both the identification and selection questions identified several trends that should be explored further in an extended FISO analysis. In these trials, educators were given very basic scenarios, particularly for selection, in which one piece of information, such as the availability of real-time data, could be the deciding factor. However, the educators clearly studied the available metadata and based decisionmaking on more fulsome information needs than the described scenario warranted, particularly what they could infer from the description about the student learning experience with the resource. Educators also tended to favor resources with more description over terse metadata and seemed to trust resources with more complete descriptions. Teachers are very articulate in describing preferred resources to support their workflows. A less directive approach than an online, structured instrument can provide, in which participants in a face-to-face environment talk through each FISO information task from “find” to “obtain,” could provide very useful information for redesigning metadata and metadata displays to support educator workflow needs in a true educator’s metadata schema.

Evaluation of the Instrument

The final set of questions asked participants to provide guidance for revising the study instrument. Participants were asked to select the statement that best represented the purpose of the exercise. The majority of participants understood the purpose to be “to evaluate how effectively digital resources can be discovered and selected in a digital collection.” Correct response rates for participants across all four groups were 29 of 31 respondents, or 94 percent. The next question provided a very interesting and unexpected result: Participants were asked which collections were evaluated in the instrument. Even though collection names were used several times in questions, most users could not recall them. Only three of 22 respondents, or 14 percent, got both collection names (NSDL and Pathway) correct. Only six respondents, or 27 percent, got one collection name (either NSDL or Pathway) correct. Comments included, “an Engineering Pathway whose name I already forgot,” “I don’t remember, I’d have to go back and check,” “I have already forgotten,” and “Is this a test of my short term memory?” Many educators replied, “Sorry, I don’t remember.” These comments indicate that collection name, and possibly even the concept of individual collections, is not an important construct for educators. Much emphasis is placed on collection name, both for branding participating collections and as a filtering element for searches, in both the NSDL portal and Pathways. It is worth exploring with educators whether this

collection level information is useful to them or instead a distraction from more important evaluative elements. Collection name may need to be placed in a much less prominent place if indeed it is “noise” to educators.

Twenty-seven of 31 respondents (87 percent) thought that the procedures were easy to navigate. The lowest score (77 percent) was given by the library science graduate students, while the other three participant subsets were 100 percent affirmatives. Only one of 30 respondents felt that the instrument included unfamiliar jargon—again, interestingly, the respondent was a library science graduate student. Eight of 30 respondents, or 27 percent, thought that the trial was too long. Seventy percent, or 21 of 30 respondents, thought that the trial length was about right. This positive score is mitigated by a significant drop-off rate from one section to the next. A couple of respondents also expressed concerns about the similarity between the two sections (NSDL and Pathway). However, comparable assessment tasks were needed for determining whether incorrect responses were due to participant incomprehension or poor metadata displays, particularly for the identification and selection questions.

Finally, users were asked to provide closing thoughts. A sampling of comments includes the following:

It might have been interesting trying to do some of the questions from a different grade level. Real science activities are frequently harder to find at the early elementary level, so it would be useful to see how well the system works for a grade level with more limited resources available.

There should have been a question whether these resources would be used by the participant.

Made me aware of more science resources. Thank you.

I love to have found out about this resource and I will use it more often for my education assignments and once I have my own classroom.

We were favorably impressed by the evaluative energy and skill shown by the educators in every core user task. Despite the navigation challenges of opening multiple PDF pages and toggling between instrument and PDF, the participants were focused and engaged, and generally did not let the mechanics interfere with performing each core information task. A rich amount of information about the metadata elements that educators need was provided even in response to fairly simple scenarios. An in-person procedure, with focused talk-throughs of each task to examine different workflow needs, from in-class activities to take-home assignments, could yield fruitful results to

support NSDL and portal administrators in retooling search strategies and metadata schemas and displays.

KEY FINDINGS

Despite the small sample size and the small number of Pathways selected, several key findings can be highlighted:

- Participants had difficulty finding important information that is buried in free-text summaries. Structured metadata elements with short information values were easier to find and interpret.
- Participants looked for more information than was provided by the metadata examples, especially to select a resource to use in class. In particular, participants wanted to know how the students interact with the resource and how they will learn.
- Participants are very literal in their interpretation of information provided, so critical information (e.g., teacher preparation) needs to be explicit rather than implied.
- Educators appreciated detailed metadata records and generally selected the resource with more metadata over a resource with less information.

The primary finding is that educators are effective interpreters of metadata and appreciate their availability for evaluating resources. This goes against “accepted wisdom” that keywords are adequate. Particularly for the important user task of selecting from competing resources, educators clearly appreciated and took full advantage of the “apples to apples” comparison that side by side metadata records afforded.

Additionally, the FISO framework provides a useful way of evaluating the effectiveness of metadata for STEM educators. However, a complex framework like that employed here is probably more useful for eliciting qualitative than quantitative data. An extremely large sample would be required to support statistical analysis of quantitative data generated by this evaluation design. However, the qualitative responses it elicited from users yielded insightful information about making metadata more effectively meet STEM educators’ needs.

RECOMMENDATIONS FOR A FUTURE NSDL EVALUATION

The trial instrument was successful in isolating key user tasks and engaging participants in qualitatively evaluating metadata. In-person, scenario-based interviews will be extremely useful in further evaluating and retooling NSDL metadata to support educators' task-oriented discovery and selection of resources in the NSDL. Realigning metadata with educators' real world task needs is a fruitful way to bring homogeneity to complex portals and very heterogeneous resources and to create a powerful and effective NSDL collection that is used and valued by teachers. A further FISO study with both in-person and instrumented online components is strongly recommended. In the future, NSF may also want to support a web-based trial of this type of evaluation to validate its qualitative conclusions, expanding them to a wider population stratified by subject matter and education level.

CHAPTER SIX. USABILITY PILOT TRIALS

PURPOSE

As we discuss in Chapter Four, there have not been enough research efforts to bring the NSDL to teachers and students to allow us to answer the question “Does the NSDL positively affect teaching and learning when it is used?” This suggests that a different question may be more timely: “Could NSDL positively affect teaching and learning if it *were* to be used?” While an experimental trial of NSDL use and its effects is beyond the scope of this evaluation, we have sought to lay groundwork by designing and conducting a pilot study of NSDL usability for teachers seeking pedagogically effective resources to bring into their STEM courses. The evaluation effort reported here had two aims: to carry out a limited assessment of the usability of a subset of NSDL resources with a small sample of science educators and to use the results of this exercise as a basis for designing a more comprehensive future usability evaluation with a sample of users large enough to support statistical generalization. (A more detailed report of the study is available in Appendix F, along with the experimental task procedures and instruments employed.)

For this purpose, we relied on the International Organization for Standardization’s definition of *usability* as “the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (1998). As this definition suggests, the usability of a product (e.g., a table saw) may not be the same for different type of users (e.g., hobbyists versus professional carpenters) or for different types of objectives (e.g., cutting straight planks versus complex curves).

In the case of the NSDL usability pilot study reported here, we took hypothetical teachers of an eighth grade earth science course as the specified users. The envisioned goal for these users was to find good online resources, represented in terms of three tasks, for an upcoming course unit on plate tectonics. Following precedents in the literature (see, for instance, the review in Jeng, 2005a), usability of the technology for achieving the goal would be examined via objective measures (e.g., whether users were able to complete the tasks correctly) and subjective assessments (e.g., users’ satisfaction with the technology). Thus, the trial was designed to answer several questions:

- How and how well do nsdl.org and the Pathways support teachers' efforts to find appropriate resources for use in the classroom?
- How do users feel about the usefulness, learnability, and quality of the sites and the resources?
- How does the usability of different NSDL sites and resources vary along these dimensions? Is usability affected by the user's starting point (in nsdl.org versus a grade-level-specific or content-domain-specific pathway)?
- How does the usability of NSDL sites and resources compare with teachers' experiences using a general search engine (Google)?

A final aim of the study was to learn, from users' perspectives, whether the selected goal and the three tasks it subsumed were representative of what teachers were likely to do in preparing to teach a course unit, how well the procedures worked for exploring usability, and what recommendations they might have for improving the study design.

METHOD

Overview

The pilot trial was designed around a hypothetical lesson plan development effort during which users would be asked to do the following:

- Carry out three typical resource acquisition tasks related to teaching plate tectonics in the context of an eighth grade earth science course.
- Document and rate the resources selected for each task, as well as the ease of locating them.
- Rate the overall value of the resources and the online system for realizing the lesson plan development goal.

Trial sessions were conducted in the computer laboratory of a university graduate school of education. Science education majors were invited to take part. All participants received exactly the same instructions, carried out the same tasks using the laboratory's

computers, and returned their results and responses at the end of the session via a SurveyMonkey[®] form.²¹ However, each participant was randomly assigned to one of four different starting conditions: Google, nsdl.org, DLESE (earth science Pathway), or MSP2 (Middle School Portal).

After completing the experimental tasks, participants convened in focus groups—one group for each starting condition—to discuss their reactions to the websites and resources, the tasks, and the trial itself. As we discuss more fully in this chapter, participants generally found the trial interesting and the tasks veridical but also offered suggestions for improving them.

Participants

Participants were recruited from two graduate-level science education classes held in the university computer laboratory. Of the 34 students enrolled, 30 (or 88 percent) volunteered to take part. Table 6.1 shows their distribution, by gender, over starting conditions. The majority were at the preservice level with student teaching and lesson plan development experience; a small minority were teachers with in-service experience, one completing a master’s degree. All were offered \$30 gift cards for taking part in this 90-minute exercise. Use of the laboratory computers allowed the task results and ratings returned via SurveyMonkey to remain anonymous.

Table 6.1 Participants by Site and Gender

Starting Site	Males	Females	Total
NSDL	6	3	9
DLESE	1	6	7
MSP2	5	1	6
Google	4	4	8

Procedures

Procedures were group-administered in two separate laboratory sessions via computers typically used for classes, so participants were already familiar with the

²¹ SurveyMonkey provides a website that allows users to create their own web-based surveys. See SurveyMonkey (undated).

technology itself. In each session, participants were randomly assigned to one of two starting conditions, to yield four different starting conditions across the two sessions. Each was given an initial practice task to gain familiarity with their assigned website and with entering responses as requested. Subsequently, participants were administered identical instructions for three experimental tasks and subjective task ratings, as outlined below. At the end of the last task, participants were asked to respond a final set of questions about their overall experience with the website and the materials they found (Appendix F provides the full protocol for the pilot). Instructions, tasks, and responses were all presented and collected online through a SurveyMonkey interface.

Practice Task: Find any material on fossils appropriate for eighth graders (5 minutes).

Plate Tectonics Tasks:

1. Find good material (text + image) that introduces students to the basic concept of plate tectonics (8 minutes).
- 2a. Find a good video or animation that illustrates to students the concept of plate tectonics (8 minutes).
- 2b. Find an interactive activity that students can do, either online or in the classroom, to reinforce any of these concepts (8 minutes).
3. Find materials (text) for students about how the theory of plate tectonics was discovered or applied (8 minutes).

Subjective Task Ratings (5-point scales):

1. How hard or easy was it to use this system to locate these resources?
2. How helpful were the search tools for zeroing in on the right resources?
3. How do you feel about the amount of time it took to find these resources?
4. Do you think that there were enough good resources from which to choose?
5. How satisfied are you with the experience of finding these resources and with the search results?

Overall Ratings (5-point scales):

1. How do you rate the overall quality of the resources you've located for teaching plate tectonics for eighth graders?

2. How do you rate the overall effectiveness of your assigned website for finding good resources for this purpose?
3. By the end of this task, how confident are you that you've found enough resources to build a complete lesson?
4. Would you be likely to recommend your assigned website to a middle school teacher attempting to build or supplement a unit on plate tectonics with these online materials?
5. Would you be likely to recommend your assigned website to a middle school curriculum coordinator attempting to revitalize or supplement the school's curriculum in plate tectonics with these online materials?

We chose an eighth grade scenario for the usability trials for several reasons:

- Middle school courses are important in making the transition to more advanced and differentiated STEM learning in high school and beyond, and they are of increasing interest to the NSDL program.
- The development of an improved middle school Pathway (MSP2) presents an opportunity to explore whether there are usability differences as a function of grade-level orientation versus subject matter domain, in comparison to generic starting points, for acquiring good teaching resources.
- Eighth grade is of particular interest because Trends in International Mathematics and Science Study (TIMSS), National Assessment of Educational Progress (NAEP), and other major learning assessments sample this middle school grade.

For the middle school level, we sought a STEM lesson unit that would be part of a typically required course and associated with learning objectives that are usually part of states' science standards for that course. Further, the NSDL would need to offer a Pathway dedicated to the subject discipline (for enabling comparisons between grade- and subject-oriented starting points, as noted earlier). After exploring several options, we decided on earth science as the course discipline and on plate tectonics, in particular, as the lesson unit. Within the lesson unit, we generated tasks that varied in level of granularity, media, and focus of the teaching materials to be found.²²

²² Initially, we had planned to use four tasks, as described earlier. However, we eliminated the third task, "find a good lesson plan to teach eighth graders about the

Finally, subjective rating scale items were designed to reflect key constructs drawn from prior usability research. (Appendix F provides a more complete account of the development of the procedures.) For all five-point scales, 5 represents the most positive rating.

FINDINGS

In this section, we report first the objective findings from the tasks, then the subjective responses to the tasks. We close with the main themes emerging from the focus groups that followed the experimental trials.

Objective Findings

Three types of objective measures are discussed here in order: number of resources reported in response to each task, number of unique resources selected by participants to satisfy each task, and extent of overlap among resources returned in response to each task. As the instructions made clear, participants were able to report as many good resources as they liked in their responses. The number and diversity of resources found in the time allotted provide some indication of the objective usability of the sites.

Table 6.2 lists the average number of resources reported per person and the number of people unable to find any resources, disaggregated by task and by website. The findings indicate that most participants in all starting conditions found resources for each task, though it appears that participants starting with Google found more resources on average than participants starting with the NSDL, MSP2, or DLESE, who found similar numbers of resources across websites. Participants appeared to find slightly more resources for tasks 1 and 3 than for task 2. If these differences hold up in a larger experiment, it could suggest that there are, in general, fewer animated or interactive resources (or fewer *good* ones) than text and image based resources, and/or that good animated or interactive resources are available but harder to find. It is not surprising that participants starting with Google returned more resources, in part because of the broader scope of Google's reach; Google, in principle, would allow access to every site

Ring of Fire," partly in the interest of limiting the trial tasks to an hour (to allow time for posttrial feedback groups) and partly because earlier exploratory work produced almost no variance on the results for this activity (as discussed later, we would include a task at the lesson plan level of granularity in future trials but would select a different topic in plate tectonics).

accessible from the other starting conditions. In part, such differences could also reflect users' implied familiarity with Google; in open-ended comments and without being prompted, participants in other starting conditions routinely compared its search facility with Google's.

Table 6.2 Average Number of URLs Reported per Person, by Task and Starting Website

Task	NSDL	DLESE	MSP2	Google
Task 1: text/image	2.2 (1)	2.3 (1)	3	4.6
Task 2a: animation	1.8 (2)	1.3	1.2 (1)	2.3
Task 2b: interactivity	1.4 (1)	1.6	1.8	1.5 (2)
Task 3: social science	3.1	2	2.3	3.5
Total	8.5	7.2	8.3	11.9

NOTE: The number of users reporting no results is noted parenthetically where applicable.

Next, we explored the extent of diversity versus commonality among resources returned for different tasks across the varied starting conditions. As noted, Google can access any resources encompassed by nsdl.org, its Pathways, and its collections, as well as many more external sites. Nsdl.org should focus on access to STEM materials in particular, including those accessible from DLESE and MSP2 Pathways, as well as others. The latter are still narrower in scope, and such narrowing might prove beneficial for teachers seeking STEM resources in a specific domain for a particular grade-level course unit.

In many cases, participants assigned to the same starting website selected the same resources. The uniqueness of participants' responses could be an indication of the different number of resources available to participants on each site and, consequently, the utility of those sites for locating resources that suit differing teaching styles or preferences. Table 6.3 lists the number of unique sites found, on average, by participants assigned to each condition, disaggregated by task. The findings suggest that Google offers participants the greatest diversity of sites, while the NSDL, DLESE, and MSP2 are comparable to one another in this respect.

Table 6.3 Average Number of Unique URLs Reported per Person, by Starting Website and Task

Task	NSDL	DLESE	MSP2	Google
Task 1: text/image	1.4	1.9	1.5	3
Task 2a: animation	0.8	0.4	0.5	1.9
Task 2b: interactivity	1.3	1.1	1.2	1.1
Task 3: social science	1	1	0.8	2
Total	4.5	4.4	4	8

The greater number and diversity of resources found using Google is not surprising, for reasons explained earlier. This does not imply that Google is more usable than the NSDL or the Pathways for finding high quality STEM resources of the type sought. Rather, a narrower search pool might yield time savings and greater usability if teachers can find the *best* resources more efficiently. We explore this possibility more fully in our examination of subjective measures of usability.

Finally, this line of inquiry prompts us to examine the extent of the overlap of resources found via the different sites. Table 6.4 lists the percentage of unique resources reported by participants assigned to a particular starting website (in columns) that were also reported by participants assigned to other websites (in rows), averaged across all tasks.²³ For example, 57 percent of the total unique resources reported by DLESE participants were also reported by one or more NSDL participants. On the other hand, 36 percent of the resources reported by NSDL participants were also reported by one or more DLESE participants.

²³ If N is the set of unique sites found by NSDL starters and D is the set of unique sites found by DLESE starters, then the value reported in cell (NSDL, DLESE) is $\frac{|N \cap D|}{|D|}$.

This is the percentage of DLESE sites that NSDL starters also found. This is not equivalent to the value reported in cell (DLESE, NSDL), which is the percentage of NSDL sites that DLESE users also found: $\frac{|N \cap D|}{|N|}$.

Table 6.4 Percentage of Common Resources Found via Different Starting Sites

Starting Site	NSDL	DLESE	MSP2	Google
NSDL		57	45	21
DLESE	36		26	10
MSP2	26	19		17
Google	33	23	47	

Overall, the values in the table suggest that the different sites lead participants to different resources. For example, resources reported by DLESE and MSP2 users were only sometimes in the set of resources reported by NSDL users, even though the NSDL portal should theoretically include all the resources in both of these pathways. Similarly, resources found by DLESE, MSP2, and NSDL users were only sometimes in the set of resources reported by Google users, even though Google should theoretically find all the resources on these sites.

Such differences are difficult to interpret, especially given a small sample of users. For instance, a larger percentage of resources reported by participants starting in DLESE were also reported by NSDL starters (57 percent) than the reverse (36 percent of sites reported by NSDL starters were reported by DLESE starters). Likewise, a larger percentage of resources found by those starting in MSP2 (45 percent) were also chosen by NSDL starters than the reverse (26 percent). A similar pattern characterizes overlap of responses between those who started in Google in comparison with the two more focused Pathways. One obvious confounding factor is that there are more NSDL and Google participants than DLESE and MSP2 participants, so the former groups would be expected to find more resources overall. On the other hand, if this is a true trend (rather than an artifact of the number of participants), at least two explanations are possible. First, it may be that users who start in more narrowly focused Pathways are more able to target the most appropriate resources to serve their purposes. Alternatively, it could be that, by virtue of their broader reach, the more general starting sites offer users a better resource selection from which to choose. Additional factors to consider have to do with the efficiency of search facilities, the order in which they present retrieved resources to users, and variation in users' skills and preferences.

The most important factor that we have not been able to take into account in any way with the objective measures for this usability pilot study is the quality of the resources found. A full scale study should include expert educator assessments of the quality of a random sample of materials retrieved, by task and starting condition. In the

meantime, we turn next to subjective ratings and open-ended comments to help shed light on usability as assessed from participants' perspectives.

Subjective Findings

As explained earlier, we gathered subjective information about usability of the resources retrieved given different starting sites. Users were asked to provide their responses to each task on five-point scales and were given an open-ended comment box for each. After the last task was rated, users were also asked to provide overall ratings of the search experience and the retrieved results on five-point scales, with a text box for a general, open-ended comment. These summary responses were supplemented by feedback in the focus group that followed. Here, we present rating scale responses and selected qualitative responses, first for the individual tasks and then for the overall session. (Appendix F provides a more complete account of the open-ended comments.)

Figure 6.1 provides average responses to each of the five usability-related rating scales, differentiated by starting sites, for task 1. Because of its greater familiarity, we had expected those in the Google starting condition to give the ease-of-use scale higher ratings than other sites received, at least for the first task. In fact, there are few notable differences between site ratings on task 1 for any scales except for plentifulness of resources among which to choose, where Google clearly outranks the others as anticipated. With a larger sample, however, the very modest differences in ease of use and speed of finding resources between the more focused and the generic starting sites might emerge as significant.

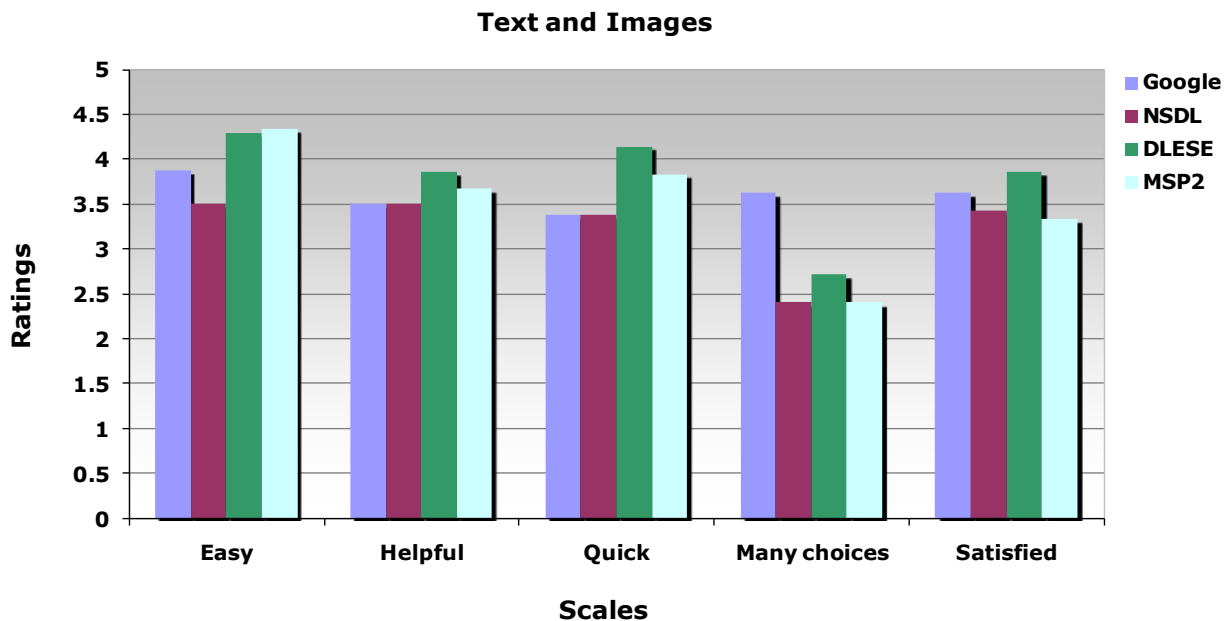


Figure 6.1 Mean Scale Ratings by Starting Site for Finding Good Text and Image Material for Introducing Plate Tectonics (Task 1)

These impressions are partially corroborated by open-ended comments. For instance, users starting with the more generic sites made such remarks as “there is a lot of fluff to search through,” “discernment [is] required to establish the validity of each source found” (Google users) or “you really had to sift through the links . . . and find material that was appropriate,” “it was a laborious process” (nsdl.org users). In contrast, participants starting with more focused sites commented that “there seemed to be a nice variety of different academic levels to choose from,” “the website was easy to navigate and narrow the search parameters for what I was looking for” (DLESE users) or “I liked that there were both teacher and student resources available” (MSP2 user).

Figure 6.2 presents combined ratings for tasks 2a and 2b. Here there are very few differences in mean ratings across the starting sites, reflecting in part a general paucity of video, animation, and interactive resources. However, except for the item on having many resources from which to choose, it appears that the two more focused Pathways may be somewhat superior in taking advantage of uniquely digital properties of material—video, animation, and interactivity—for exposing learners to plate tectonics concepts. A larger sample would, of course, be required to learn whether these differences are significant.

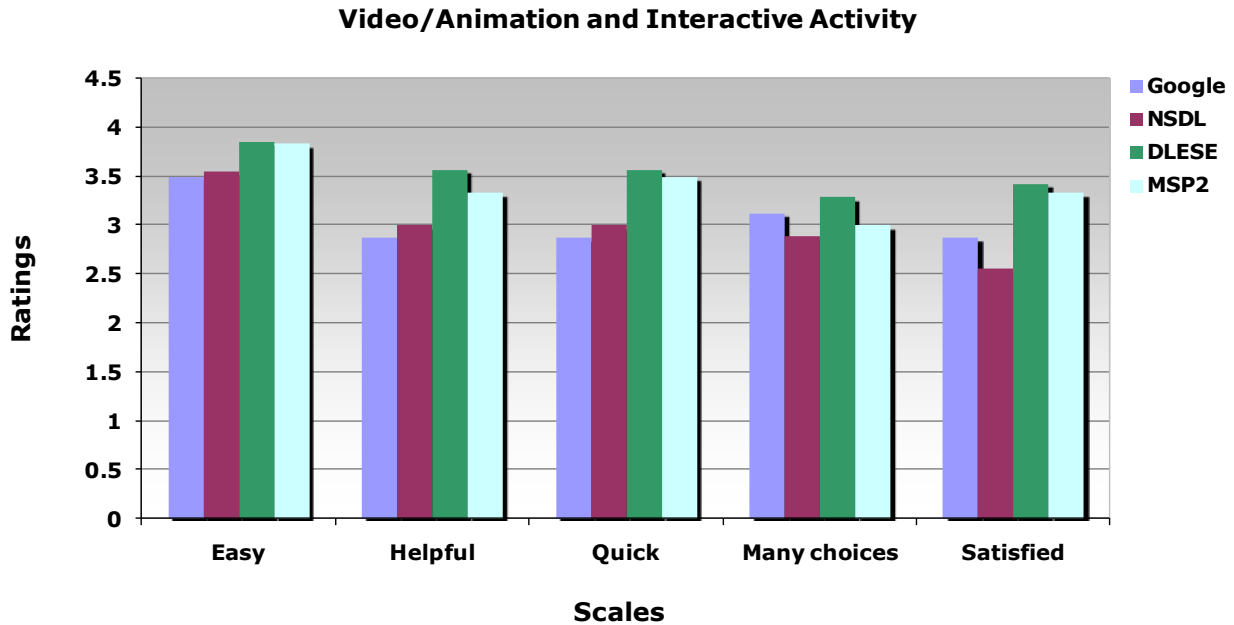


Figure 6.2 Mean Scale Ratings by Starting Site for Finding Good Video, Animation, and Interactive Material to Illustrate and Reinforce Plate Tectonics Concepts (Task 2)

Open-ended comments confirm that materials satisfying task 2 were much harder to find than text and image materials responsive to task 1. Further, user comments indicate that videos are generally easier to locate than interactive exercises, except in the case of DLESE, for which one user commented, “I found it so much easier to find activities than video demonstrations.” Such remarks suggest that, in the future, it would be better to elicit separate ratings for the two subtasks comprising task 2. Participants in two starting sites (nsdl.org and MSP2) also remarked about ending up with a frustratingly large number of broken links.

Figure 6.3 provides mean subjective usability ratings for a task we included to get at the history and social context of plate tectonics, with the idea that teachers may want to locate such material to interest students who are not particularly attracted to physical sciences. For this task, users starting in the more focused sites generally found the request more difficult to satisfy than the previous task requests, compared with participants assigned to the generic starting conditions. Comments from those assigned to generic sites include, “overall it is very easy to find explanatory text” (Google user) and “surprisingly there were several places where I could acquire information about

[scientist Alfred Wegener] and his ideas in addition to the social perspective of the time in which he lived” (nsdl.org user). In contrast, those assigned to the narrower starting conditions made such remarks as, “it was very hard to just search for history or historical information,” and “I could only find one site that actually discussed the theory/discovery of plate tectonics” (DLESE users), that it was “harder to find this information as compared to the other task questions,” “I found one not so good site and that was it,” and “When I searched [for] ‘Alfred Wegener’ only one result came up” (MSP2 users).

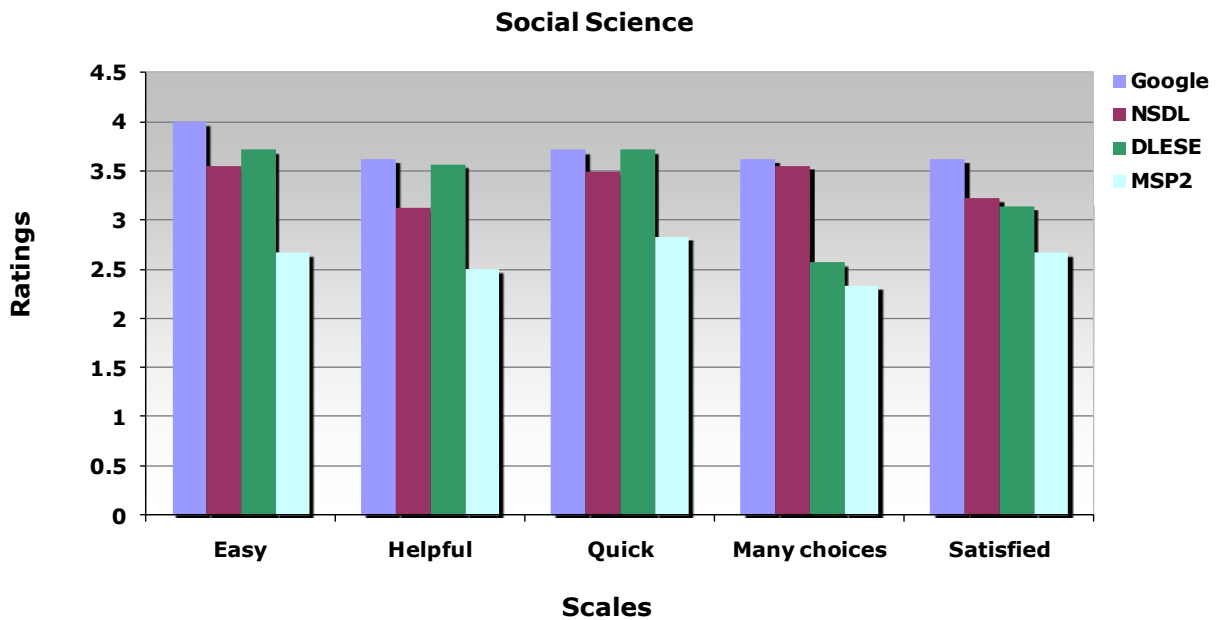


Figure 6.3 Mean Scale Ratings by Starting Site for Finding Good Materials to Explain How the Theory of Plate Tectonics Was Discovered or Applied (Task 3)

Item responses are consistent with these remarks, indicating that participants rate both of the generic starting sites higher with respect to providing many good resources from which to choose in response to this task. Across the task 3 rating scales, however, MSP2 consistently scores lower than DLESE; the reason for this difference between ratings of the two more narrowly focused starting sites could lie in users’ dissatisfaction with the MSP2 search engine and the number of nonworking links encountered.

A final set of items elicited responses to the overall usability of the tools and resources for the purpose of preparing a course unit in plate tectonics for an eighth grade earth science class. These scales aimed to elicit participants’ cross-task evaluations

given different starting sites. Users starting in Google, the NSDL, and DLESE generate relatively close mean ratings across the summary items, although, for all but one item (confidence in having located sufficient resources to build a complete lesson plan), DLESE appears to be judged somewhat superior for the hypothetical context and purpose. In contrast, it is surprising to see MSP2—the other more narrowly focused starting site—systematically rated lower than all the others (all item means for overall usability ratings are below 3 on the five-point scales).

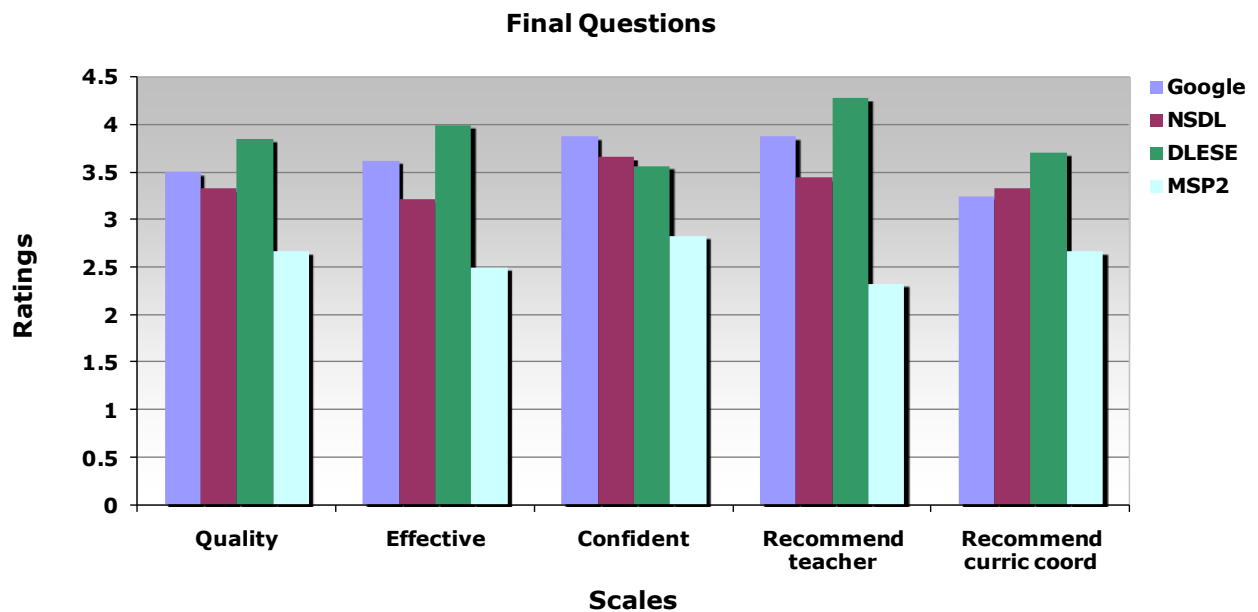


Figure 6.4 Mean Scale Ratings for Overall Usability of the Starting Site and Resources Located

We relied chiefly on the focus group discussions to explore these tentative findings. In the group discussion, users of both DLESE and MSP2 again valued the focus of the sites on the resources they were seeking. Users said, “I liked how you could search by grade level, there were not too many options. . . . [S]ometimes too many is too much” (DLESE user), or “It wasn’t like Google that would find a site that just had the words somewhere on the site” (MSP2 user), and at least one participant specifically noted that DLESE offered a nice alternative to Google. On the other hand, in their respective group discussions and written comments, NSDL and Google users both reported that there were too many resources through which to sift.

As was first suggested by the task 3 results, the relatively lower ratings of MSP2 may be a result of users' experiences with the search tools—they reported many broken links, sometimes too few resources, and difficulty using the search engine. Users said, for example, “Only active websites should be listed!!!!” “Search bar on the main page gives no results. User has to first locate the ‘search’ tab before they can search. Slightly confusing!” and “This site was great for some things but not good at all for others,” referring to difficulties of finding social science material. Collectively, these frustrations seem to have led to the overall negative reactions to MSP2, despite its value as a focused search tool.

However, at least one participant found and responded very favorably to the wiki-based “Learning Guides” that MSP2 offers as an alternative method for finding resources. The user reported, “I *really* liked this website, easy to navigate, wiki page puts everything right in front of you and all you have to do is go through and click to find what you are looking for. Definitely will use in the future.” This suggests that the Learning Guides portion of MSP2 may be highly usable, while the search function is less user friendly.

The slightly higher rankings of DLESE could be because DLESE offers the benefits of a focused search but has far fewer broken links. Additionally, during the group discussion, participants' criticisms about the search in DLESE reflected the desire for additional features—“Lacked information (or tabs to narrow search) to look for research, or history”—rather than dissatisfaction with the basic search, as participants had with MSP2.

Feedback on the Pilot Trials

As mentioned earlier, focus groups were convened by starting condition after completing the trials. Participants were asked first to respond to questions about the overall usability of the tools and resources they encountered. In the latter half of the group session, participants were asked to provide feedback on the experimental procedures, the specific tasks performed, the questions following each task, and the time allotment for each task. Here, we summarize what they had to say.

The majority of participants agreed that the tasks were appropriate for testing the starting site's usability. All 30 participants reported that the pilot trial tasks were similar to those that they would do in preparation for a real class. Additionally, they suggested several other search tasks that would have been appropriate and interesting. These include the tasks of finding the following:

- worksheets or handouts
- PowerPoint presentations
- recent science articles or original science literature
- Webquests²⁴

Participants also suggested additional survey questions that might elicit signs of usability, including these:

- How do participants see themselves using the sites/materials?
- How heavily would participants expect to use the site?
- How much time do participants think the website would save them?
- How does the tested website compare with other websites participants might use?

Regarding study procedures, participants observed that it took time to gain familiarity with a website in order to use it effectively, and many believed it would have been helpful to have time for open-ended exploration of the website before beginning the tasks. The majority of participants also reported that the time for each trial was adequate, although a few reported it was too short, while a few reported it was too long. Those who reported needing more time tended to be those who also appeared to be very engaged in the task or those citing the need to take a closer look at sites to understand their features. A minority of participants reported that the time for each trial was too long. One participant noted that the trials probably provided more time than a teacher in a real classroom setting would likely have to search for materials to use for an upcoming unit lesson plan.

DISCUSSION

The pilot trials described in the previous section yield suggestive information about usability that is consistent with and complements what we learned in the metadata study. Further, we believe the experimental usability scenario, tasks, and response options work fairly well. We would suggest using them as the basis for

²⁴ A webquest is an assignment that asks students to use the Internet to learn about or synthesize their knowledge on a specific topic.

designing a larger trial to be conducted in a future evaluation effort with a larger sample capable of producing statistically significant results. However, given the pilot experience along with participant suggestions, we would recommend the following kinds of changes for a full scale experiment.

First, it would be desirable to extend the practice task to include some time for users to explore and become more familiar with the starting site to which they have been assigned. Focus group participants explicitly made such a recommendation, and some open-ended task responses included such comments as “I don’t know whether these kinds of materials are easier to find or I’m just getting better at it.” Although a practice exploration period would not eliminate learning effects over time, it would reduce some of the false starts on the first task. It would not, of course, be sufficient to produce the level of familiarity participants have with Google.

Second, on the basis of user feedback, we would make 2a and 2b (find illustrative video or animation and find an interactive exercise) into separate tasks because, although they are at a similar level of granularity, each requests a different digital format with a distinctive advantage as a teaching or learning resource. We would probably add a third type of resource at this level of granularity: a worksheet or other student handout that would assist hypothetical teacher-users to develop a homework assignment related to the course unit. Additionally, we recommend incorporating a task to find a lesson plan, which represents a different level of granularity and one that we think reflects a much-needed type of resource. Eliminating the posttrial feedback sessions should allow the expanded trials to be completed in the same 90-minute time frame.

With respect to grade level, we recommend retaining eighth grade for a larger usability trial. It would be possible to add other grade levels (e.g., fourth grade, 12th grade), but we think that the added effort to design grade-appropriate counterparts to the current tasks and the much larger pool of users such a design would require would not do much to extend the usability findings. As we noted above, the eighth grade is an interesting choice because so many national and international math and science assessments target that level. However, we would recommend expanding the subject domains, retaining earth science as one but selecting a second domain (e.g., mathematics, because the MathDL pathway is dedicated to this subject area), and designing relevant tasks modeled after those used for earth science.

Finally, we suggest using the same group-administered approach to such trials, ideally conducting them in university computer laboratories with science education

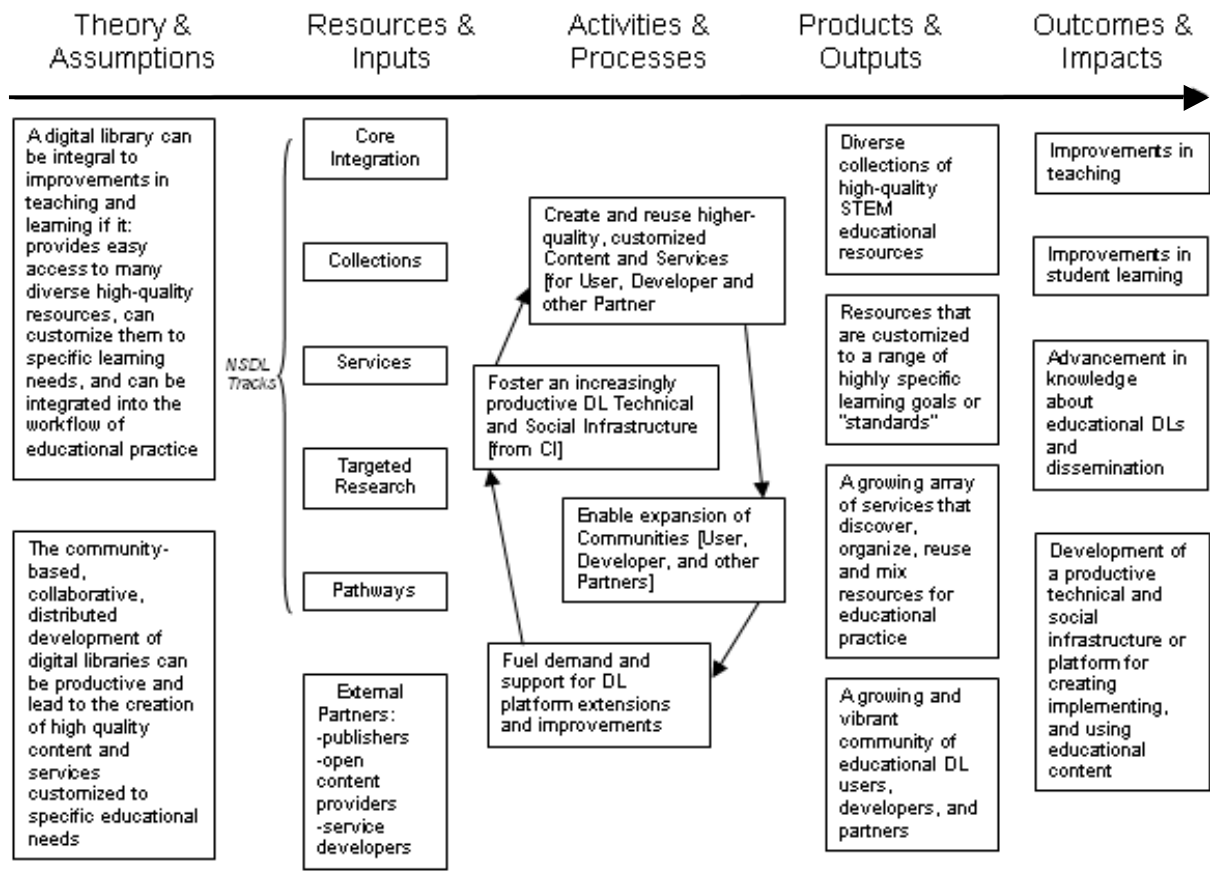
students recruited as participants. Two or more universities would likely need to agree to serve as sites in order to generate sufficiently large samples. Participation should be rewarded, as before, with appropriately valued gift cards.

The results of a full scale study designed along the lines set out above should valuably inform future efforts to shape and enhance NSDL resources to become better suited to meet the program's STEM teaching and learning goals. Additionally, they would be expected to make an independent contribution to usability research literature in general and to cyberlearning usability literature in particular.

CHAPTER SEVEN. MINICASE STUDY OF A SUCCESSFUL IMPLEMENTATION OF THE NSDL MODEL

As the review of NSDL projects to date indicates (see Chapter Four), because of the very small number of studies that attempted to assess potential teacher or learning effects of putting NSDL resources to use in classrooms, we were not able to conduct a case survey of such studies. The review did, however, succeed in identifying a few efforts to provide evidence of teaching and learning effects. Among them, one project stands out: a demonstration project carried out with the Denver Public Schools (DPS) aimed to introduce the NSDL-funded CCS into earth science instruction there to enhance teaching and learning through the use of NSDL digital library materials. Specifically, the project drew digital resources from DLESE and applied CCS tools to enable teachers to complement standardized textbook material and to customize their instruction to students' learning needs (see also Sumner, Devaul, et al., 2009).

To our knowledge, this demonstration project is the most complete realization of the NSDL logic model (see Figure 7.1), which starts with support for developing and making available high quality digital science library resources and promoting their use to improve science education in U.S. schools. For this reason, we gave it special attention as an exemplary case, the third of three primary data collection activities discussed in this report. For convenience, we refer to this pilot project as the *DPS CCS* study.



SOURCE: McArthur, D., *NSDL Evaluation: Phase 1*, Washington, D.C.: National Science Foundation, 2008.

NOTE: DL = digital library. CI = Core Integration.

Figure 7.1 NSDL Program Logic Model

AIMS OF THE MINICASE STUDY

The primary goal of the minicase study reported here was to explore the factors that might account for this seemingly successful instantiation of the NSDL logic model. For this purpose, we relied on a sociotechnical systems conceptual framework that has been applied previously by researchers at RAND and elsewhere to explain successful diffusion of new technologies to enable organizational innovation. The framework suggests three classes of explanatory factors:

- Characteristics of the preexisting user context (the demand side) account in part for willingness and ability to adopt a new technology.
- Characteristics of the technology itself (the supply side) also account, in part, for adoption and use.

- Characteristics of the implementation process, or the series of decisions made and actions taken to integrate the new technology into the existing user context, are expected to comprise the major antecedents explaining successful innovation.

For purposes of this type of project, success outcomes should include (1) extent of use, (2) user satisfaction, (3) improved teaching, and (4) improved student learning. For purposes of a larger NSDL evaluation, broader impacts of success should be explored as well, including (5) whether the innovation is sustainable in the given context after the demonstration project ends, (6) whether the results are replicable (e.g., with another STEM discipline), and (7) whether the results are scalable (e.g., whether they can be reproduced in multiple other schools).

We refer to the present study effort as a *minicase* because it is able to provide only a snapshot of outcomes 1 and 2 at a single point in time and because it can make only hypothetical inquiries about the potential for broader impacts.

METHODS

Study researchers made a two-day site visit to gather qualitative case information from CCS representatives at CU-Boulder's Institute of Cognitive Science and at Digital Learning Sciences at the University Corporation for Atmospheric Research (UCAR), as well as from DPS representatives in Denver. For this purpose, we designed a semistructured interview protocol organized around the elements of the conceptual framework sketched earlier. Additionally, we developed a discussion guide, reflecting top-level constructs in the interview protocol, for facilitating focus groups with CCS and DPS staff.

Participants in each data collection effort included the following:

- semistructured individual interviews:
 - two CCS project leaders
 - two DPS science curriculum coordinators
- focus group discussions:
 - CCS project team members (n ≅ 10)
 - DPS earth science teachers (n ≅ 12).

We also explored generic features of the CCS site, as well as DLESE. Privacy protections for teachers and administrators prevent outsiders (including our research team) from accessing users' customized individual or shared sites or other system-

logged aspects of the DPS-specific implementation, as reflected in the articulated user participation policies related to privacy. As part of the participation agreement, however, CCS project staff will be able to analyze those logs and present findings in unidentifiable form in research reports. In the next section, we present main findings from this minicase study.

FINDINGS

The DPS CCS project began in January 2008 with primary funding from NSF and additional support from CU-Boulder. During the school term beginning in winter 2008, DPS leaders and CCS representatives met to share and discuss ideas, get background information, arrive at decisions, and plan next steps.

Among other things, it was decided to form a Teacher Advisory Board (TAB) of 10 earth science teachers, half from middle schools and half from high schools; DPS requires earth science courses in grades 6 and 9. The TAB was formed to help design and develop the CCS prototype interface to support DPS earth science curriculum needs. They would then serve as “alpha” users, testing the trial system in their own classrooms during the 2008-2009 academic year, providing the CCS team with regular feedback to enable iterative user-driven improvements.

In summer 2009 this pretested and improved system would be rolled out to regular users—the entire cohort of earth science teachers in DPS (>120). Training sessions were conducted in person a full 2-week period in late summer; those not available were able to take the training online. Training sessions included explanations, guided practices, and demonstrations led by CCS representatives as well as TAB members; the latter presented some examples of materials they themselves had developed for use in their own classes and then made available on the shared site. Teachers received compensation for taking part in these professional development sessions.

The full pilot project, involving all DPS earth science teachers and students, was conducted over the 2009–2010 academic year. All teachers received a computer and projector for classroom use, conditional on their agreement to permit CCS researchers to track their system use and to deidentify, analyze, and report the resulting data. Participation in the pilot project was voluntary, but the promise of a dedicated computer and room projector, along with pay for extra time spent in training and research sessions, led to a zero refusal rate.

At the time of our site visit in January 2010, two of three planned teacher surveys—focused on attitudes, usage behavior, and changes in teaching practices—had been administered; these were supplemented by some short interviews and observations conducted by the CCS team. No student outcome data were available or planned. Standardized achievement tests would be administered near the end of the 2010 academic year, but these would be “blunt instruments,” according to a CCS researcher, and not likely to reflect any effects attributable to possible improvements in earth science instruction.

The discussion of findings in the remainder of this chapter is organized to reflect the conceptual framework guiding this qualitative minicase study.

CHARACTERISTICS OF THE USER CONTEXT

One factor found to contribute to successful innovation in previous research is a need—recognized by the user community—that a new technology could fulfill. In the present case, DPS had a clearly articulated need. DPS had adopted a new, district-wide curriculum for earth science in grades 6 and 9, and had chosen text books from the It’s About Time science series along with the publisher’s associated teachers’ guides. Curriculum units were framed in terms of standards, key concepts, and learning goals to be achieved. What was lacking were high-quality interactive teaching and learning resources—the sorts of visual images, animations, simulations, and exercises likely to engage diverse students with varying levels of English language fluency, quantitative skills, and other academic abilities in mastering a science course. Materials of this type were expected to be important in a large urban school district, like DPS, where 77 percent of the approximately 75,000 students are minorities and 66 percent qualify for free or reduced lunch (Sumner, Devaul, et al., 2009). In this context, a curriculum customization service aimed at complementing text-based material with selected high-quality, interactive resources tailorable to the lessons and the students, if offered in a user friendly way to teachers, could create “demand pull” in the user context.

A second important feature of the user context was strong support from key stakeholders. Among them, the DPS Chief Information Officer (CIO) had a close, collegial relationship with members of the UCAR CCS team and played a major facilitative role. Additionally, the senior DPS science curriculum coordinator had a strong relationship with the publisher of the chosen earth sciences texts. Perhaps most critical, however, the top district officers demonstrated vision and leadership in pushing the plan forward. Even when end users are enthusiastic about a new technology,

previous research suggests that, without support from the top levels of an organization, it is difficult to summon the resources required for successful implementation.

Third—and possibly for these first two reasons—DPS managed to establish technological readiness. Specifically, every earth science teacher in the district was provided with a laptop, a room projector, and internet connectivity in the classroom by the start of the 2009–2010 academic year. The funding awarded for the DPS CCS pilot covered only about half this equipment; DPS managed to arrange funding for the remainder. Additionally, although the pilot trial had been planned initially to last for just one semester, continuation of the pilot trial for the entire two-semester course became a condition of participation. It is likely that a half-year trial with half the teachers involved may have provided an adequate proof of concept. But fully equipping all classrooms to create a community of practice among all earth science teachers and extending the use of the new technology to support instructional preparation for the whole school year may have been strongly instrumental in motivating acceptance and use.

Technology Provision

While the DPS context exhibits many of the attributes of successful early adopters of organizational innovations, it is important not to underestimate significant aspects of the technology provision—the supply side of the picture. Perhaps most salient here is the supply of highly competent and willingly supportive technical expertise represented by the faculty and researchers at CU’s Institute of Cognitive Science and at Digital Learning Sciences at UCAR who comprised the development team for the CCS. The CCS is designed to support teachers’ planning activities. Effective planning typically involves identifying learning goals and reviewing curriculum resources for a given unit first, and then devising lesson plans and complementary learning activities and resources to help students achieve the desired unit outcomes.

It is assumed that the latter efforts involve customization of instructional approaches to connect with students’ cognitive capabilities and interests. But such purposeful planning takes time, typically outside of school hours, and has to compete with other demands on teachers’ busy schedules. CCS is designed to facilitate such planning, treating key concepts to be learned as the central organizing structure, linking varied types of instructional resources to those learning goals. Teachers may assemble selected resources related to a given goal, saving them in a personal space online (“my stuff”); they may also send materials they have customized to a shared space or browse

that space to see whether others have provided learning materials there that they may find useful.

For purposes of the DPS CCS pilot trial, the CCS team could draw on DLESE's digital resources. As is evident from Chapters Two and Six, the DLESE Pathway and associated collection constitute an exceptionally high quality, well maintained digital library hosted at The National Center for Atmospheric Research (NCAR). Thus, the CCS for earth science instruction could be populated initially with a range of digital instructional materials that were well known to the CCS team. Additionally, access to other NSDL tools, such as EduPak, automatic cataloging, and the Strand Map Service for concept mapping, made the job of organizing such resources within the CCS easier.

A final ingredient on the supply side of the picture was the willingness of the publisher of *It's About Time* to make the earth science texts and teacher guides available to the DPS CCS project in digital format. This would enable provision of a one-stop shop for earth science instructors in search of needed teaching resources. While both DPS and the publisher in principle had something to gain from this arrangement, the close relationship between the senior science coordinator and the publisher was surely helpful in overcoming the sensitive intellectual property issues implicated in enabling use of the digitized texts.

Implementation Process

NSDL facilities have been sometimes characterized as being driven from a supply-side, "if you build it, they will come" perspective (see, e.g., Giersch et al., 2004). In contrast, the implementation process for the DPS CCS project was essentially collaborative in nature but user driven. Once the go-ahead decision for the pilot project had been taken jointly by the district and CCS leaders, TAB members led the participatory design process.

At the first meeting between these representative prospective users and CCS developers, the teachers discussed their instructional resource needs and their current methods for meeting them, brainstorming about the ways the CCS might be designed to meet them. At the next meeting, the CCS team came with screen sketches and story boards—a rudimentary system prototype attempting to respond to teachers' requests. Such meetings continued, with initial sketches moving to development server screens.

One user requirement, identified early in the process, was to be able to bring up learning-goal-based subsets of the text and teacher guide and associate these with selected relevant digital resources from DLESE and elsewhere (e.g., online news images

of recent environmental events, teacher-developed materials). Among other things, this requirement necessitated breaking up the very large PDFs supplied by the publisher into separately manageable, object-sized chunks—by itself quite a substantial task. Another user requirement was to pare down the vast resources offered by DLESE to some hand-selected “top picks” for teachers of grades 6 and 9, along with other visual, animated, or interactive materials that would complement (rather than repeat) textual material.

By the start of the 2008–2009 school year, a functioning online prototype system was in place. Throughout the year, TAB members used the system to support their classroom teaching and to generate user-initiated improvements to it. At the same time, they began to populate the Shared Stuff space with teacher-developed resources. Figures 7.2–7.6 provide some illustrative web pages from the resulting system.



Curriculum Customization Service: Units of Study Nidhi Kalra (nkcalra) | [Sign off](#) | [My profile](#) | [Find people](#) | Units of Study
Development server (for testing and demonstrations)

DPS Grade 6 Earth Science Curriculum

- Investigating Rocks and Landforms**
 - [Rocks and Landforms](#)
- Investigating Our Dynamic Planet**
 - [Our Dynamic Planet](#)
- Earth in Space**
 - [Astronomy](#)

Development CCS

This is the development instance of the CCS. New features and functionality will be previewed here. Users, resources, tags, ratings and so forth can be modified for testing without affecting the live CCS. The database of users and contributed resources were copied here from the live site on 9/8/2009. The curricula displayed here are the same as those on the live site.

Figure 7.2 Front Page of Curriculum Customization Service

Investigating Rocks and Landforms Nidhi Kalra (nkala) | [Sign off](#) | [My profile](#) | [Find people](#) | [Units of Study](#)
Development server (for testing and demonstrations)

Rocks and Landforms

Rocks and landforms are part of the geosphere but are changed over time by interaction with hydrosphere, atmosphere and biosphere through constructive and destructive forces.

Rocks and Landforms

[Units of Study](#) » [Investigating Rocks and Landforms: Rocks and Landforms](#) » [View All Stuff](#)

Rocks and Landforms

» [Big Idea](#)

Key Concepts

a. Earth's Crust

The Earth's crust is made of rocks which can be igneous, sedimentary or metamorphic.

- [Introduction to Rocks and Landforms](#)
- [Investigation 1: Different Types of Rock+](#)

e. Erosional Processes

Weathering and other erosional processes involve the geosphere, hydrosphere, atmosphere and biosphere. Erosion can be the result of running water, wind, glaciers and gravity. Some landforms are shaped by erosion.

- [Investigation 4: Rock Abrasion](#)
- [Investigation 5: Erosional Landforms](#)

b. Rocks by Region

Different types of rocks occur in different regions.

- [Investigation 2: Rocks and Landforms in Your Region](#)

f. Delta & Floodplains

Delta and floodplains are formed by sediment deposition.

- [Investigation 6: Delta and Floodplains*](#)

c. Rock Cycle

Rocks form and break down by processes collectively known as the "rock cycle"

Figure 7.3 First Page of Curriculum Customization Service Under “Rocks and Landforms”

Investigating Rocks and Landforms Nidhi Kalra (nkala) | [Sign off](#) | [My profile](#) | [Find people](#) | [Units of Study](#)
Development server (for testing and demonstrations)

Rocks and Landforms

Rocks and landforms are part of the geosphere but are changed over time by interaction with hydrosphere, atmosphere and biosphere through constructive and destructive forces.

Rocks and Landforms

[Units of Study](#) » [Investigating Rocks and Landforms: Rocks and Landforms](#) » [Earth's Crust](#) » [View All Stuff](#)

Key Concepts

a. Earth's Crust

The Earth's crust is made of rocks which can be igneous, sedimentary or metamorphic.

[b. Rocks by Region](#)

[c. Rock Cycle](#)

[d. Weathering](#)

[e. Erosional Processes](#)

[f. Delta & Floodplains](#)

[g. Glacial Processes](#)

Earth's Crust

IES Investigations | Interactive Resources | **Education Standards** | My Stuff for this Concept | Shared Stuff for this Concept

Colorado > Science > Grades 6 - 8

Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. (Focus: Geology, Meteorology, Astronomy, Oceanography)

4.3. natural processes shape the Earth's surface (for example: landslides, weathering, erosion, mountain building, volcanic activity)

AAAS Benchmark > Changes in the Earth's Surface > weathering and erosion > Grades 6 - 8

Sedimentary rock buried deep enough may be reformed by pressure and heat, perhaps melting and recrystallizing into different kinds of rock. These re-formed rock layers may be forced up again to become land surface and even mountains. Subsequently, this new rock too will erode. Rock bears, evidence of the minerals, temperatures, and forces that created it.

[View interactive benchmark with pre- and post-requisite learning goals](#)

[View interactive Changes in the Earth's Surface Strand Map](#)

AAAS benchmarks describe the learning progression of what all students should know or be able to do in science, mathematics, and technology by the end of

Figure 7.4 “Investigating Rocks and Landforms” Education Standards Tab

Investigating Rocks and Landforms Nidhi Kalra (nkala) | Sign off | My profile | Find people | Units of Study
Development server (for testing and demonstrations)

Rocks and Landforms
Rocks and landforms are part of the geosphere but are changed over time by interaction with hydrosphere, atmosphere and biosphere through constructive and destructive forces. **Rocks and Landforms**

Units of Study » Investigating Rocks and Landforms: Rocks and Landforms » Earth's Crust » View All Stuff

Key Concepts

a. Earth's Crust
The Earth's crust is made of rocks which can be igneous, sedimentary or metamorphic.

b. Rocks by Region

c. Rock Cycle

d. Weathering

e. Erosional Processes

f. Delta & Floodplains

g. Glacial Processes

Earth's Crust

IES Investigations Interactive Resources Education Standards My Stuff for this Concept Shared Stuff for this Concept

All resources Search

Resources 1 - 10 out of 27 [Next >>](#)

Wiki Rocks Save
<http://en.wikipedia.org/wiki/Rocks>

Rating: (not yet rate) **This site rocks!**
***** Submitted on Sep 4, 2009 by Christine Wheeler » christine_wheeler@dpsk12.org

Saved by 1 user
Tags:
At grade 6 (1)
5-15 min. (1)

Earth Science Week Oct 11th - 17th. site Save
<http://www.earthsciweek.org/forteachers/index.html>

Rating: (not yet rate) **A site for teachers offering ideas for planning activities to celebrate this week.**
***** Submitted on Sep 3, 2009 by Mary Devore » mary_devore2@dpsk12.org

Saved by 1 user

Geology for Kids Current Events Save
<http://www.geology.com/news/category-for-kids.shtml>

Figure 7.5 "Investigating Rocks and Landforms" Shared Stuff Tab

Investigating Rocks and Landforms Nidhi Kalra (nkala) | Sign off | My profile | Find people | Units of Study
Development server (for testing and demonstrations)

Rocks and Landforms
Rocks and landforms are part of the geosphere but are changed over time by interaction with hydrosphere, atmosphere and biosphere through constructive and destructive forces. **Rocks and Landforms**

Units of Study » Investigating Rocks and Landforms: Rocks and Landforms » Earth's Crust » View All Stuff

Key Concepts

a. Earth's Crust
The Earth's crust is made of rocks which can be igneous, sedimentary or metamorphic.

b. Rocks by Region

c. Rock Cycle

d. Weathering

e. Erosional Processes

f. Delta & Floodplains

g. Glacial Processes

Earth's Crust

IES Investigations Interactive Resources Education Standards My Stuff for this Concept Shared Stuff for this Concept

Top Picks (5) Images / Visuals Animations Inquiry With Data

Clastic Sedimentary Rock Formation Save
http://www.classzone.com/books/earth_science/terc/content/visualizatio...

Scientific visualization
This animation depicts how dissolved minerals carried by water are deposited between grains, forming a natural cement that holds the sediments together.
Rating: ***** From: DLESE Community Collection (DCC)

Saved by 33 users
Tags:
At grade 6 (13)
5-15 min. (12)
Extension (6)
[» more](#)

Igneous Rock Crystallization Animations Save
http://www.classzone.com/books/earth_science/terc/content/investigatio...

Scientific visualization
These animations features microscopic views of igneous crystals forming under different cooling conditions and examines the relationship of the resulting texture of each rock to its cooling rate.
Rating: ***** From: DLESE Community Collection (DCC)

Figure 7.6 "Investigating Rocks and Landforms" Interactive Resources Tab

In July and August, the entire cohort of DPS earth science teachers was trained in CCS use, with TAB instructors providing some examples from their own prior experience. Those not able to attend in-person training sessions (nearly half the cohort) were provided with online training. Teachers rated the training as equally effective whether they took part in person or via the web. In focus groups, teachers said they found it especially useful to see how other DPS teachers had used the materials in their classrooms during the alpha trial. Those who took part in the training person also enjoyed the opportunity to meet and talk with earth science instructors from other schools. Those who took the online training, however, turned out to become more frequent CCS users, for reasons that are not known.

Throughout the year-long pilot project, the CCS team was on call to answer help lines and provide user support. Interestingly, those who staffed the technical support lines reported in the focus group that they received few questions and the majority were easy to address—the forgotten password being the most common problem. Generally, close communication had characterized the interaction between DPS users and the CCS team for the period preceding our minicase study. In summary, the characteristics of the implementation process observed with the DPS CCS project illustrate the kinds of modifications made to new technologies that can help integrate them effectively into contexts of use.

At the same time, the implementation process required changes in user behaviors to take advantage of the affordances of the innovative system provided.

Outcomes

As noted earlier, the current minicase is short on outcomes. The pilot trial still had several months to go at the time of our January site visit. Logged data about the extent and nature of system use and findings from the three waves of self-report survey data from teachers would likely become available in summer or fall 2010, and no student learning outcomes would be forthcoming from the pilot year.

Focus group discussions provided some qualitative insights into potential outcomes of interest. For instance, some earth science teachers had not previously known about the NSDL in general or DLESE in particular, although all had used the web to search for course materials. However, even those who had previously used DLESE said that the DPS CCS system eliminated the need to spend a great deal of time searching in order to arrive at the right teaching materials for their classes. The value of the DPS-specific implementation of the CCS was confirmed by a previous TAB member

who had transferred to a school in an adjacent district for the 2009–2010 academic year. He reported that, although he still had access to DLESE and the generic CCS tool, these resources were not nearly as useful as the district-specific implementation to which he no longer had access.

Another advantage was cited by a teacher new to the district who had graduated the previous spring with a science education credential but no prior experience teaching earth science. She found the DPS CCS system—and especially some teacher-generated sample materials in the Shared Stuff area—invaluable in coming up to speed in her first teaching year. However, focus groups constitute small, self-selected, convenience samples, so the findings are, at best, suggestive.

Evidence of potential broader impact is even more speculative. Among such longer term outcomes, sustainability of the current implementation beyond the period of pilot funding seems likely. The project has already survived turn-over of several district leaders who were critical to its initiation, a key predictor of sustainability in prior research literature (Yin et al., 1973). Another positive predictor of sustainability is the transition to line-item support for DLESE from NCAR. Further, focus group participants believe that, as more teacher contributions are made to Shared Stuff over time, the CCS will become increasingly useful and used, generating the virtuous circle envisioned by the NSDL logic model.

For other broader impacts, such as replicability or scalability, the prospects are less clear. The CCS team has been approached by DPS and is in discussions with the current leadership about implementing the service for another science curriculum. Additionally, the CCS team has been approached by education officials in other states who hope to improve their public school science offerings. When we asked interview and focus group participants about the extent to which the seeming success of the DPS CCS effort might be due to physical proximity, opinions were mixed: Some believed it was extremely important in enabling communication, mutual understanding, and cooperation; others thought the interactions could have been carried out successfully via distributed social media of the sort on which the system itself relies. When asked whether the excellence of the DLESE digital library played a pivotal role, opinions were again varied: Some regarded it as a necessary condition for success, while others suggested that, for curriculum customization purposes, only a small number of resources of “top pick” quality per learning goal would be required.

CONCLUSIONS AND RECOMMENDATIONS

We would expect some valuable lessons could be learned about how to put NSDL resources into teachers' hands for classroom use through a full scale case study of the DPS CCS project. The effort depicted here reflects the characteristics that sociotechnical systems theory suggests are most important for jointly optimizing the capabilities of the technology and the users in the attempt to reach the goals envisioned in undertaking the innovation.

For a full scale case study, it would be desirable to include some measures of teaching or learning outcomes—or credible intervening antecedents or proxies for these—on a longitudinal basis to yield some evidence of positive change over time. It would also be desirable (but not necessarily feasible), in a future formative evaluation, to seek some sort of quasi-experimental comparison data (e.g., from a socioeconomically similar school district also offering earth science in grades 6 and 9). Further, even a single district DPS evaluation extended in time could help shed light on answers to broader impact questions related to sustainability and replicability).

However, a future evaluation should not assume that the DPS CCS approach is the only feasible way to instantiate the NSDL model just because it appears to be the best documented. A second approach worth studying might be the Noyce Scholars program. Based at California State University, Long Beach (CSULB), but associated broadly with education programs at other CSU campuses, this initiative provides stipends to science education majors along with training in the use of NSDL instructional resources in exchange for their promise to bring their teaching skills to disadvantaged schools after receiving their teaching credentials (Andrews et al., 2009).

Identifying and studying at least two promising cases (or more, if others should surface) would enable comparing antecedents, processes, and outcomes of very different approaches to accomplishing the transition from digital libraries to distributed learning in the STEM disciplines. Leaders of both the Noyce Scholarship program and the DPS CCS project have indicated their willingness to participate in a future NSDL evaluation.

CHAPTER EIGHT. FORMATIVE EVALUATION OF THE NSDL: RESULTS AND NEXT STEPS

The first part of this chapter provides a brief summary of key conclusions and recommendations from the main foci of the present evaluation—the collected digital resources, the web-based infrastructure through which they are accessed, and the expected support they can provide for facilitating teaching and learning in the STEM disciplines. The recommendations are divided into steps that NSF and the NSDL should take now to improve the program and implications of the findings for designing a future evaluation phase.

In the second part, we synthesize these implications and suggest a conceptual approach, dimensions, and elements of a desirable third-phase formative evaluation for the NSDL.

STATE OF HEALTH OF THE RESOURCE COLLECTIONS

As we explained in Chapter Two, the project relied on existing data derivable from NSDL sites to evaluate the authoritativeness, usability, and integration of the resources they make available. For this purpose, we cataloged and analyzed measurable characteristics representing attributes of interest for assessing their state of health. The three-tiered sample included 50 still viable collections (of 71 funded by NSF), the 14 functioning Pathways, and nsdl.org as a one-stop shop for finding NSDL resources. Here, we highlight key findings and recommendations for future improvements.

Authoritativeness

Currency of the collections is questionable. Of the 50 collections, 14 of them (over a quarter) are not current, yet 13 of these are still available for search and retrieval via the NSDL. However, stability of the collections themselves is noteworthy, with 95 percent or more of the records sampled from collections and Pathways being still available.

Evidence of scientific authoritativeness of the resources is weaker than would be desired. Just over half of the Pathways and just under half of all collections have published peer review practices. Further, only 40 percent of collections have evidence of professional oversight, compared with 86 percent of Pathways.

Usability

Metadata are generally problematic across resources—just over a third of Pathways and just over a tenth of collections have good metadata. Sample searches often turn up heterogeneous resources (e.g., activities, articles, historical images) in a single display because results are subject-matter-based and not use-based.

When resources are found, users are not clear about what can be done with them. The majority of Pathways and collections provide some kind of copyright guidance, but the guidance is inconsistent and usually hard to interpret. Privacy policies (i.e., what information will be tracked about users and uses) are available in the majority of Pathways but in less than half of the collections.

Integration

Nsdl.org is not an integrated one-stop shop—it does not appear to be substantially greater than the sum of its parts. For instance, only about half the resources in collections and about two-thirds of the resources in Pathways are available via nsdl.org; in contrast, about a quarter of the Pathway resources in nsdl.org have duplicate records, complicating rather than facilitating searches.

Further, there is no real evidence of Pathway collaboration across the NSDL—no common elements of look, feel, and service characterize them, and the NSDL is mainly acknowledged as a funding source. Moving from Pathway to Pathway creates a sense of dislocation and of starting over.

Recommendations to the National Science Foundation and the NSDL

Noncurrent resource collections should be identified and removed. For viable collections, it is important to promote regular checking to find and fix broken links. Additionally, policies and practices that evidence authoritativeness (e.g., peer reviews, professional oversight) should be encouraged and promulgated.

With respect to usability, we recommend that the NSDL resource team and Pathways researchers work with educator audiences to develop common metadata elements and vocabularies for core filtering elements that would address the workflow needs of STEM teachers. Presently, resources are cataloged in ways that reflect discipline-based subject matter but are not contextualized to meet pedagogical requirements. As a start, core elements should include genre, format, and education level. (See also related recommendations for a third-phase evaluation design.)

Using the Pathways consecutively is an arduous task because of the lack of any uniformity of design or consistency of core tool availability and presentation. The Pathways should strongly consider a core web design template that places basic information (such as scope, mission, and audience) and basic services (such as search) in consistent locations that enable a general familiarity across Pathways and improved ease of navigation in moving across Pathways.

NSF and the NSDL, in consultation with Pathways leaders, should consider focusing nsdl.org on a social networking service model. For instance, the NSDL resource team could provide centralized statistics and surveys, Creative Commons licensing, and a standardized privacy policy for consistent information gathering and user support. Users could join Pathways and manage their memberships, while central registration and a single sign-on for all memberships (e.g., OpenID) could be enabled.

Centralized folders and workspaces might be offered for each user, which would support multidisciplinary resource management. More generally, a number of avenues should be pursued to realize the aim of having the NSDL be more than just the sum of its parts.

Recommendations for Future Evaluation

In our judgment, evaluation of the state of health of the resource collections is largely complete on the basis of work done and reported here. For a future evaluation, we recommend two types of initiatives.

First, it would be desirable to revisit the Pathways and collections periodically (e.g., at six-month intervals) to assess the extent to which noteworthy shortfalls are being remedied. In particular, such inquiries should determine whether regular link checking has been instituted to find and repair broken links. They should also determine whether sites are more systematically manifesting peer review and professional oversight, especially with respect to accessioning and deaccessioning. Additionally, follow-up assessments should look for more clearly articulated user policies.

More ambitiously, metadata evaluation should be undertaken to identify and address educators' needs for more context-friendly and useful core filtering elements. For this purpose, we would recommend an extension of the FISO-based metadata pilot reported here. Extensions could include cognitive walk-throughs with representative users and experimental trials with added "educator schema" filtering elements.

EVALUATIVE EVIDENCE FROM WEB METRICS

The evaluation effort reported here turned on exploring web metrics to see what evidence they might provide for addressing questions about the composition and growth of user communities, users becoming reusers and resource contributors, “cross-pollination” among Pathways, and other aims envisioned in the NSDL logic model. For this purpose, as Chapter Three describes, we interviewed researchers responsible for nsdl.org web metrics at the NSDL Resource Center and TNS. Additionally, we interviewed web metric staff at five Pathways selected for their reputation using web metrics. We supplemented these interviews with a review of web metrics literature, including the report from the NSDL’s working group on web metrics. Main findings and recommendations follow.

Nsdl.org and Web Metrics

The primary uses of web metrics at the top-level site are for overall traffic monitoring and for site modification and redesign. It is not presently feasible for nsdl.org to develop a better understanding of its users because it lacks any way of getting data about them. The only avenue for learning more about its user community appears to be brief pop-up online surveys, where responses are of unknown quality and representativeness.

Presently, there is also not an ability to classify and characterize users by general site usage patterns, although this is a desired future goal for web metrics. Additionally lacking are data about the pattern of traffic into and out of nsdl.org; it is unknown how users get there and where they head after their visit. Thus, nsdl.org now has no knowledge about the demographic characteristics of its user community nor a general understanding of its usage patterns.

Pathways and Web Metrics

Like nsdl.org, Pathways chiefly use web metrics for monitoring overall traffic and for site redesign purposes. Only Teachers’ Domain requires registration (because teachers are able to get continuing education credits via its programs and services) and thus has demographic data across user visits; other Pathways, like nsdl.org, rely on pop-up surveys.

Similarly, Pathways undertake only very limited assessments of users’ site usage patterns. Additionally, they do not know whether specific other Pathways, nsdl.org, or still other sites are the main sources or the main destinations of their users.

There is little communication about web metrics between Pathways and nsdl.org, and no mandated reporting of web statistics either to the Resource Center or to TNS. There had been some attempt at standardization of web data using Omniture, but, presently, some Pathways have moved to Google Analytics because it is available at no cost; it is likely to become the de facto standard. In any case, the net result is that no summaries are available from Pathways related to overall traffic flow, sources of users, and the like to help inform the second-phase evaluation.

Recommendations to NSF and the NSDL

Standardized basic web metrics should be selected and shared by nsdl.org and the Pathways. Additionally, there should be mandated reporting of some web metrics (e.g., overall traffic flow, immediate sources and destinations of users) at designated intervals.

Further, NSF and the NSDL should plan for future usage data collection when new technologies (e.g., social media) are likely to play a greater role in nsdl.org and the Pathways. Some current web metrics may not be applicable to these technologies, although the new media are likely to become important in the growth and vitality of user communities.

Recommendations for Future Evaluation

Recommendations for a third evaluation phase are dependent, in part, on the ability to obtain standardized web metrics from nsdl.org and the Pathways. To examine whether user communities are exhibiting vitality, growth, and connectivity, as anticipated by the program's logic model, it would be desirable (at minimum) to measure basic traffic volumes over time, plus to-from patterns (sources and destinations of site visitors). These data would be useful for constructing a map of traffic relationships between nsdl.org, the Pathways, and other key sites. They would also enable identification of high and low traffic sites for further study.

It is also important to measure the extent of use of private spaces by users to retain and tailor materials to their own needs and the rate or volume of contributions by users to shared spaces, for sites that offer these services. Such measures would shed light on whether customized or customizable resources were being developed to meet particular teaching/learning goals.

A third recommendation would be to gain a richer picture of users by classifying them based on site usage patterns. While this is a goal of the NSDL web metrics committee, it could be aided by future research. Specifically, in given sites, it might be

possible to carry out experiments where user computers—with users’ consent—are instrumented for more detailed data collection and analysis. Instructional Architect was able to accomplish this, and the DPS CCS project has such data collection under way.

SIGNS OF TEACHING OR LEARNING EFFECTS

The evaluation reported here further sought early signs that use of NSDL resources might improve teaching or learning in the STEM disciplines. Accordingly, we examined abstracts for the 250+ NSDL-funded projects to identify and review in detail those that directly involved teachers or learners. Such a case survey was expected to yield a taxonomy of project features, as well as emerging themes or promising trends related to teaching or learning. Additionally, the review could be suggestive of hypotheses for further testing in a future evaluation while identifying exemplary cases for site visits. Chief findings and recommendations follow.

Body of Teaching or Learning Research

Among more than 250 projects funded by the NSDL during its decade-long lifetime, less than a dozen touch in some way on teaching or learning. Each of the studies addresses a different tool or resource, and each uses a different context and different procedures. These great variations in a very small body of work preclude categorizing project features or approaches.

Additionally, the methods typically employed by the projects are not ones that support speculation about teaching or learning effects. Experimental or quasi-experimental methods are largely absent. Assessments rely in the main on teachers’ self-reported behavior changes or intentions to change behaviors, gathered at a single point in time. Consequently, a systematic case survey was not feasible. However, examination of this body of work surfaced some research sites that might be good candidates for case study. It also contributed to the design of a pilot usability study with a small sample of current and prospective STEM teachers.

Recommendations to NSF and the NSDL

The NSDL program should be strengthened by allocating more funding for targeted research to explore and evaluate teaching and learning effects associated with use of NSDL resources. As Figure 1.1 in Chapter One shows, teaching and learning have been key aspects of the program’s logic model from the start, even at the “products & outputs” stage, as well as part of the longer-term outcomes and broader impacts. In

particular, it is critical to direct more research toward understanding and facilitating the transition from NSDL “activities & processes” to education-specific products & outputs. Both basic research (e.g., on how STEM subject matter cognition and learning are facilitated by interactive digital resources) and applied implementation research (e.g., on how such resources can be brought into day-to-day use in STEM classrooms) are highly recommended.

Recommendations for Future Evaluation

A future evaluation should routinely examine all forthcoming project reports (those produced since the review done for this study) to look for indicators of teaching or learning effects. However, because of the length of time that would likely be needed to elicit such effects, we would not expect to find major new contributions to the existing body of work. Consequently, we recommend continuing in two evaluative directions related to teaching and learning effects; both approaches have been piloted and reported here.

First, we recommend extending and replicating the usability study reported above, with a sample of current or future science educators large enough to yield statistically significant results. The study should investigate the relative advantages of orienting Pathways by grade level versus subject matter or remaining generic. Results of such an experiment should valuably complement the suggested metadata study and help inform efforts to shape and enhance the NSDL to better meet the needs of STEM teachers and learners.

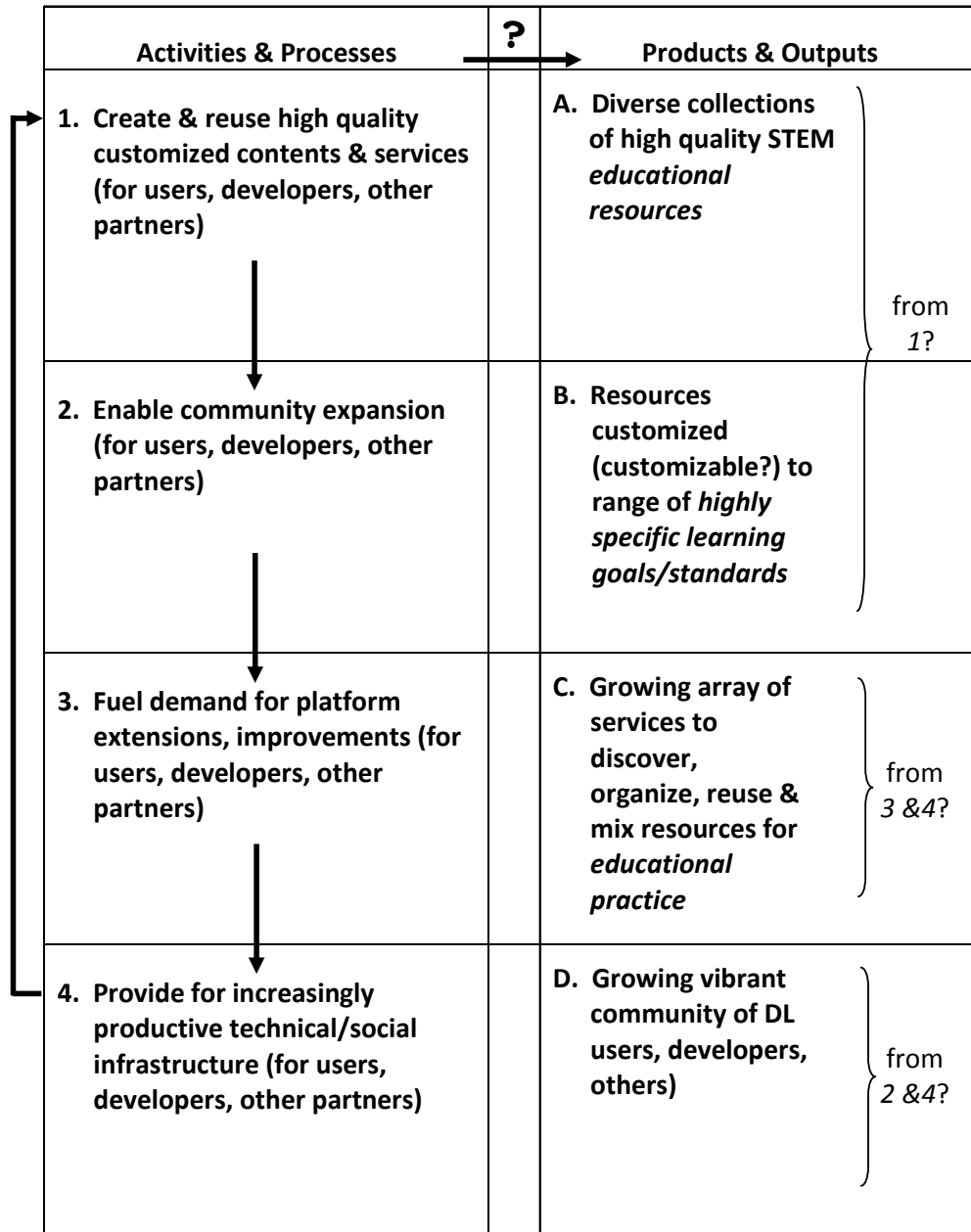
A second direction involves full case studies of projects that are currently putting NSDL resources into teachers’ hands for ongoing classroom use. One such case is the DPS CCS project, which was the focus of the minicase study reported earlier. Another attempt to instantiate the NSDL program model is represented by the Noyce Scholarship project, which takes a quite different approach to attempting to introduce digital resources into STEM teaching and learning. The third phase of evaluation should document and compare alternative avenues for bridging the gap between digital libraries and distributed learning.

SUGGESTED DESIGN FOR A FUTURE EVALUATION

Earlier, we identified a number of specific research recommendations for inclusion in the next phase of formative evaluation of the NSDL program. In this section, we suggest an overall design for the third-phase program evaluation.

Conceptual Framework

We suggest beginning again with a focus on the intermediate components of the logic model—activities & processes, and products & outputs—for two principal reasons. First, as we have explained, it is still too early to look for longer term outcomes & impacts. As we have learned, NSDL resources are only just beginning to find their way into contexts of use, so significant effects of the NSDL on STEM teaching and learning in U.S. education still lie in the future. Second, it is appropriate to look more closely at whether and how the activities & processes specified in the logic model are leading to envisioned products & outputs, especially because they are expected to facilitate the transition from digital library resources to distributed learning uses (see Figure 8.1).



NOTE: Emphases are ours.

Figure 8.1 Proposed Logic Model Components for Future Evaluation

In Figure 8.1, we have added arrows among the four types of activities & processes called out in the logic model, indicating that they are supposed to be mutually influential. That is, they are intended to give rise to a virtuous circle in which valued NSDL contents and services engender growing use, which generates demand for improvements, which, in turn, lead to an increasingly productive social and technical infrastructure where initial resources are reused, customized, and supplemented. We have also added hypothetical links, with question marks, between the two intermediate components of the logic model. The initial account of the logic model implies, but does not explain how, the activities & processes set out in the left half of Figure 8.1 will result in the four types of products & outputs on the right—especially the products & outputs that will constitute high quality educational resources (A) customized to a range of highly specific learning goals (B) and will yield a growing array of services for finding and organizing these resources to meet educational practice needs (C). A third phase of evaluation, while still formative in nature, should investigate, assess, and ideally make recommendations for strengthening transitions between activities & processes and the educationally relevant products & outputs set out in the logic model.

Sociotechnical Systems Research Foundation

A sociotechnical systems-theoretic foundation guided our approach to the evaluation reported here and should continue to provide a research base for a third phase of research. It is evident that the NSDL is envisioned as a complex, interconnected sociotechnical community (see, for example, the fourth activities & processes box in Figure 8.1). This intermixing of social and technical dimensions also appears throughout the substantive chapters of this report where, for instance, we need to make a distinction between the NSDL as the top-level program organization and nsdl.org as the top-level site in the technical system or between Pathways as nodes and Pathways as providers of contents, services, and tools.

From the standpoint of sociotechnical systems theory as it applies to understanding the adoption of new technologies (Bikson and Eveland, 1998), successful outcomes can be viewed as a function of properties of the technologies, the contexts of use, and the implementation processes by which the former are integrated into the latter. Implementation is construed as the series of decisions made and actions taken once an organization makes the go-ahead decision to adopt a new technology; sociotechnical systems theory sees implementation processes as aiming at the joint optimization of the capabilities of the social and technical constituents of the system. In this process, the

technologies are modified to better fit the aims and capacities of the user context; concurrently, users' behaviors and environments will need to change (via, e.g., training, revisions of practice) to take advantage of the affordances of the new technologies. The guiding assumption is that, like the terms of a simultaneous equation, social and technical challenges cannot be separately resolved. Research carried out at RAND and elsewhere consistently finds characteristics of implementation processes to be the strongest predictors of successful technological innovation in social contexts (see, e.g., the review in Bikson and Eveland, 1991). This theoretic lens guided the minicase study reported in Chapter Six.

A future evaluation effort should look for evidence that NSDL resources can be or are being customized for use in educational contexts (see Figure 8.1, elements B and C under "products & outputs"). Prior research suggests that user involvement (or "demand side input" as characterized in Chapter Six) is a strong factor in optimizing a technology to suit the needs of a particular context in either basic or field research.

"Nested" Design and Methods

We suggest a four-tiered evaluation design, although we have put "nested" in quotes because, while the envisioned levels are interdependent in varied ways, the proposed design is not truly nested. What follows is a brief account of each level of the hierarchical sociotechnical system design approach (see Figure 8.2).

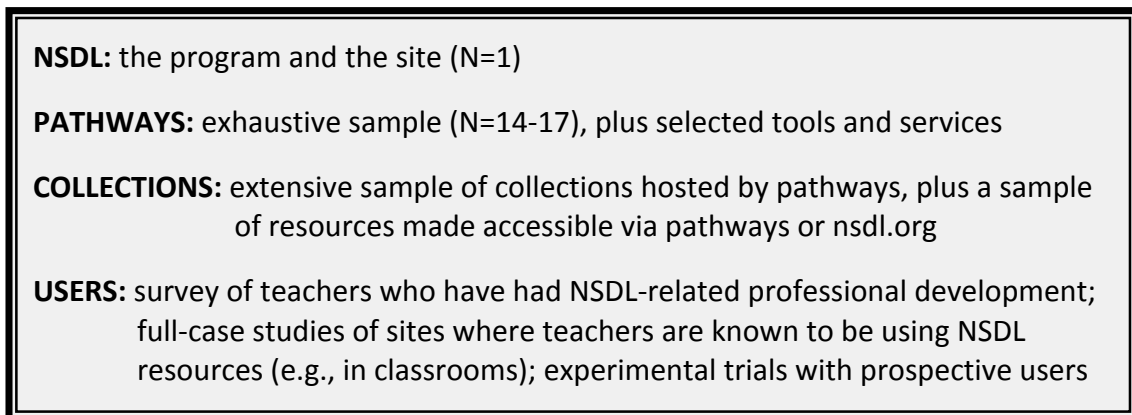


Figure 8.2 Proposed Hierarchical Research Approach

The top level is the program itself, including both the program and the site, the two top dimensions of the sociotechnical system. At this level, there is an N = 1,

susceptible only to a case study approach. Interviews with key stakeholders within and outside NSF and the NSDL would be the method of choice, supplemented by a review of recent integration efforts (see Chapter Two) and an examination of web metrics focused on overall volumes, as well as source/destination traffic patterns (see Chapter Three).

Next is the level of Pathways, for which an exhaustive sample is appropriate given their small number (N will range from 14 to 17, depending on whether and when those funded in FY 2009 and FY 2010 become available for use). Here, we would conduct semistructured interviews with Pathways project leaders and (if different) those in charge of web metrics. Additionally, we would propose an examination of web metrics, including volumes and source/destination patterns. We also suggest an examination of the level of use of personal spaces, where offered (see Chapters Two and Three). At both this and the top levels, it should be possible to learn whether there are growing and contributing user communities.

Resource collections constitute the third level, where current NSF-funded collections are expected to number about 50. At this level, the future evaluation effort should be limited to follow-up checks to determine extent of broken links (ideally, this can be done automatically) and extent to which policy recommendations have been implemented (see Chapter Two). As we have noted, the evaluation of collections per se is largely complete.

The lowest level, comprising users, merits the greatest attention in a future evaluation. Here, the methods should attempt to elicit evaluative information about the transition to educational uses of NSDL resources for teaching and learning. For this purpose, we recommend a survey of teachers who have completed courses on how to use the available resources for STEM teaching. Because Teachers' Domain requires registration so that its professional development courses can be taken to obtain continuing education credits, that Pathway would be the most feasible source for reaching a sizable population of prospective users to inquire about actual resulting use and related experiences. Additionally, at the user level, we would suggest building on the trials piloted as part of the present work. In particular, a more in-depth metadata assessment and an expanded resource usability study would help determine whether high-quality STEM educational resources could be discovered, organized, used, mixed, and reused to meet educators' needs. Further, it would be desirable to carry out full size case studies of projects that are making concentrated efforts to put NSDL-based STEM resources into teachers' hands for classroom use. For this purpose, the DPS CCS effort

(reported in Chapter Seven) and the Noyce Scholarship program would merit study, along with any other such projects that emerge in the coming year.

Evaluation Focus

As an evolving, complex, distributed sociotechnical system, the NSDL program has—in a manner of speaking—multiple “personas.” It is an interconnected library of digital resources that should provide a platform for enabling advances in STEM teaching and learning. Further, like other NSF programs, it is charged with stimulating innovative research, but it must also be concerned about the sustainability of the systems that can support such endeavor. Figure 8.3 displays these varied personas in the following matrix.

		Sociotechnical Infrastructure for	
		Digital Library	Distributed Learning
Innovative Research			
Sustained Capability			

NOTE: The shaded areas represent the evaluation domains we recommend for future emphasis.

Figure 8.3 Evaluation Foci: Alternative Options

Each quadrant of the matrix represents a plausible domain within which formative evaluation results might be sought. For instance, where the *L* in *NSDL* means “library,” as in previous proposal solicitations and implicit in the activities & processes component of the logic model (Figure 8.1), evaluation might focus on the extent to which the program yields cutting-edge methods and tools for understanding and advancing library science for STEM resources in the ever-changing digital era. As an example, Chapter Two calls attention to as yet unresolved questions about how to analyze web data to understand patterns of user behavior through a distributed library space. Or evaluation might focus on how well efforts are working to sustain and improve the resources the distributed library makes available for future research and development, much like a distributed “facility” comparable, say, to geoscience facilities funded by NSF.

On the other hand, where *L* primarily means “learning,” as seems implicit in the products & outputs component of the logic model emphasizing educational suitability, as well as in the changed title of the 2010 NSDL call for proposals, the target of evaluation might shift to education-related results. If so, a future evaluation might focus on advances in research on how and why digital resources can markedly improve teaching and learning in the STEM disciplines. Alternatively, it could emphasize how sustainable such instructional improvements are after the initial period of research funding ends.

These options are not mutually exclusive in principle. In practice, they may not all be feasible to include in a third-phase formative evaluation design, given limited resources. The shaded areas in Figure 8.3 represent the evaluation domains we suggest for emphasis in a future evaluation phase. Innovative research in digital library science in general and advanced analytic techniques for understanding user behavior in particular could reasonably be supported by other funding programs within and outside NSF; we would encourage NSF to make available and publicize its NSDL resources for research purposes beyond the NSDL program itself while not including this domain as a focus of future NSDL evaluation. On the other hand, both to support digital library science research and to enable advances in research on educational uses of digital STEM resources, it is critical to sustain the developed contents and services. We therefore recommend that a third phase of formative evaluation examine progress toward sustaining the distributed digital library infrastructure (bottom left quadrant).

On the other hand, our present study indicates that efforts to put digital STEM education resources into classroom contexts have only just begun and are too few in number to justify an evaluation of their sustainability; rather, that should be the aim of a future summative evaluation. In the meantime, a future formative evaluation should pursue and examine factors that affect or could affect the adoption, implementation, use, and usability of the developed digital library infrastructure to meet the needs of STEM educators (top right quadrant). In these ways, the evaluation can inform and assist the anticipated transition from digital libraries to distributed learning. The NSDL should move aggressively to orient its program resources toward understanding how STEM education can be improved given a supportive high-quality digital teaching and learning infrastructure.

APPENDIX A. FUNDED COLLECTIONS SUMMARY OF ASSESSMENT DATA

This Appendix summarizes data obtained from the sample of funded collections evaluated for the analysis of collection health (Chapter Two). Funded collections are those collections that are not Pathways but that were funded via competitively bid proposals to the NSDL. Projects to develop tools or to do research are not included, with the exception of MERLOT, which was funded outside of the Collections funding track but is an active and prominent collection in the NSDL.

Information was collected by completing a standardized form for each active collection. Items in the assessment form are listed below. It should be noted that, besides the collection portal itself, approximately six resources were searched in each collection, although the number varied occasionally due to the variable nature of the collection being searched.

1. Collection name
2. NSF project ID(s)
3. URL for collection portal website
4. Currency: Has the website or its collection been updated since 2009?
5. Is the collection listed in the NSDL collection list or discoverable as a collection through an NSDL search?
6. Is a mission statement discoverable on the collection portal site?
7. Where does the mission statement appear on the website?
8. Is a collection development policy discoverable on the collection portal site?
9. Is a collection scope statement discoverable anywhere on the collection portal site (not limited to within a formal collection development policy)?
10. Is the intended audience identified anywhere on the collection portal site?
11. Is a policy or procedure for accessioning (adding) resources discoverable anywhere on the collection portal site?
12. Is a policy or procedure for deaccessioning (weeding) resources discoverable anywhere on the collection portal site?

13. Is evidence of peer review policy or practice available on the collection portal site?
14. Is the presence of an advisory board or sponsoring organization(s) discoverable on the collection portal site?
15. Is an intellectual property policy governing site resources discoverable on the collection portal site?
16. Does the intellectual property policy include guidance or support for contributors (who are sharing their own work with the portal)?
17. Does the intellectual property policy provide guidance on use of resources for collection users (including guidance about copyright status and rights holders in resource metadata)?
18. Are Creative Commons licenses used at the collection portal?
19. Is a privacy policy for portal site users discoverable at the portal site?
20. Is registration available at the site to use personal services, contribute a resource, or for other purposes?
21. If registration is available at the site, is it required?
22. Does the collection portal offer public review, comment, or rating of resources?
23. Does the site offer the ability to create personal folders or workspace for organizing site resources?
24. Is the use of metadata for search, retrieval, and display discoverable at the collection portal site?
25. If yes, is a discoverable metadata standard being used?
26. What is the rating of the metadata based on such factors as jargon free, understandable display, coordination with search engine, support for user workflow?
27. Is simple ("Google") search offered at the collection portal site?
28. Is advanced ("filtered") search offered at the collection portal site?
29. Is browse search offered at the collection portal site?
30. Is another search methodology (e.g., georeferencing) offered at the collection portal site?
31. Does the collection portal reference the NSDL?

32. Does the collection portal offer other added value services particularly worth noting?
(no attempt is made to be inclusive here)

APPENDIX B. PATHWAYS SUMMARY OF ASSESSMENT DATA

This Appendix summarizes the data obtained from the exhaustive sample of operational Pathways and the active collections they host. Pathways data were collected through the use of standardized forms. Items listed here reflect properties of the Pathways-level portal as well as their active collections.

SUMMARY OF COLLECTIONS-LEVEL DATA FOR THE PATHWAYS ASSESSMENT

1. Collection name
2. NSF project ID(s)
3. URL for collection portal website
4. Currency: Has the website or its collection been updated since 2009?
5. Is a mission statement discoverable on the collection portal site?
6. Where is the mission statement located on the website?
7. Is a collection development policy discoverable on the collection portal site?
8. Is a collection scope statement discoverable anywhere on the collection portal site (not limited to within a formal collection development policy)?
9. Is the intended audience identified anywhere on the collection portal site?
10. Is a policy or procedure for accessioning (adding) resources discoverable anywhere on the collection portal site?
11. Is a policy or procedure for deaccessioning (weeding) resources discoverable anywhere on the collection portal site?
12. Is evidence of peer review policy or practice available on the collection portal site?
13. Is the presence of an advisory board or sponsoring organization(s) discoverable on the collection portal site?
14. Is an intellectual property policy governing site resources discoverable on the collection portal site?

15. Does the intellectual property policy include guidance or support for contributors (who are sharing their own work with the portal)?
16. Does the intellectual property policy provide guidance on use of resources for collection users (including guidance about copyright status and rights holders in resource metadata)?
17. Are Creative Commons licenses used at the collection portal?
18. Is a privacy policy for portal site users discoverable at the portal site?
19. Is registration available at the site to use personal services, contribute a resource, or for other purposes?
20. If registration is available at the site, is it required?
21. Does the collection portal offer public review, comment, or rating of resources?
22. Does the site offer the ability to create personal folders or workspace for organizing site resources?
23. Is the use of metadata for search, retrieval, and display discoverable at the collection portal site?
24. If yes, is a discoverable metadata standard being used?
25. What is the rating of the metadata based on such factors as jargon free, understandable display, coordination with search engine, support for user workflow?
26. Is simple ("Google") search offered at the collection portal site?
27. Is advanced ("filtered") search offered at the collection portal site?
28. Is browse search offered at the collection portal site?
29. Is another search methodology (e.g., georeferencing) offered at the collection portal site?
30. Does the collection portal offer other added value services particularly worth noting? (no attempt is made to be inclusive here)
31. Does the collection portal reference the NSDL?
32. Where does the reference or link to the NSDL appear on the website?

SUMMARY OF PATHWAYS-LEVEL DATA FOR THE ASSESSMENT

1. Pathway collection name
2. Name of resource discovered through a search at the site (approximately 15 titles were identified for each Pathway).
3. Resource still available at link?

APPENDIX C. WEB METRICS

It is essential for the NSDL in both its “Digital Library” and “Distributed Learning” incarnations to measure its use as a first approximation to assessing its impact. One of the most important data sources for measuring usage is web metrics. This appendix gives a brief overview of web metrics and their analysis, as a primer for the comments and recommendations made in the body of the report. It also reviews briefly some of the literature on the topic, highlighting the fact that advanced web metric analysis is an area of very active research in computer science and statistics, as well as in the commercial world. Continuing evolution in web technology will require continued development of website usage analysis.

Web metrics are based on the data automatically captured as web servers (such as those of nsdl.org, the Pathways, and the collections) send requested pages and other web objects to user browsers. These data provide detailed insights into how users make use of the NSDL, help inform the design of websites, and indicate where users are having problems. Additionally, if some information available about the user (e.g., whether the user is a teacher or middle school student), then patterns of use revealed by web metrics can allow websites to be tuned to the needs of different segments of the education and learning community. For the purposes of this appendix, we define *web metrics* as the information gleaned from the recording and analysis of web object accesses in the course of a user’s browsing of a website.²⁵

THE BASICS

After the inception of the web in the early 1990s, interest grew in analyzing the voluminous data captured by the servers providing web pages to users’ web browsers.

²⁵ There are two other important sets of metrics that are related to web use that we will not discuss in this appendix on web metrics, although they feature in other areas of the report: (1) user activity on collaborative sites, such as the number of participants, messages posted and threads discussed, and the number of resources created and shared by NSDL-related website users, and (2) usability measurements, such as the comprehensiveness of search engine results, their presentation, and user actions with the results. These metrics are more static in nature, and their analysis is somewhat different from that of site visits.

Initially, this was the domain of academic and industry computer scientists, driven by the need to understand traffic patterns and hardware performance on the web.²⁶ With the rise of commercial retail websites, web enterprises needed information on customer behavior; this provided a very large additional incentive to analyze user behavior on websites²⁷—in particular, on obstacles to completing a sale. However, as noted in a recent review article (Sen, Dacin, and Pattichis, 2006), few commercial companies use their website data effectively.

The source data of web metrics is conceptually quite simple: Users request web objects, such as web pages, pictures, audio tracks, and videos, by using their browsers, either clicking a link or typing a URL (e.g., <http://www.nsd1.org>) directly. The browser establishes a connection with the server that hosts the web object and requests the object from it, which the server, in turn, provides, logging the transaction in a file. The transaction information includes a time stamp for the access, the object provided, the address of the requester (the IP address of the computer), and additional information, such as the browser being used.²⁸ Other information can be provided to the log by the accessed web object itself through programming statements that are executed as the object is sent to the user. The result is a detailed record of every request satisfied by the server to each user: where the user entered the site, whether a search engine provided the link, each page the user visits, each link the user clicks, and where the user went after leaving the website. User path data are often called *clickstream data* because the user initiates the access with a mouse click. Analyses of users' paths aim to infer qualitative and quantitative characterizes of users' visits.

In practice, the log data must be cleaned substantially before they are usable. A partial list of issues that can arise includes the following:

- If a user repeatedly requests the same object, it may be cached on a server closer to the user. This cuts down on web traffic but means that the website

²⁶ E.g., Chen, Park, and Yu, 1998.

²⁷ In the ultimate indication of general interest, there was a book on web metrics in the “Dummies” series (supplanted now by a range of “dummies” books on website design) (Sostre and LeClaire, 2007), aimed at smaller retailers with substantial web-based businesses.

²⁸ The information logged depends to a certain extent on the object requested and has changed as the web has matured.

server may not log each access of the object. In some cases, the “missing” transaction can be inferred.

- Automated “web crawlers” that index web pages also generate page views as they scan a website, and these transactions must be eliminated since the crawlers are not real users.
- Some users’ sessions never end by leaving a site, so these sessions have to be terminated after detecting no activity for some time period.
- Users are only identified by internet address, which are dynamically reassigned by internet service providers as users log on, so the same IP address may be used by different users at different times. There is a rough mapping from IP addresses to geographic location, but it is not perfect and can be coarse.

For examples with more details of the types of data cleaning that must be done for web logs, see Mobasher (2007), Dalal et al. (2003), and Khoo et al. (2008). Different choices of procedure can result in cleaned log files that have significant differences in basic statistics.

A busy website can have millions of users in a given day, with each user accessing many pages, resulting in very large server log files. Analysis is often well beyond the capacity of usual websites, so there is an increasing number of commercial web metrics analysis systems that provide for log hosting, data cleaning, and different levels of detailed analysis. Two that have been used by the NSDL are Omniture (www.omniture.com) and the free Google Analytics (www.google.com/analytics).

THE GOALS OF WEB METRICS

The primary purpose of web metrics is to understand the behavior of users on a website. This provides the basic material for website management decisions: inferring the needs of different groups of users, modifying the website in order to eliminate problems for users, and helping users accomplish the tasks for which the website is designed.²⁹

Making inferences about user needs requires answers to such questions as these:

- Where did the users come from?

²⁹ The NSDL has already used some of these techniques in driving changes to the main NSDL site. See Khoo et al. (2008).

- On which web page did they land?
- What path (page and object sequences) did they take through the website?
- Where did the users go from the website?
- Can the users be classified or identified from behavior or registration?

To suggest website modifications, website designers must match user behavior against what they intend users to be able to do on particular pages. If users shuttle back and forth between pages, that may indicate confusion. If they leave the site from pages that are not logical conclusions of their path, it may suggest frustration in trying to accomplish a task, such as finding a resource. For commercial websites, the desired end result is clear: Entice the user to stay on the website long enough to make a selection and then make a purchase. For non-commercial sites, the desired behavior is less clear. For example, in its portal function, the NSDL might aim for *short* user sessions because that could indicate that users find the link to the information they want quickly and leave to get that information.

WEB METRICS FOR THE NSDL

Members of the NSDL community have been very active in using web metrics to evaluate both the main NSDL website and various Pathways. Representative accounts include Donahue (2006a, 2006b, 2006c, 2006d), Khoo et al. (2008), Palmer and Recker (2009), and Recker, Xu, et al. (2009). However, available effort at all levels of the NSDL is constrained, and some of the Pathways are particularly short of resources beyond maintenance of the main website. There are at least two areas in which the NSDL could use web metrics more extensively: descriptive web metrics and user path analysis.

Descriptive Web Metrics

We use this term to refer to the basic metrics of the entrance points for users into the NSDL, its Pathways, and collections; where they came from; where they go when they leave; and some aggregate measures of what they do (e.g., relevant downloads, participation in collaboration). The references in the introduction to this section provide examples of this type of analysis but are usually limited to a particular Pathway. For example, Donahue (2006a, 2006b, 2006c, 2006d, 2006e) gives examples of how to use raw aggregate statistics to characterize the Teachers' Domain users. Time on site shows both extended browsing, in and out with apparently no activity, and a medium length stay of about 10 minutes, which, he conjectures, comprise successful visits with a "find." He

also tried to localize users, noting that Georgia, Hawaii, and Massachusetts have high user rates per capita. These descriptive statistics provide the basis for a set of hypotheses that can serve as guides for further investigation.

Although the Pathways often share such statistics with the central NSDL core team, there does not appear to be a program to standardize the data or to make them comprehensive across all Pathways. The standardization problem stems from the complex nature of the raw web metric data (as noted earlier) and, therefore, the requirement to ensure that the data are prepared uniformly. Earlier efforts at standardization had been unsuccessful, but the growing availability of commercial programs to analyze web data could be of great help here. The decision by the NSDL to use Omniture as the web analysis system of choice was a step in this direction, but there now seems to be a movement toward the use of Google Analytics, which is free.

This last point also has relevance to the comprehensiveness of web metrics. Most Pathways are resource-constrained, particularly after they mature and must search for partial or full sustainment funding. For most Pathways, the staff consists of academic staff who are Pathway administrators only part time, sometimes supported by graduate students or university staff. In addition, some Pathways predated the NSDL or developed outside its purview and therefore are not as closely linked as the newer ones funded by NSDL-related grants. However, one responsibility of NSDL management should be an annual reporting of traffic across the NSDL sites using the data gathered by the Pathways and collections and an accounting of traffic that enters from elsewhere.

User Path Analysis

An emerging area of interest is that of clustering user path patterns to identify different user groups with varied interests and goals. This effort has gotten special impetus from the commercial sector, which seeks to use web metrics to do customer segmentation. However, the “noisiness” of user paths (e.g., moving back and forth, pursuing multiple pathways with similar intentions, having missing data due to caching) makes the clustering task nontrivial and an active subject of current research (Chen, Park, and Yu, 1998; Spiliopoulou, Faulstich, and Winkler, 1999; Pei et al., 2000; Cadez et al., 2003; Dalal et al., 2003; Moe and Fader, 2004; Sen, Dacin, and Pattichis, 2006; Giannella et al., 2007; de Bock and Van den Poel, 2009). Given the understandable reluctance of the NSDL and its Pathways to register most users and the prohibition on the use of cookies to identify return users, clustering is a way to utilize the data from all

users to understand the different segments of the NSDL audience (unlike pop-up surveys, which have problems with response and bias).

For an interesting view of the insights path analysis and clustering can provide to an NSDL site, see Recker, Xu, et al. (2009). Utilizing a wide set of metrics, the researchers clustered users from Instructional Architect, a collaboration project that is funded by the NSDL. They identified five groups of users on the basis of their productivity (contribution of materials), willingness to share their materials, focus on narrow goals, and other characteristics. The analyses also relied on usage data from users' storage areas for projects and lessons, as well as results from pop-up surveys.

THE FUTURE OF WEB METRICS

One future issue with web metrics is that changes in web page technology may change the types of data that are collected. In our interviews, one interviewee noted that some complex web pages could provide the user with multiple pages without the server logging the individual page views, an omission that could severely distort both descriptive and user-level analysis.

The current focus now is in user path analysis, particularly inferring demographics from the user paths (see de Bock and Van den Poel, 2009). Besides the obvious use of allowing the site managers to segment users to identify their audience and to make sure the site supports the users in which they are most interested, user-level analysis can provide more advanced services. One example is that of *recommender systems*, which can provide tailored help or web pages based on the user's characteristics, either explicitly stated or inferred from clickstream analysis (Gaul and Schmidt-Thieme, 2001, 2002). This has become a major research area, with periodic conferences held by the Association for Computing Machinery. Such systems could be very useful to the NSDL community.

Finally, new digital media, technologies, and venues are continually arising, which the NSDL is interested in pursuing. Measuring any enterprise in these areas (e.g., Twitter, Facebook) is challenging, and the NSDL will be no exception.

APPENDIX D. NSDL TEACHING AND LEARNING PROJECT SYNOPSIS

1. Award Title(s) and Numbers DLI—Phase 2: A Digital Library of Reusable Science and Math Resources for Undergraduate Education (0002935)	
2. PI(s) and Organization Graves, William, University of North Carolina at Wilmington	3. Funding Track, Award Amount, and Award Dates Funding track unknown; \$1,212,917; 5/15/00–6/30/03
4. Text in the Abstract That Suggests Teaching or Learning “The main objectives of this two-year project are . . . to use the library as a testbed to address several important research issues in the evolution and use of digital libraries.”	5. Findings on Teaching and Learning Effects No findings Could not find publications Unsuccessful follow-up with PI
6. Publications None found	

1. Award Title(s) and Numbers National Digital Library for Technological Literacy (0121650)	
2. PI(s) and Organization Sterry, Len, International Technology and Engineering Educators Association	3. Funding Track, Award Amount, and Award Dates Collection; \$893,277; 9/15/01–8/31/04
4. Text in the Abstract That Suggests Teaching or Learning “Field testing of the collection and its services is being undertaken with diverse groups of users to evaluate ease of navigation and discovery of content-rich, pedagogically sound resources.”	5. Findings on Teaching or Learning Effects No findings Could not find publications Unsuccessful follow-up with PI
6. Publications None found	

<p>1. Award Title(s) and Numbers A Digital IdeaKeeper for K–12: NSDL Scaffolded Portal Services for Information Analysis and Synthesis (0226241)</p>	
<p>2. PI(s) and Organization Quintana, Christopher, University of Michigan Ann Arbor</p>	<p>3. Funding Track, Award Amount, and Award Dates Services-O; \$473,798; 10/1/02–9/30/06</p>
<p>4. Text in the Abstract That Suggests Teaching or Learning “This project addresses the needs to . . . (2) deploy versions of IdeaKeeper in Detroit middle school classrooms to assess the impact of such supportive digital library services on learning.”</p>	<p>5. Findings on Teaching or Learning Effects Study: Evaluated the effects of using IdeaKeeper for online digital-library use compared with students who used only the digital libraries, using screen capture of computer use, audio recordings, web metrics, web projects and digital artifacts, and observation. Findings: Students who use IdeaKeeper to browse online might engage in more cognitive thinking than students who do not. However, results are stated as-is in publication, and statistics and supporting data are not provided.</p>
<p>6. Publications [1] C. Quintana, M. Zhang, and J. Krajcik, “A Framework for Supporting Metacognitive Aspects of Online Inquiry Through Software-Based Scaffolding,” <i>Educational Psychologist</i>, Vol. 40, No. 4, 2005, pp. 235–244. [2] C. Quintana and M. Zhang, “IdeaKeeper Notepads: Scaffolding Digital Library Information Analysis in Online Inquiry,” <i>Conference on Human Factors in Computing Systems</i>, New York: Association for Computing Machinery, 2004, pp. 1329–1332. [3] H. Chang and C. Quintana, “Student-Generated Animations: Supporting Middle School Students’ Visualization, Interpretation and Reasoning of Chemical Phenomena,” <i>Proceedings of the 7th International Conference on Learning Sciences</i>, International Society of the Learning Sciences, 2006, pp. 71–77. [4] C. Quintana, B. Reiser, E. Davis, J. Krajcik, E. Fretz, R. Duncan, E. Kyza, D. Edelson, and E. Soloway, “A Scaffolding Design Framework for Software to Support Science Inquiry,” <i>Journal of the Learning Sciences</i>, Vol. 13, No. 3, 2004, pp. 337–386.</p>	

1. Award Title(s) and Numbers Viewing the Future: Aligning Internet2 Video to K–12 Curriculum (0226323)	
2. PI(s) and Organization Mardis, Marcia, Merit Network	3. Funding Track, Award Amount, and Award Dates Collection; \$699,896; 10/1/02–9/30/05
4. Text in the Abstract That Suggests Teaching or Learning “The project is allowing teachers to attach feedback and contexts-of-use, and to place descriptive records for the Internet2 resources into Merit Network’s widely used and scalable Michigan Teacher Network (MTN).”	5. Findings on Teaching or Learning Effects No findings A review of publications suggested that this project did not study teaching or learning effects. Rather, this project surveyed educators about their ongoing use of videos in the classroom.
6. Publications M. Mardis, “Viewing Michigan’s Digital Future: Results of a Survey of Educators’ Use of Digital Video in the USA,” <i>Learning, Media and Technology</i> , Vol. 34, No. 3, September 2009, pp. 243–257.	

1. Award Title(s) and Numbers Effective Access: Using Digital Libraries to Enhance High School Teaching in STEM (0226483)	
2. PI(s) and Organization Hanson, Katherine, Education Development Center	3. Funding Track, Award Amount, and Award Dates Research; \$249,999; 10/1/02–2/28/05
4. Text in the Abstract That Suggests Teaching or Learning “This NSDL Targeted Research project is studying the use of networked digital resources by secondary school science, technology, engineering, and mathematics (STEM) teachers as they seek and select quality materials and tailor them to fit the learning environment of their classroom.”	5. Findings on Teaching or Learning Effects No findings A review of publications suggested that this project did not study teaching or learning effects. Rather, this project used focus groups, interviews, and surveys to understand how teachers already use digital resources.
6. Publications K. Hanson and B. Carlson, <i>Effective Access: Teachers’ Use of Digital Resources in STEM Teaching</i> , Gender, Diversity, and Technology Institute, Education Development Center, 2005.	

1. Award Title(s) and Numbers Infusing NSDL in Middle Schools: Obstacles and Strategies (0333632)	
2. PI(s) and Organization Hoffman, Ellen, Eastern Michigan University	3. Funding Track, Award Amount, and Award Dates Research; \$449,832; 10/1/03–9/30/07
4. Text in the Abstract That Suggests Teaching or Learning “Through surveys, experimental studies, focus groups, interviews, and observations of teacher activities in curricular development and classroom practice, the project is establishing a research foundation to successfully develop and deploy new K–12 resources within NSDL.”	5. Findings on Teaching or Learning Effects No findings A review of publications suggested that this project did not study teaching or learning effects. Rather, it focused on issues associated with digital libraries and the challenges of bringing them to the classroom.
6. Publications [1] M. Mardis and R. Payo, “Making the School Library Sticky: Digital Libraries Build Teacher-Librarians’ Strategic Implementation Content Knowledge in Science,” <i>Teacher-Librarian Seattle</i> , Vol. 34, No. 5, 2007, p. 8. [2] M. Mardis, E. Hoffman, and T. Marshall, “A New Framework for Understanding Educational Digital Library Use: Re-Examining Digital Divides in US Schools,” <i>International Journal on Digital Libraries</i> , Vol. 9, No. 1, 2008, pp. 19–27.	

1. Award Title(s) and Numbers Mobilizing Enduring NSDL Resources in Plate Tectonics Research for Earth Science Education (0333705)	
2. PI(s) and Organization Miller, Stephen, University of California, San Diego, Scripps Institute of Oceanography	3. Funding Track, Award Amount, and Award Dates Collection; \$608,795; 10/1/03–9/30/08
4. Text in the Abstract That Suggests Teaching or Learning “The project is also enabling the professional development of teachers through interactions with a local school district and 40 teachers nationwide who are attending two intensive summer workshops. This is followed up through mentoring during the subsequent implementation of the resources of the plate tectonics collection in the classroom.”	5. Findings on Teaching or Learning Effects No findings From communication with project staff, we learned that this project conducted a series of workshops several years ago that involved 24 teachers in total. Although they gathered daily feedback, there was no evaluation of effect on teaching practice.
6. Publications None found	

1. Award Title(s) and Numbers SIMPLE Science: Image-Based Learning Tools for K–12 Education (0333723)	
2. PI(s) and Organization Moore, Steven, Center for Image Processing in Education	3. Funding Track, Award Amount, and Award Dates Collection; \$396,203; 1/1/04–5/31/07
4. Text in the Abstract That Suggests Teaching or Learning “Schools, teachers, and districts from across the United States have been recruited to be testers for the project, representing a cross-section of the educators and students who can be expected to use the finalized system.”	5. Findings on Teaching or Learning Effects No findings Could not find publications Unsuccessful follow-up with PI
6. Publications None found	

<p>1. Award Title(s) and Numbers CoMPASS-DL: Design and Use of a Concept Map Interface for Helping Middle School Students Navigate Digital Libraries (0434624)</p>	
<p>2. PI(s) and Organization Puntambekar, Sadhana, University of Wisconsin—Madison</p>	<p>3. Funding Track, Award Amount, and Award Dates Research; \$435,655; 9/1/04–8/31/08</p>
<p>4. Text in the Abstract That Suggests Teaching or Learning “CoMPASS-DL is being used in middle schools in Wisconsin to understand the impact of digital libraries in classroom learning.”</p>	<p>5. Findings on Teaching or Learning Effects Study: Evaluated effects of using an “outline” versus “concept map” version of CoMPASS, a hypertext learning tool, in middle-school science classrooms. Findings: Results suggest that students using concept maps might have a greater understanding of interconnectedness between concepts but not factual knowledge. The differences are statistically significant. But the instrument used to measure interconnectedness might be overaligned with the concept-map intervention.</p>
<p>6. Publications [1] S. Puntambekar, “Learning from Digital Text in Inquiry-Based Science Classes: Lessons Learned in One Program,” <i>Proceedings of the 7th International Conference on Learning Sciences</i>, International Society of the Learning Sciences, 2006, pp. 564–570. [2] S. Puntambekar and J. Goldstein, “Effect of Visual Representation of the Conceptual Structure of the Domain on Science Learning and Navigation in a Hypertext Environment,” <i>Journal of Educational Multimedia and Hypermedia</i>, Vol. 16, No. 4, 2007, p. 429.</p>	

1. Award Title(s) and Numbers Teachers' Domain Pathways to Science: Rich-Media Sources for K–12 Teachers (0434813)	
2. PI(s) and Organization Sicker, Theodore, WGBH Educational Foundation	3. Funding Track, Award Amount, and Award Dates Pathways; \$2,849,133; 10/1/04–9/30/08
4. Text in the Abstract That Suggests Teaching or Learning “This initiative features . . . (3) dissemination, outreach, and support provided through digital pathways produced specifically for this target audience, including a professional development course, online workshops, classroom videos, and CD-ROM demonstrations, to [ensure] widespread distribution and informed use in schools.”	5. Findings on Teaching or Learning Effects Study: Assessed effects after one year of informal use of Teachers' Domain resources by elementary, middle, and high-school teachers and students. No comparison group. Findings: Effects on teacher practices (more use of video and inquiry) and increases in student interests are self-reported and not necessarily reliable. Pre/post test gains in achievement cannot be attributed to Teachers' Domain resources because there is no comparison group.
6. Publications [1] J. Schindel and W. Martin, <i>Teachers' Domain Earth and Space Science Final Evaluation Report</i> , WBGH, 2008.	

<p>1. Award Title(s) and Numbers Collaborative Research: DLConnect: Connecting Underserved Teachers and Students with NSDL Learning Resources and Tools (0435098) The Instructional Architect: A System for Discovering, Recommending, and Combining Learning Objects (0333818)</p>	
<p>2. PI(s) and Organization Mimi Recker, Utah State University; Marcia Mardis, Eastern Michigan University</p>	<p>3. Funding Track, Award Amount, and Award Dates Services-O, Services-W; multiple awards; multiple dates, approximately 9/1/03–8/31/06</p>
<p>4. Text in the Abstract That Suggests Teaching or Learning “The project is having a direct impact on 250 middle schools and a large number of middle school teachers within the service areas of the two universities.”</p>	<p>5. Findings on Teaching or Learning Effects Study: Assessed changes in teachers’ instructional practice and attitudes about online resources from participation in professional development workshops with Instructional Architect. Findings: Attitudes about online resources improved and teachers self-reported intentions to use Instructional Architect were high. Although teachers did make some use of Instructional Architect, actual changes in practice are largely unknown, and one study suggests that use might be limited and unsustainable.</p>
<p>6. Publications [1] M. Recker, S. Giersch, A. Walker, S. Halioris, X. Mao, and B. Palmer, “A Study of How Online Learning Resources Are Used,” <i>Proceedings of the 7th ACM/IEEE-CS Joint Conference on Digital Libraries</i>, New York: Association for Computing Machinery, 2007, pp. 179–180. [2] M. Recker, <i>NSF Annual Report for the Instructional Architect and DLConnect</i>, Utah State University, 2005. [3] M. Recker, “Instructional Architect, DLConnect, and Digital Libraries Go to School Evaluation Overview,” 2006.</p>	

1. Award Title(s) and Numbers Professional Development Institutes to Increase Afterschool Educators' Use of the NSDL (0532756)	
2. PI(s) and Organization Hsi, Sherry, Exploratorium	3. Funding Track, Award Amount, and Award Dates Services-W; \$649,999; 9/1/05–8/31/08
4. Text in the Abstract That Suggests Teaching or Learning “This project makes use of new curricular modules and existing STEM resources found in the Exploratorium digital library and the NSDL to create and offer professional development institutes for use by state and regional after school organizations.”	5. Findings on Teaching or Learning Effects Study: Evaluated the effects of a professional development related to the Exploratorium website on teacher attitudes about instructional practice. Findings: Participants expressed increased confidence in carrying out inquiry-based science, though statistics were not available.
6. Publications [1] S. Hsi, “Afterschool Survey: Compiled Results from Fairfield, Girl Scouts, Buchanan YMCA,” unpublished internal report, May 2006.	

1. Award Title(s) and Numbers Leadership Development for Technology Integration: Developing an Effective NSDL Teacher Workshop Model (0532796)	
2. PI(s) and Organization Klotz, Eugene, Drexel University	3. Funding Track, Award Amount, and Award Dates Services-S; \$650,000; 10/1/05–9/30/08
4. Text in the Abstract That Suggests Teaching or Learning “The project is directly engaging over 900 teachers of grades 5–9 over its three years, including teacher leaders and those who are not yet making use of technology in their classes.”	5. Findings on Teaching or Learning Effects No findings A review of publications suggested that this project did not study teaching or learning effects.
6. Publications None found	

1. Award Title(s) and Numbers Earth Exploration Toolbook Workshops to Facilitate the Use of Earth Science Data in Education (0532881)	
2. PI(s) and Organization Multiple, including McAuliffe, Carla, TERC	3. Funding Track, Award Amount, and Award Dates Services-W; \$684,884; 9/1/05–8/31/08
4. Text in the Abstract That Suggests Teaching or Learning “In this project, the use of Earth science data by students is being facilitated through [Earth Exploration Toolbook] Data Analysis Workshops: two-hour professional development experiences for teachers on using the NSDL, DLESE, and an [Earth Exploration Toolbook] chapter.”	5. Findings on Teaching or Learning Effects Study: Evaluated the effects that online professional development courses on the use of Earth Exploration Toolbooks had on intended instructional practice. Findings: In survey of intended changes in instructional practice, about 80% of the participants reported that they would use DLESE or the NSDL to find a teaching resource on a monthly, weekly, or daily basis. However, self-reported measures of intended teaching practices might be a weak indicator of actual changes in teaching practice.
6. Publications None found	

<p>1. Award Title(s) and Numbers Collaborative Research: A Comprehensive Pathway for K–Gray Engineering Education (0532922) (0532755) (0532808) (0532835) (0532709)</p>	
<p>2. PI(s) and Organization Multiple, including Agogino, Alice, University of California, Berkeley; Cyr, Martha, Worcester Polytechnic Institute; Tront, Joseph, Virginia Polytechnic Institute and State University; Ybarra, Gary, Duke University; Sullivan, Jacquelyn, CU-Boulder</p>	<p>3. Funding Track, Award Amount, and Award Dates Pathways; multiple awards; multiple dates, approximately 10/1/05–9/30/09</p>
<p>4. Text in the Abstract That Suggests Teaching or Learning “The K–Gray Engineering Education Pathway is having far-reaching impact by engaging K–12 communities and institutions of higher education, engineering professional societies, engineering research centers, NSF K–12 programs, and [Accreditation Board for Engineering and Technology]. Key elements of the evaluation plan include a community-based needs analysis, definition and collection of usage metrics, and mid-term and final evaluations.”</p>	<p>5. Findings on Teaching or Learning Effects No findings A review of publications suggested that this project did not study teaching or learning effects.</p>
<p>6. Publications [1] A. Agogino and M. Smith, “Broadening Participation in Computing with the K–Gray Engineering Pathway Digital Library,” <i>Proceedings of the 8th ACM/IEEE-CS Joint Conference on Digital Libraries</i>, New York: Association for Computing Machinery, 2008, pp. 417–417. [2] J. F. Sullivan, M. N. Cyr, M. A. Mooney, R. F. Reitsma, N. C. Shaw, M. S. Zarske, and P. A. Klenk, “The <i>TeachEngineering</i> Digital Library: Engineering Comes Alive for K–12 Youth,” <i>American Society for Engineering Education Annual Conference and Exposition</i>, 2005.</p>	

1. Award Title(s) and Numbers Collaborative Project: The NSDL Curriculum Customization Service (0734872)	
2. PI(s) and Organization Sumner, Tamara, and Marlino, Mary, UCAR	3. Funding Track, Award Amount, and Award Dates Services-I; \$387,889; 1/1/08–3/31/10
4. Text in the Abstract That Suggests Teaching or Learning “This project is being conducted through a partnership of the university and UCAR with Digital Learning Sciences, the Denver Public Schools (DPS).”	5. Findings on Teaching or Learning Effects Pending: We conducted a case study and site visit of this project. Although teaching and learning effects are being studied, the project is currently under way, and results are not yet available.
6. Publications T. Sumner and J. Weatherley, “Fedora Goes to School: Experiences Creating a Curriculum Customization Service for K–12 Teachers,” 2009.	

1. Award Title(s) and Numbers The Science and Math Informal Learning Educators (SMILE) Pathway (0735007)	
2. PI(s) and Organization Porcello, Darrell, University of California, Berkeley	3. Funding Track, Award Amount, and Award Dates Pathways; \$2,247,001; 11/1/07–10/31/10
4. Text in the Abstract That Suggests Teaching or Learning “Project staff are creating professional development programs and a robust online community of educators and content experts to showcase best practices tied to digital resources.”	5. Findings on Teaching or Learning Effects No findings Could not find publications Unsuccessful follow-up with PI
6. Publications None found	

1. Award Title(s) and Numbers Where Have We Come From and Where Are We Going? Learning the Lessons and Disseminating Exemplary Practices from the Projects of the NSDL (0737821)	
2. PI(s) and Organization Muramatsu, Brandon, Utah State University	3. Funding Track, Award Amount, and Award Dates Research; \$89,974; 9/1/07–2/28/09
4. Text in the Abstract That Suggests Teaching or Learning “This project is creating an open knowledge collection of promising practices and lessons learned from the work to date on the development of NSDL.”	5. Findings on Teaching or Learning Effects No findings A review of publications suggested that this project did not study teaching or learning effects.
6. Publications None found	

1. Award Title(s) and Numbers Project Tomorrow Test Drive (no award number)	
2. PI(s) and Organization Smith, Laurie, Project Tomorrow	3. Funding Track, Award Amount, and Award Dates Not applicable
4. Text in the Abstract That Suggests Teaching or Learning Not applicable	5. Findings on Teaching or Learning Effects Study: Evaluated the teachers' use of NSDL resources in the classroom. Teachers participated in professional development at the start of the school year and were asked to select seven to ten NSDL resources for use in the classroom. A survey of teachers' self-reported changes in instructional practice, attitudes, and students' achievement showed general enthusiasm and belief that the resources were beneficial for students attitudes and performance and supported independent study and various teaching styles. Detailed results were nuanced; teachers did not feel that resources were always appropriate or beneficial.
6. Publications [1] J. Evans, L. Smith, and A. Ford, "Project Testdrive Recap," internal report on project findings, January 15, 2009.	

APPENDIX E. NSDL TEACHING AND LEARNING STUDY SYNOPSIS

<p>1. Project Name Teachers' Domain Pathways to Science: Rich-Media Sources for K–12 Teachers</p>			
<p>2. Outcome Evaluated Teachers' instructional practice; student achievement and attitudes</p>			
<p>3. Method Summative evaluation of Teachers' Domain "Physical Science." Naturalistic study of outcomes after one year of informal and unstructured use of resources by a total of eight teachers (two high school, four middle school, two elementary) with a total of 483 students. No comparison group.</p>	<p>4. Data Collected Pre/post survey of changes in (1) teachers' instructional practice, (2) student attitudes and interests, and (3) pre/post test of student achievement.</p>	<p>5. Results/Effects Results were similar across all grade levels. Teachers report using more video and more inquiry and self-guided lessons. Students' interests in related areas increased; more than 70% attribute this increase to use of Teachers' Domain. Student achievement was assessed only for middle and high-school students. There was a statistically significant improvement in achievement for both groups.</p>	<p>6. Strengths/Weaknesses Strengths: - Evaluation involved a diverse group of teachers and students. Weaknesses: - Changes in teaching practice are self-reported, so reliability and size of change is uncertain. - Achievement instrument could be overaligned with Teachers' Domain resources. - The extent to which gains in students' achievement and greater interest are due to the Teachers' Domain resources versus natural gains through exposure to topic area, or other factors, is unknown.</p>
<p>7. Reference Publication A. Johnson, "Summative Evaluation Teachers' Domain: Physical Science," 2004.</p>			

<p>1. Project Name Collaborative Research: DLConnect: Connecting Underserved Teachers and Students with NSDL Learning Resources and Tools (0435098) The Instructional Architect: A System for Discovering, Recommending, and Combining Learning Objects (0085855)</p>			
<p>2. Outcome Evaluated Teachers' instructional practice and attitudes about online resources</p>			
<p>3. Method Evaluation of effects of two professional development workshops with 16 teachers for Instructional Architect. No comparison group.</p>	<p>4. Data Collected Pre/post survey of attitudes and intended changes in instructional practices; analysis of websites created by teachers and of web metrics</p>	<p>5. Results or Effects There was a slight increase (0.3 and 0.2 on Likert scale) in teachers' responses to "Online resources are important" and "Online resources make teachers' jobs easier." Intended behavior changes (post only) had high means—3.4 and 3.5, respectively—for "I will use [Instructional Architect]" and "I will tell others about [Instructional Architect]" Teachers did create Instructional Architect projects after the workshop, indicating some change in practice. Analysis of web metrics suggested that students might have accessed these projects as well.</p>	<p>6. Strengths and Weaknesses Strengths: - Use of web metrics offered some analysis of actual, rather than self-reported, changes in teaching behavior. Weaknesses: - It is unclear how extensively Instructional Architect was actually used to change teaching practice or what the eventual outcomes of use were (no follow-up). - Participants were self-selected.</p>
<p>7. Reference Publication M. Recker, A. Walker, S. Giersch, X. Mao, S. Halioris, B. Palmer, D. Johnson, H. Leary, and M. Robertshaw, "A Study of Teachers' Use of Online Learning Resources to Design Classroom Activities," <i>New Review of Hypermedia and Multimedia</i>, Vol. 13, No. 2, 2007, pp. 117–134.</p>			

<p>1. Project Name Collaborative Research: DLConnect: Connecting Underserved Teachers and Students with NSDL Learning Resources and Tools (0946444) The Instructional Architect: A System for Discovering, Recommending, and Combining Learning Objects (0085855)</p>			
<p>2. Outcome Evaluated Teachers' instructional practice</p>			
<p>3. Method Evaluation of IA use from (1) five professional development workshops with 100 teachers and (2) 50 teachers with no formal instruction on IA use. No comparison group.</p>	<p>4. Data Collected Survey of attitudes and intended behaviors; teachers' creation of websites and analysis of web metrics</p>	<p>5. Results or Effects Respondents across the workshops were positive about the quality of resources and the value of IA and the workshop and reported that they would recommend IA to other teachers. However, only a small portion of users created multiple or complex projects (1.3 per person), suggesting that there was not sustained use after the workshop.</p>	<p>6. Strengths and Weaknesses Strengths: - Use of web metrics offered some analysis of actual, rather than self-reported, changes in teaching behavior. Weaknesses: - No experimental design.</p>
<p>7. Reference Publication M. Recker, J. Dorward, D. Dawson, Y. Liu, X. Mao, and B. Palmer, "You Can Lead a Horse to Water: Teacher Development and Use of Digital Library Resources," <i>Proceedings of the 5th ACM/IEEE-CS Joint Conference on Digital Libraries</i>, 2006, pp. 1–8.</p>			

1. Project Name Earth Exploration Toolbook Workshops to Facilitate the Use of Earth Science Data in Education (0532881)			
2. Outcome Evaluated Teachers' instructional practice			
3. Method Evaluation of online professional development courses on the use of Earth Exploration Toolbooks. In sum, approximately 200 teachers and administrators participated in the 17 total courses.	4. Data Collected Survey of intended changes in instructional practice	5. Results or Effects 45% of the participants reported that they would use DLESE or the NSDL to find a teaching resource on a weekly or daily basis. Another third (34%) predicted that they would visit these sites at least monthly.	6. Strengths and Weaknesses Weaknesses: - Self-reported measures of intended teaching practices might be a weak indicator of actual changes in teaching practice.
7. Reference Publication T. S. Ledley, L. Dahlman, C. McAuliffe, and N. Haddad, "The Earth Exploration Toolbook: Facilitating Access to Scientific Data and Tools," <i>Journal of Geoscience Education</i> , Vol. 54, No. 3, 2006, pp. 223–229.			

1. Project Name Professional Development Institutes to Increase Afterschool Educators' Use of the NSDL (0532756)			
2. Outcome Evaluated Teachers' attitudes about instruction			
3. Method Evaluation of professional development related to the Exploratorium website (N ≈ 60)	4. Data Collected Pre/post survey	5. Results or Effects Participants' confidence in carrying out inquiring-based science increased (statistics not available).	6. Strengths and Weaknesses Weaknesses: - No statistical analysis of results - Measure of attitude, not practice
7. Reference Publication S. Hsi. "Afterschool Survey: Compiled Results from Fairfield, Girl Scouts, Buchanan YMCA," unpublished, May 2006.			

<p>1. Project Name CoPASS-DL: Design and Use of a Concept Map Interface for Helping Middle School Students Navigate Digital Libraries</p>			
<p>2. Outcome Evaluated Student achievement</p>			
<p>3. Method Evaluated effects of using CoPASS, a hypertext learning tool, in middle-school science classrooms. Compared the effect of CoPASS outline format with that of the concept-map format on student learning in two studies, one with 36 eighth-grade students using it for three days and another with 80 sixth-grade students using it for seven weeks. In both cases, half used the text format, half used the concept map. There was no comparison with students who did not use CoPASS.</p>	<p>4. Data Collected Pre/post test with multiple choice to test factual knowledge, open-ended questions for reasoning, and concept-mapping questions</p>	<p>5. Results or Effects In both groups, students using concept maps outperformed those using outlines on the concept-mapping exercises (suggesting greater understanding of interconnectedness between concepts) but not on factual knowledge. The differences are statistically significant.</p>	<p>6. Strengths and Weaknesses Strengths: - Measures student achievement rather than attitudes Weaknesses: - Concept-map exercise might be overly aligned with concept-map tool.</p>
<p>7. Reference Publication S. Puntambekar, "Learning from Digital Text in Inquiry-Based Science Classes: Lessons Learned in One Program," <i>Proceedings of the 7th International Conference on Learning Sciences</i>, International Society of the Learning Sciences, 2006, pp. 564–570. S. Puntambekar and J. Goldstein, "Effect of Visual Representation of the Conceptual Structure of the Domain on Science Learning and Navigation in a Hypertext Environment," <i>Journal of Educational Multimedia and Hypermedia</i>, Vol. 16, No. 4, 2007, p. 429.</p>			

1. Project Name Project Tomorrow Test Drive (no award number)			
2. Outcome Evaluated Teachers' instructional practice; student achievement and attitudes			
3. Method Evaluated the teachers' use of NSDL resources in the classroom. Teachers participated in professional development at the start of the school year and were asked to select seven to ten NSDL resources for use in the classroom. Thirty-six teachers and 1,418 students were recruited. Response rate is unclear.	4. Data Collected Survey of teachers' self-reported changes in instructional practice, attitudes, and students' achievement.	5. Results or Effects There were multiple items for many of these issues, and results were nuanced. We present some highlights. Student achievement: Teachers reported that resources challenged students to engage in higher-order thinking (~85%), motivated students (~80%), and helped develop students' content understanding (~90%). Teaching practices: Teachers also reported that resources supported independent study (85%) and group study (60%) and work with a variety of learning styles (86%), but not as well for special needs or English-language-learning students (46% and 31%, respectively). Some teachers said they would incorporate the NSDL into the teaching curriculum (57%) and that they learned new strategies for engaging students (43%).	6. Strengths and Weaknesses Strengths: Used NSDL resources in a natural classroom setting. Weaknesses: All self-reported measures. Not indicative of actual or sustained effects.
7. Reference Publication J. Evans, L. Smith, and A. Ford, "Project TestDrive Recap," unpublished report, January 15, 2009.			

1. Project Name A Digital IdeaKeeper for K–12: NSDL Scaffolded Portal Services for Information Analysis and Synthesis			
2. Outcome Evaluated Student achievement			
3. Method Evaluated the effects of using IdeaKeeper for online digital-library use compared with students who used only the digital libraries. Participants were four eighth-grade science classes (N = 47), taught by two teachers. Two classes (N = 22) used the full IdeaKeeper environment, while another two classes (N = 25) did not. The project lasted three to five days.	4. Data Collected Screen capture of computer use, audio recordings, web metrics, web projects and digital artifacts, and observation	5. Results or Effects Researchers report that the IdeaKeeper students spent more time on higher-level cognitive activities (i.e., reading, note taking, discussing, writing, reflecting, and synthesizing information) than students who used only the online digital libraries.	6. Strengths and Weaknesses Strengths: - Used observed behaviors for analysis Weaknesses -Statistical measures not provided
7. Reference Publication M. Zhang and C. Quintana, "Facilitating Middle School Students' Sense Making Process in Digital Libraries," <i>Proceedings of the 5th ACM/IEEE-CS Joint Conference on Digital Libraries</i> , June 2005, pp. 19–20.			

APPENDIX F. USABILITY STUDIES

As described in Chapter Six, we designed and piloted a usability study to understand the potential value of the NSDL for teachers. This appendix presents

- related work in the field of usability testing in general and usability in the NSDL in particular
- our design and protocol for the usability study
- a copy of the usability instrument
- the detailed results of the pilot trial, including the websites that users found, their comments after the task, and comments during the group discussion.

RELATED WORK

Background on Usability Trials

The International Organization for Standardization defines *usability* as “the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (1998). As this definition suggests, the usability of a product (e.g., a table saw) may not be the same for different type of users (e.g., hobbyists versus professional carpenters) or for different types of objectives (e.g., cutting straight planks versus complex curves).

There are a number of frameworks to describe what constitutes usability (see Jeng, 2005a, for a review). For example, Booth (1989) suggests that usability consists of usefulness, effectiveness, learnability, and user attitude; Nielsen (1994) similarly argues that it is learnability, efficiency, memorability, low error rate or easy recovery, and user satisfaction. The common theme among these frameworks is that usability consists of both the objective and subjective user experience:

- Objective aspects of usability address the question “How well was the user able to complete the task?” As Booth (1989), Nielsen (1994), and other researchers suggest, this can include how quickly the user learned to use the product, how quickly task was completed, whether it was performed correctly, what kinds of errors were made, and what the consequences of those errors were.

- Subjective aspects of usability address the question “How did the user feel about using the product?” This includes the look and feel of the tool, as well as users’ *attitudes* about the objective elements, e.g., how did they *feel* about the time required to learn or use the tool or about the end result or outcome?

Evaluating and understanding usability can be critical to improving the product’s value and effectiveness and, ultimately, to ensuring that the product meets its intended purpose. There are two broad categories of usability evaluation: inspection and testing. Usability inspection involves experts (rather than end users) who assess the usability of a product by inspecting its design, determining its conformance to design principles, and conducting cognitive walkthroughs in which experts role play as users. While this is valuable at early stages of product design, it may be insufficient for assessing the true usability of a product.

In usability *testing*, on the other hand, potential users exercise the system with realistic objectives and in realistic contexts (Nielsen, 1994). Often, this is task based: Users are asked to perform specific, predetermined tasks that closely mimic ways in which the tools would be used in real settings. For digital libraries, usability testing typically involves such tasks as finding particular items or types of items in the library (e.g., a particular eBook, or any eBook on a particular topic), finding information about items (e.g., the year in which the eBook was published), and using those items (e.g., checking out the eBook and reading it) (Jeng, 2005b; Kim and Kim, 2008). Several types of data can be collected to assess usability, including web and computer logs of users’ activities, survey questions of users’ experiences, and focus group discussions (Jeng, 2005a).

Other Efforts to Assess NSDL Usability

There have been previous efforts to evaluate usability in the context of the NSDL. Sumner, Khoo, et al. (2003) conducted a usability study with K–Gray educators to understand their expectations and needs for digital resources that are to be used in the classroom, with the goal of shaping DLESE. They conducted five sessions with a total of 38 educators in which educators were asked to visit and rate the overall quality of specific websites for Earth science education, to provide open-ended explanations of their rating criteria, and to discuss their experiences in focus groups. This study offered

insights into educators' perceptions of quality, scientific accuracy, bias, advertising, design and usability, and other aspects of digital libraries.

Khoo (2006) conducted a usability study of the NSDL's search tool and search results page, which, based on previous assessment efforts, appeared to be a significant need and weak point of the NSDL.³⁰ Khoo asked participants to complete a series of simple search tasks using a paper prototype of the NSDL's search tool. Participants were asked to think aloud during the tasks and explain their experiences to an observing researcher, and then to complete a survey about the importance of various search features.

In an effort similar to Khoo's work, and as part of the evaluation reported here, we have outlined a design for assessing the effectiveness and usefulness of NSDL metadata using the framework of search tasks identified by IFLA: FISO. This is described in Chapter Five.

All of these efforts offer insights about NSDL usability. Nevertheless, their different purposes (assessing requirements of educational digital libraries in general and evaluating search tools and metadata in particular) suggest that the need for a general NSDL usability study remains.

STUDY DESIGN AND PROCEDURES

Our design of the usability study is shaped by the broad goal of understanding how the NSDL and its component Pathways and collections could support teachers and ultimately support teaching and learning. As described in the literature review, usability is ability of *specific* users to achieve *specified* goals. Therefore, our usability study must be designed to help teachers in a particular K–Gray level and subject area find particular kinds of resources that might vary by purpose, media type, granularity, and other factors.

Study Design

We chose an eighth grade scenario for the usability trials for several key reasons: middle school courses are important in making the transition to more advanced and

³⁰ Khoo (2006) reports that a few earlier NSDL usability evaluation studies had been undertaken, but these appear to have been informal, and the results were primarily for internal use and not published.

differentiated STEM learning in high school and beyond and are of increasing interest to the NSDL program; the development of an improved middle school Pathway presents an opportunity to explore whether there are usability differences as a function of grade-level orientation versus subject matter domain, in comparison to generic starting points, for acquiring good teaching resources; and eighth grade is of particular interest because TIMSS, NAEP, and other major learning assessments sample this middle school grade.

We sought to develop one usability instrument for middle school science and one usability instrument for middle school math, each of which would focus on a specific course unit. We used several criteria in selecting these units:

1. The unit must be part of a course that is typically required for middle school students.
2. The unit must be associated with learning objectives that typically are part of states' science standards for that course.
3. There must be a Pathway dedicated to that course unit.
4. There must sufficient and diverse resources addressing that unit in the chosen Pathway and in nsdl.org.

The first two criteria help ensure that the study broadly represents the needs and practices of middle school teachers. The last two ensure that the topic is well represented so that a usability trial is feasible and appropriate and so that we can design diverse and realistic tasks for participants to complete. These criteria also ensure that we can compare grade-oriented Pathways (namely, MSP2, which focuses on all STEM topics taught in middle school), subject-oriented Pathways (which vary based on the subject chosen), and nsdl.org.

We further wanted to determine whether the NSDL or the Pathways are better at meeting certain types of needs over others, and we therefore sought to design the usability study with several tasks that would cover a wide range of resources that teachers might seek. Specifically, we sought diversity in resource content, media type, and granularity. This led to a general framework for the usability instruments, in which each instrument would include the following four classes of search tasks:

- static text and images, for teachers seeking to improve their students' or their own content knowledge

- animations, videos, and interactive classroom activities, for teachers seeking to supplement textbook material with engaging and dynamic resources and activities
- complete lesson plans, for teachers seeking resources with more context
- social science material, for teachers seeking to provide a social context for math and science topics.

This array of tasks further clarified the requirements for “sufficient and diverse resources” as described in criterion 4.

With these requirements in mind, we reviewed several middle school math and science state standards and developed a candidate list of course and unit areas. In science, we considered fossils and plate tectonics units in earth science and a mitosis unit in a life science; in math, we considered the Pythagorean theorem, areas and volumes, and angles units in plane geometry. We then examined the quantity and diversity of resources (as defined by the task framework) for each of these topics in the NSDL, in MSP2, and in their subject-matter portals: DLESE for earth science, BEN for life science, and MathDL for plane geometry.

Of the three science areas—fossils, plate tectonics, and mitosis—we found that only plate tectonics was sufficiently represented in the NSDL, MSP2, and DLESE. None of the three math areas—Pythagorean theorem, areas and volumes, or angles—was sufficiently represented in the NSDL, MSP2, and MathDL. We informally broadened our search to include other possible topics but again found that the resources were limited—in particular, in MSP2 and in MathDL. Given the time constraints of conducting the pilot trial, we therefore opted to continue with the plate tectonics usability trial only, with the hope that a math trial could be developed during a future phase of research.

Study Protocol

Our design of the complete survey instrument and study protocol is based on the usability frameworks developed in the literature and our task framework and design decisions. This usability study is computer based, with each participant using a computer and completing tasks independently. The instructions, tasks, and responses are all presented and collected online through a single SurveyMonkey interface. A copy of the online study is included below.

At the start of the study, participants are randomly assigned to one of the four websites selected for comparison: nsdl.org, DLESE.org, MSTeacher2.org (MSP2's website), or Google.com. Then, participants are asked to imagine that they are eighth grade science teachers seeking good online resources with which to build a lesson plan that introduces students to plate tectonics. They are subsequently led through a series of search tasks—one practice task to gain familiarity with the website and four real tasks—in which they must find specific types of resources and document the URLs by starting with their assigned websites. Each task is given a fixed amount of time, and, after each of the four real tasks, the participants are asked a series of five questions about their experiences on the task. At the end of all tasks, they are asked to answer five additional questions about the experience as a whole. Overall, this procedure requires approximately one hour.

To more closely simulate the goals and constraints of real teachers—the need for high quality resources and limited time to find them—we encourage participants to find good resources and best examples, give them the option of indicating that they found no suitable resources, and require them to remain on a task until the full time has expired. Chapter Six provides a complete account of how this protocol was used in the pilot trials.

USABILITY STUDY INSTRUMENT

In this section, we present the usability study instrument constructed on SurveyMonkey. Note that each image in Figures F.1–F.12 is a different page from the survey.

NSDL Usability Study

Fossils Practice Task

We'll start first with a quick practice task designed to familiarize you with the process of finding educational materials on your assigned website. You have 5 minutes for this practice task.

1. Open a new browser window (e.g., in Firefox or Internet Explorer) and go to your website.
2. Starting from this website, find some instructive material about fossils appropriate for 8th graders. This can be an image, some explanatory text, or both — anything that fits the request.

Please note that the website you have been assigned is a portal to other websites and content. While you should always start at the assigned website, the resources you ultimately find may be from linked sites.

3. Once you have found a web page about fossils, please copy the web address (URL) into the box below on the left. The web address will almost always begin with `http://` and can be found at the top of your browser.
4. Add the title of the web page in the box below on the right.
5. Then click the "Next" button.

1. Resource Web Page URLs
(write each URL on a new line)

2. Resource Web Page Titles
(write each title on a new line)

Figure F.1 NSDL Usability Study: Fossils Practice Task

NSDL Usability Study

Scenario and Instructions

Scenario: You are an 8th grade science teacher and your class is studying earth science. Your students have studied fossils and layers in the earth and your next lesson introduces plate tectonics and the movement of continents. You are trying to put together a lesson plan built with good online resources for your students.

Instructions: In this exercise, you will perform four tasks aimed at finding online resources that could contribute to such a lesson plan. For each task, start at your website. Spend the entire allotted time finding the best examples you can of the online resources described in the task instructions. For each resource that you are satisfied with, please copy and paste its web page's URL (web address) in the box titled "Resource Web Page URLs." Please also write the title of the web page in the box titled "Resource Web Page Titles." If in the allotted time you have not found any resources that you are satisfied with, please write "No Resources Found" in the first box.

When a task's time has expired (as indicated by the study administrator), please click "Submit Resources" and move on to rate the tasks and results. When all four tasks are complete, you will answer a few final questions and then submit the exercise.

Figure F.2 NSDL Usability Study: Scenario and Instructions

NSDL Usability Study

Task 1: Finding Text and Images

Task: Go to your assigned website and spend 8 minutes finding good material (text + image) that introduces students to the basic concept of plate tectonics.

Remember, please stay on this task until prompted to move on by the administrator.

1. Resource Web Page URLs
(write each URL on a new line)

2. Resource Web Page Titles
(write each title on a new line)

Figure F.3 NSDL Usability Study: Task 1

NSDL Usability Study

Task 2: Finding Interactive Resources

Task 2: Go to your assigned website and spend 10 minutes finding
(1) a good video or animation that illustrates to students the concept of plate tectonics, and
(2) an interactive activity that students can do, either online or in the classroom, to reinforce any of these concepts.

Note that there are two sets of answer boxes: one for the video/animation and one for the activity.

Remember, please stay on this task until prompted to move on by the administrator.

1. Resource Web Page URLs for Video/Animation
(write each URL on a new line)

2. Resource Web Page Titles for Video/Animation
(write each title on a new line)

3. Resource Web Page URLs for Interactive Activity
(write each URL on a new line)

Figure F.5 NSDL Usability Study: Task 2

NSDL Usability Study

4. Resource Web Page Titles for Interactive Activity
(write each title on a new line)





Figure F.6 NSDL Usability Study: Task 2, Continued

NSDL Usability Study


Task 3: Finding Entire Lesson Plans

Task: Spend 5 minutes finding a good lesson plan to teach 8th graders about the Ring of Fire.
Remember, please stay on this task until prompted to move on by the administrator.

1. Resource Web Page URLs
(write each URL on a new line)



2. Resource Web Page Titles
(write each title on a new line)



NOTE: This was the task that was subsequently dropped.

Figure F.8 NSDL Usability Study: Dropped Task 3


NSDL Usability Study

Task : Bringing in the History of Science

Task: Spend 8 minutes finding materials (text) for students about how the theory of plate tectonics was discovered or a biography of the person who discovered it.

Remember, please stay on this task until prompted to move on by the administrator.

1. Resource Web Page URLs
(write each URL on a new line)



2. Resource Web Page Titles
(write each title on a new line)




Figure F.10 NSDL Usability Study: Task 3

NSDL Usability Study

Final Questions

Now we'd like to ask you to evaluate your overall experience with these activities.

- 1. How do you rate the overall quality of the resources you've located for teaching plate tectonics for 8th graders?**

not at all high quality somewhere in between very high quality

Choose:
- 2. How do you rate the overall effectiveness of your assigned website for finding good resources for this purpose?**

not at all effective somewhere in between very effective

Choose:
- 3. By the end of this task, how confident are you that you've found enough resources to build a complete lesson?**

not at all confident somewhere in between very confident

Choose:
- 4. Would you be likely to recommend your assigned website to a middle school teacher attempting to build or supplement a unit on plate tectonics with these online materials?**

not at all likely somewhere in between very likely

Choose:
- 5. Would you be likely to recommend your assigned website to a middle school curriculum coordinator attempting to revitalize or supplement the school's curriculum in plate tectonics with these online materials?**

not at all likely somewhere in between very likely

Choose:
- 6. If you have additional comments, enter them below.**

Figure F.12 NSDL Usability Study: Final Questions

F.4 Results in Detail

Chapter Six summarizes the results of the pilot trial and describes the overall conclusions. Here, we provide the detailed objective and subjective responses from the pilot trial. This includes the resources that participants found, their open-ended comments about the tasks during the trial, and their comments in the group discussion. The URLs and open-ended written comments are organized by pilot trial part (task 1, task 2a, task 2b, task 3, and final comments) and site (Google, the NSDL, DLESE, and MSP2). The group discussion comments are provided next and are also organized by site.

Note that, where URLs are reported, if multiple users found the same site, that site is listed only once, but the number in parentheses after that URL indicates how many users found that particular site. No number appears when only one user found the site. This notation is used throughout this section. A similar notation is used if more than one user made the same comment.

F.4.1 Task 1 (Text + Image) Resources and Comments

F.4.1.1 Resources and Comments from Google Users in Task 1

Google users collectively found the following resources:

- http://en.wikipedia.org/wiki/Plate_tectonics
- <http://faculty.kutztown.edu/friehauf/plate-tectonics.jpg>
- <http://geology.com/nsta/> (3)
- <http://msteacher.org/epubs/science/science1/science.aspx>
- <http://nat704.wordpress.com/2008/11/26/evidence-for-plate-tectonics/>
- <http://pubs.usgs.gov/gip/dynamic/dynamic.html> (3)
- <http://quizlet.com/33337/vocabulary-volcanoes-earthquakes-plate-tectonics-and-fossils-flash-cards/>
- <http://school.discoveryeducation.com/lessonplans/programs/continentaldrift/>
- <http://science.pppst.com/platetectonics.html>
- <http://scign.jpl.nasa.gov/learn/plate.htm>
- <http://sites.google.com/a/st-ignatius-edu.org/bcake/8th-grade-science/plate-tectonic-unit>
- http://volcano.oregonstate.edu/education/vwlessons/plate_tectonics/plate_activities.html
- <http://www.cotf.edu/ete/modules/mseese/earthsysflr/plates1.html> (2)

- <http://www.enchantedlearning.com/subjects/astronomy/planets/earth/Continents.shtml> (2)
- http://www.encyclopedia.com/topic/plate_tectonics.aspx
- <http://www.geologyshop.co.uk/platet~1.htm>
- <http://www.kidsgeo.com/geology-for-kids/0043-plate-tectonics.php>
- <http://www.le.ac.uk/geology/art/gl209/lecture3/lecture3.html>
- <http://www.learner.org/interactives/dynamicearth/drift.html>
- <http://www.pbs.org/wgbh/aso/tryit/tectonics/index.html>
- <http://www.pbs.org/wgbh/aso/tryit/tectonics/shockwave.html> (2)
- <http://www.scotese.com/earth.htm>
- <http://www.ucmp.berkeley.edu/fosrec/Metzger2.html>
- <http://www.ucmp.berkeley.edu/geology/tectonics.html> (3)
- <http://www.williamsclass.com/SixthScienceWork/PangeaProject.htm>
- www.pctechmaui.com/MrsG/Calendar/Plate_Tectonics.pdf.

Google users made the following comments in response to task 1:

Discernment required to establish the validity of each source found using Google.

There is a lot of fluff to search through. For the novice Earth and Space person I assume it might be more difficult than a person who has a geology background.

I've done something similar to this in the past and once I looked at the documents wasn't too happy with my findings.

F.4.1.2 Resources and Comments from NSDL Users in Task 1

NSDL users collectively found the following resources:

- <http://cddis.nasa.gov/926/slrrecto.html>
- <http://msteacher.org/epubs/science/science1/background.aspx>
- <http://pubs.usgs.gov/gip/dynamic/understanding.html>
- http://www.amnh.org/ology/earth#features/bigideas_earth?TB_iframe=true&height=590&width=765
- http://www.classzone.com/books/earth_science/terc/content/visualizations/es0804/es0804page01.cfm?chapter_no=visualization
- <http://www.cotf.edu/ete/modules/msese/earthsysflr/plates1.html>
- <http://www.k12science.org/curriculum/musicalplates3/en/index.shtml>
- <http://www.moorlandschool.co.uk/earth/>
- <http://www.pbs.org/wgbh/aso/tryit/tectonics/>

- http://www.sio.ucsd.edu/voyager/earth_puzzle/puzzle_together.html
- http://www.teachersdomain.org/asset/ess05_vid_wegener2/
- http://www.visionlearning.com/library/module_viewer.php?mid=65
- http://www.windows.ucar.edu/tour/cool_stuff/tour_surface_earth_1.html.

NSDL users made the following comments in response to task 1:

The Titles should have had Topics tied to them so that you could glance through quickly [without] having to read an entire paragraph.

You really had to sift through the links that came up and find material that was appropriate. It was a laborious process.

F.4.1.3 Resources and Comments from Digital Library for Earth System Education Users in Task 1

DLESE users collectively found the following resources:

- http://astroventure.arc.nasa.gov/teachers/geo_train.html#1
- http://earthquake.usgs.gov/learn/topics/plate_tectonics/rift_man.php
- <http://library.thinkquest.org/17701/high/tectonics/>
- <http://pubs.usgs.gov/gip/dynamic/understanding.html>
- <http://web.ics.purdue.edu/~braile/edumod/foammod/foammod.htm>
- http://www.classzone.com/books/earth_science/terc/content/visualizations/es0808/es0808page01.cfm?chapter_no=visualization
- <http://www.dlese.org/library/query.do?q=FOSSILS%20AND%20TECTONICS&s=0>
- <http://www.nature.nps.gov/geology/usgsnps/pltec/pltec1.html>
- http://www.sio.ucsd.edu/voyager/earth_puzzle/
- http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.lp_platetectonics/
- <http://www.tomsnyder.com/products/product.asp?SKU=SSKHID>
- <http://www.ucmp.berkeley.edu/geology/anim1.html>
- <http://www.ucmp.berkeley.edu/geology/tectonics.html> (2)
- <http://zebu.uoregon.edu/1996/ph123/l13a.html>.

DLESE users made the following comments in response to task 1:

If I had more time, I would have been able to really use the search engine options.

I noticed that the first time I spelled *tectonics* I spelled it in correctly, but it
[unfinished comment]

There seemed to be a nice variety of different academic levels to choose from concerning the information. Some had more text and appeared to be geared

more toward college level students. But others had more images and clips, which would be more helpful for high school students.

The website was easy to navigate and narrow the search parameters for what I was looking for; however, I was dissatisfied with the quality of the resources.

F.4.1.4 Resources and Comments from MSP2 Users in Task 1

MSP2 users collectively found the following resources:

- <http://csmres.jmu.edu/geollab/Fichter/PlateTect/synopsis.html>
- <http://msteacher.org/epubs/science/science1/science.aspx>
- <http://pubs.usgs.gov/gip/dynamic/dynamic.html> (4)
- <http://scign.jpl.nasa.gov/learn/plate2.htm>
- <http://web.vims.edu/bridge/archive0902.html?svr=www> (2)
- http://wiki.nsdl.org/index.php/MiddleSchoolPortal/Plate_Tectonics:_Moving_Middle_School_Science
- http://www.classzone.com/books/earth_science/terc/content/visualizations/es0804/es0804page01.cfm?chapter_no=visualization (2)
- http://www.sio.ucsd.edu/voyager/earth_puzzle/ (2)
- http://www.windows.ucar.edu/tour/link=/teacher_resources/teach_snacktectonics.html (2).

MSP2 users made the following comments in response to task 1:

This was much better for text than images. It would be easier to go without a proper textbook when using this site.

I liked that there were both teacher and student resources available.

At times the site led me to links that were not available to be seen and gave me error messages. This is frustrating as what the link described seemed like a good resource but there was nothing to view when I clicked on the link. This site should remove links that no longer are active.

Search bar on the main page gives no results. User has to first locate the “search” tab before they can search. Slightly confusing!

F.4.2 Task 2 (Video, Animation, and Interactive Activity) Resources and Comments

F.4.2.1 Resources and Comments from Google Users in Task 2

Google users collectively found the following resources for part A:

- <http://dsc.discovery.com/videos/understanding-volcanoes-plate-tectonics.html>
- <http://ettc.lrhdsd.org/archives/pangaea.shtml>

- <http://msteacher.org/epubs/science/science1/animations.aspx>
- <http://science.discovery.com/videos/100-greatest-discoveries-shorts-plate-tectonics.html> (3)
- <http://scign.jpl.nasa.gov/learn/plate4.htm>
- <http://video.yahoo.com/watch/1595682/5390276>
- <http://videos.howstuffworks.com/hsw/21687-plate-tectonics-volcanoes-and-earthquakes-video.htm>
- http://www.classzone.com/books/earth_science/terc/content/visualizations/es0808/es0808page01.cfm?chapter_no=visualization
- <http://www.scotese.com/pangeanim.htm>
- http://www.ucmp.berkeley.edu/geology/tecall1_4.mov
- <http://www.wwnorton.com/college/geo/egeo/animations/ch2.htm>
- <http://www.youtube.com/watch?v=ANeH9W-HMPc>
- <http://www.youtube.com/watch?v=ft-dP2D7QM4> (2)
- <http://www.youtube.com/watch?v=ZLJLFYXp-0Q>.

Google users collectively found the following resources for part B:

- <http://ettc.lrhdsd.org/archives/pangaea.shtml>
- <http://www.cotf.edu/ete/modules/mse/earthsysflr/plates1.html>
- <http://www.enchantedlearning.com/subjects/astronomy/activities/radiobuttonquiz/Tectonicspz.shtml>
- <http://www.k12science.org/curriculum/musicalplates3/en/index.shtml>
- <http://www.learner.org/interactives/dynamicearth/drift.html>
- <http://www.pbs.org/wgbh/aso/tryit/tectonics/#> (2)
- <http://www.purposegames.com/game/1806>
- http://www.sio.ucsd.edu/voyager/earth_puzzle/
- www.amnh.org/education/resources/rfl/pdf/dinos_plate_tectonics.pdf.

Google users made the following comments in response to task 2:

Too many commercials at the beginning of each video.

Video were easier to come by and easier to validate as legitimate . . . resources. . . [A]ctivities took longer to validate and were not as easy to come by. . . [O]verall I was pretty satisfied with the results.

It was more difficult to find appropriate animations or interactive activities than it was to find text and image resources.

More difficult. Easier when have experience with certain sites like [D]iscovery [E]ducation.

Not sure if I'm just getting better or not but I found this search much easier.

Would be easier if this was in my content area. I feel like I didn't know if it fit what I was trying to accomplish.

I think I could have found more good videos/animations had I spent less time looking for activities, as well. I tried to split the time I spent looking between videos and activities, but it was less easy to find good activities.

F.4.2.2 Resources and Comments from NSDL Users in Task 2

NSDL users collectively found the following resources for part A:

- <http://emvc.geol.ucsb.edu/download/pacnorth.php>
- <http://oceanexplorer.noaa.gov/explorations/03fire/logs/subduction.html>
- http://www.classzone.com/books/earth_science/terc/content/visualizations/es0904/es0904page01.cfm?chapter_no=visualization (3)
- http://www.hsdvl.org/video.php?record_serial=1736
- <http://www.pbs.org/wgbh/aso/tryit/tectonics/intro.html>
- <http://www.pbs.org/wgbh/nova/ice/continents/>
- http://www.teachersdomain.org/asset/ess05_vid_wegener2/ (2)
- http://www.ucmp.berkeley.edu/geology/tecall1_4.mov (2).

NSDL users collectively found the following resources for part B:

- <http://csmres.jmu.edu/geollab/Fichter/PlateTect/index.html>
- <http://earth.rice.edu/activities/earthupdate/activities/EUactivities/activity13.html>
- <http://web.vims.edu/bridge/archive0902.html?svr=www>
- http://www.amnh.org/ology/earth#features/plates?TB_iframe=true&height=500&width=750
- http://www.classzone.com/books/earth_science/terc/content/investigations/es0801/es0801page01.cfm?chapter_no=investigation
- <http://www.exploratorium.edu/origins/antarctica/ideas/gondwana2.html>
- <http://www.geosociety.org/educate/LessonPlans/SeaFloorSpreading.pdf>
- <http://www.le.ac.uk/geology/art/gl209/lecture1.html>
- <http://www.learner.org/interactives/dynamicearth/structure.html>
- <http://www.pbs.org/wgbh/aso/tryit/tectonics/#> (2)
- http://www.teachersdomain.org/asset/ess05_int_tectonic/
- http://www.windows.ucar.edu/tour/link=/teacher_resources/teach_snacktectonics.html.

NSDL users made the following comments in response to task 2:

In only ten minutes, I was really only able to become familiar with one site so time was a limitation. [T]here were other resources that I wanted to look at but couldn't.

Six of the 10 sites I tried to open did not work. Two of the websites said I had the wrong address and four of them would not load. It may have been the computer; I am not sure.

Again, you really have to take time and sift through the material to evaluate whether or not it's good and this takes some time because the search filter isn't very good at filtering.

I had trouble loading some pages. There were many links that [led] to a list of more links, which got a bit overwhelming.

F.4.2.3 Resources and Comments from Digital Library for Earth System Education Users in Task 2a

DLESE users collectively found the following resources for part A:

- <http://emvc.geol.ucsb.edu/downloads.php>
- http://www.teachersdomain.org/asset/ess05_vid_hawaii/ (5)
- <http://www.ucmp.berkeley.edu/geology/tectonics.html> (3).

DLESE users collectively found the following resources for part B:

- <http://web.ics.purdue.edu/~braile/edumod/foammod/foammod.htm> (2)
- <http://www.dnr.state.oh.us/Portals/10/pdf/HandsOn/HandsOn02.pdf> (2)
- <http://www.learner.org/interactives/volcanoes/activty1/tempmain.html>
- <http://www.math.montana.edu/~nmp/materials/ess/geosphere/inter/activities/exploration/index.html>
- <http://www.msnuceus.org/membership/html/k-6/pt/plate/4/ptpt4.html>
- <http://www.rsc.org/education/teachers/learnnet/jesei/onmove/index.htm>
- http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.lp_platetectonics/
- http://www.windows.ucar.edu/tour/link=/teacher_resources/teach_snacktectonics.html.

DLESE users made the following comments in response to task 2:

I liked having the drop down menu to refine my search.

I found it so much easier to find activities [than] video demonstrations.

Websites need to be added that are more teacher friendly.

I seemed to be stuck on just one website, and I felt like it was good, but I did not get to others. There may have been other better sites out there.

F.4.2.4 Resources and Comments from MSP2 Users in Task 2a

MSP2 users collectively found the following resources for part A:

- <http://scign.jpl.nasa.gov/learn/plate5.htm>

- http://www.classzone.com/books/earth_science/terc/content/visualizations/es0804/es0804page01.cfm?chapter_no=visualization (4)
- <http://www.pbs.org/teachers/connect/resources/4049/preview/>
MSP2 users collectively found the following resources for part B:
- <http://terra.rice.edu/plateboundary/home.html>
- <http://web.vims.edu/bridge/archive0902.html?svr=www> (2)
- <http://www.geosociety.org/educate/LessonPlans/SeaFloorSpreading.pdf>
- <http://www.k12science.org/curriculum/musicalplates3/en/index.shtml> (3)
- <http://www.learner.org/interactives/dynamicearth/drift2.html>
- <http://www.nationalgeographic.com/xpeditions/lessons/15/g912/ring.html>
- http://www.windows.ucar.edu/tour/link=/teacher_resources/teach_snacktectonics.html (2).

MSP2 users made the following comments in response to task 2:

Tab containing survey accidentally paged out, but work was complete. [T]hese comments correspond to findings on both activity one and two.

The things I found were ok but not great. Again, I think this site is best for text.

The animations that I found were very short, grainy, and not very educational.

Again, this site led me to a lot of inactive websites. Very frustrating! The small paragraphs the MSteacher2 site provides me with in the search tool sound so good and when I click the link it prompts me with an error message! Only active websites should be listed!!!

Not a lot of resources when it came to videos; only three came up when I searched them the way I normally would have.

F.4.3 Task 3 (Social Science) Resources and Comments

F.4.4.1 Resources and Comments from Google Users in Task 3

Google users collectively found the following resources:

- <http://earthobservatory.nasa.gov/Features/Wegener/> (2)
- http://en.wikipedia.org/wiki/Plate_tectonics (2)
- <http://library.thinkquest.org/17175/history.html>
- <http://pubs.usgs.gov/gip/dynamic/historical.html> (4)
- <http://scign.jpl.nasa.gov/learn/plate2.htm> (4)
- <http://www.enchantedlearning.com/subjects/dinosaurs/glossary/Pangaea.shtml>
- <http://www.extremescience.com/PlateTectonicsmap.htm>

- http://www.google.com/#q=Alfred+Wegener&hl=en&tbs=tl:1&tbo=u&ei=vMR5S72DGt3k8Aaz0YD0CQ&sa=X&oi=timeline_result&ct=title&resnum=20&ved=0CFEQ5wIwEw&fp=c5aa4278f68e4a4
- http://www.indiana.edu/~geol105/images/gaia_chapter_3/wegener.htm
- <http://www.pangaea.org/wegener.htm>
- <http://www.pbs.org/wgbh/aso/databank/entries/bowege.html> (2)
- <http://www.tulane.edu/~sanelson/geol111/pltect.htm>
- <http://www.ucmp.berkeley.edu/geology/techist.html> (4)
- http://www.visionlearning.com/library/module_viewer.php?mid=65
- <http://zebu.uoregon.edu/~soper/Earth/tectonics.html>.

Google users made the following comments in response to task 3:

Theory was a bit harder to come about. . . . [B]iographies on Alfred Wegener were fairly common and all seemed to be very similar. Overall, once again I was pretty satisfied.

Overall, it is very easy to find explanatory text. I may not use the whole text, but rather edit some of the text to use only the pieces I want.

F.4.3.2 Resources and Comments from NSDL Users in Task 3

NSDL users collectively found the following resources:

- <http://earthobservatory.nasa.gov/Features/Wegener/> (3)
- <http://pangaea.org/wegener.htm> (3)
- <http://pubs.usgs.gov/gip/dynamic/historical.html> (6)
- <http://volcano.oregonstate.edu/vwdocs/vwlessons/lessons/Pangea/Pangea1.html>
- http://www.amnh.org/education/resources/rfl/web/essaybooks/earth/p_hess.html
- <http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.wegener1/> (3)
- <http://www.ucmp.berkeley.edu/geology/techist.html> (3)
- http://www.visionlearning.com/library/module_viewer.php?mid=65
- oceanservice.noaa.gov/education.

NSDL users made the following comments in response to task 3:

I have been looking at titles and URLs for a while now and I know the name Wegener, so I knew what to look for and surprisingly there were several places where I could acquire information about him and his ideas in addition to the social perspective of the time in which he lived.

It took a few minutes to figure out the name of the man that made the theory, but after that I searched for his name and it was very easy.

Again, filtering wasn't what I'm used to on a search engine such as Google or any of the other popular search engines.

I found it difficult to find who I was looking for the person who discovered it.

F.4.3.3 Resources and Comments from DLESE Users in Task 3

DLESE users collectively found the following resources:

- <http://egov.oregon.gov/DSL/SSNERR/docs/EFS/EFS26platetect.pdf>
- <http://pubs.usgs.gov/gip/dynamic/wegener.html> (3)
- http://www.amnh.org/education/resources/rfl/web/essaybooks/earth/p_hess.html
- <http://www.dlese.org/library/query.do?q=harry%20hess%20&s=0&gr=05>
- <http://www.rsc.org/education/teachers/learnnet/jesei/onmove/students.pdf>
- <http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.plateintro/>
- <http://www.ucmp.berkeley.edu/geology/techist.html> (4).

DLESE users made the following comments in response to task 3:

It was very hard to just search for history or historical information.

Lacking a large amount of sources. Resources available are good, but adding more would be helpful in teaching.

I could only find one site that actually discussed the theory/discovery of plate tectonics. All others were devoted more toward showing this theory and explaining the concept in further detail.

I found that while the site is useful for finding resources to be used by teachers, it lacks in helping find resources (text) geared towards the students.

This was easier, but I could have spent more time searching to find some better information.

F.4.3.4 Resources and Comments from MSP2 Users in Task 3

MSP2 users collectively found the following resources:

- <http://pangaea.org/wegener.htm> (3)
- <http://pubs.usgs.gov/gip/dynamic/developing.html> (5)
- <http://scign.jpl.nasa.gov/learn/plate2.htm>
- <http://web.vims.edu/bridge/archive0902.html?svr=www>
- http://www.amnh.org/education/resources/rfl/web/essaybooks/earth/p_hess.html.

MSP2 users made the following comments in response to task 3:

Harder to find this information as compared to the other task questions; still found the website very helpful.

The historical and biographical part of plate tectonics was not well covered. I found one not so good site and that was it.

The search engine is not very user friendly. Every word must be typed exactly right or no results are found. There were not many sites that had Wegener mentioned or the four pieces of “evidence” he used to prove plate tectonics.

There were tons of inactive links!! Furthermore, typing in *plate tectonics - theory* and *Theory of plate tectonics* gave me two separate things. I think they should have provided me with the same.

Again, not a lot of resources once you narrowed down your search. When I searched [for] “Alfred Wegener,” only one result came up.

F.4.4 Comments on Final Questions

F.4.4.1 Comments from Google Users on the Final Questions

Google users made the following comments in response to the trial overall:

Although these materials are very helpful in lesson planning and for finding resources for the enacted curriculum, I would look for something more substantial to recommend to a curriculum planner.

I feel question 5 is difficult to answer without looking at the school’s current curriculum, in order to judge which is better.

F.4.4.2 Comments from NSDL Users on the Final Questions

NSDL users made the following comments in response to the trial overall:

NSDL seems to have an endless supply of options for teachers; however, I think that it would be challenging for elementary teachers of science to navigate this kind of task. They most likely don’t know fact from fiction and there are many concepts that could – and probably would be confusing. Perhaps having a check list in place for the elementary level – like “key ideas/concepts patterns tied to plate tectonics” would be helpful.

Not good for finding quick facts, but lots of good websites with in depth information

I think that this website can be very beneficial because of the search options.

F.4.4.3 Comments from DLESE Users on the Final Questions

DLESE users made the following comments in response to the trial overall:

It is a good search engine for classroom activities and lesson plans. I think it can also be helpful for online demonstrations. I do not, however, think [that] it is a good tool to find a lot of info on a certain topic.

Just needs a little more work. On the right track to helping teachers! Add more resources. Searches are quick and easy.

I would recommend this site much more if it would only provide better search results for the history and theory of introduction of plate tectonics.

I think that without prior knowledge about plate tectonics, it would be difficult to sort through the resources to determine which are useful for planning a lesson geared towards eighth grade students. In addition, I think not enough resources are available directly for students.

The site DLESE seems pretty helpful in general to find educational websites.

F.4.4.4 Comments from MSP2 Users on the Final Questions

MSP2 users made the following comments in response to the trial overall:

I really liked this website, easy to navigate, wiki page puts everything right in front of you and all you have to do is go through and click to find what you are looking for. Definitely will use in the future.

This site was great for some things but not good at all for others. Its strengths are texts and its biggest weakness is in history of science and biographical information on scientists.

I would only recommend this site to help supplement the teacher, not to use as the only source.

The search engine in the website itself was good; it provided me with a lot of website resources. However, the repeated inactive links could cause me to try and find a different search engine that would provide me with only active links.

F.4.5 User Comments During Group Discussion

As described earlier, we grouped participants by sites during the group discussion. Their comments are also reported by site. We draw out general statements, statements about the strengths and weaknesses of each site, and statements about the circumstances in which the site might not be useful. Numbers in parentheses indicate the number of respondents agreeing with or making a particular statement.

F.4.5.1 Discussion from Google Users

Participants reported a high degree of familiarity with Google as a search tool and, therefore, reported that the site was easy to use. Participants also stated that Google was versatile in its ability to search across a wide array of sites; however, this also meant participants felt they had to wade through a substantial amount of information to find what they were looking for, searching multiple irrelevant links to find the needed material. Although nearly all participants stated that the site would likely meet their needs (yes = 7, or 85 percent; no = 1), several participants expressed concern that

Google's query answers usually offered links to more popular sites (due to its search algorithm), such as YouTube, which are typically blocked by public schools.

Google users' comments are presented in three categories below, reflecting the strengths and weaknesses of the tool as well as when it would not meet users' needs.

F.4.5.2 Perceived Google Strengths

- Cache tool is helpful.
- Versatile for finding whatever is needed.
- Easy to use. No learning curve.

F.4.5.3 Perceived Google Weaknesses

- Presents too many advertisements.
- Top sites for videos offered often have commercials in the videos.
- Difficult to wade through all of the material.
- Videos offered may not actually be usable because of the school filtering system (YouTube).
- Site didn't necessarily guide you where you needed to go. Needed to know what you were looking for and where to go to find it.
- Required subject area experience to find accurate and quality sites.
- Needs better sorting capability specific to the type of things users are looking for.
- Hard linking to actual information. There were links to books about the information, but actual information was harder to find.
- Lacks the ability to narrow search by material format (e.g., worksheets, lesson plans etc.).
- Lacks the ability to identify grade and reading level content.

F.4.5.4 Perceived Conditions Under Which Google Would Not Meet User Needs

- Time is limited (Google provided much information that required wading through).
- Students need to find usable and appropriate material on their own.
- Searching for
 - usable animations and videos quickly
 - last-minute planning.

F.4.5.5 Discussion from Nsdl.org Users

The top-level NSDL portal was reportedly easy to use. Further, participants in the NSDL focus group agreed that the sources they found on nsdl.org tended to be those that they trusted. Because Google is ubiquitous, participants repeatedly compared the nsdl.org to Google spontaneously. The NSDL portal was reportedly similar to Google in that it took participants to other search engines and other sites. However, it was reported to be better because it provided only educational materials. Some respondents suggested that using this site with Google would be the best approach. Further, the majority of participants said that the site would likely meet their needs for gathering information for class preparation and delivery (yes = 6, or 66 percent; no = 3).

F.4.5.6 Perceived Nsdl.org Strengths

- Process for searching was clear and straightforward.
- The fact that the site provided the link to the site as well as the purpose and [intended] audience made it easy to filter.
- Was a safe place kids could be “let loose” to search and find appropriate information.
- Took users to education sites directly and not to extraneous sites (like Google does).
- Provided literacy maps, learning goals, and big ideas for focus.
- The user interface made filtering and narrowing easy.

F.4.5.7 Perceived Nsdl.org Weaknesses

- Filter may have narrowed too much. Some respondents reported that the quality of the materials was not good.
- Those without an MS background reported difficulty sifting through the material.
- Google was reportedly a better engine for sorting and searching because of familiarity.
- NSDL was better when there was more time to search rather than quick searches which would reportedly still be done on Google.

- Some links led to circular sources, taking respondents to the same page over and over (>2).³¹
- Some websites were dated or had older information.
- Some pages didn't load, particularly those with animations.
- Does not filter well, providing too large of a range of content (2).
- Content overly technical and lacking laymen's content.
- Google was preferred (3).
- Led, eventually, to quality.

F.4.5.8 Perceived Conditions Under Which Nsdl.org Would Not Meet User Needs

- Time was limited.
- Respondents needed to learn content to stay a step ahead of students.
 - searching for animation
 - current events
 - material provided by other teachers, as opposed to formal organizations, colleges, or universities.
 - doing last-minute planning

F.4.5.9 Discussion from DLESE Users

Participants reportedly enjoyed the experience of using the site and said the site was easy to learn. Participants reported that there was not really anything difficult about using the site. It was reportedly self-explanatory. Respondents favored the ability to search by grade level and the drop down to refine you're a search. Interestingly, one of the greatest assets, that it was "teacher focused," was also mentioned as a deficit, and a few participants mentioned that it was difficult to find information and activities geared to students. Five of the seven participants (71 percent) reported that the DLESE site would meet their needs for gathering information for class preparation and delivery.

³¹ Often, as a participant gave a response, others would nod in agreement. Nodding is not captured in this summary; however, when other participants gave the same response, the number of similar responses is in parentheses.

F.4.5.10 Perceived DLESE Strengths

- DLESE provided sites you can download in schools (as opposed to YouTube, which is blocked).
- Searches were easy to narrow by grade level; I liked how you could search by grade level; there were not too many options. . . . sometimes too many is too much.
- Sources include lots of information from colleges.
- Site provided a good alternative to Google.

F.4.5.11 Perceived DLESE Weaknesses

- DLESE was more difficult to use to find sources for students, as opposed to teachers.
- DLESE was scientist focused rather than focused on teachers.
- Pull down search tabs were not easy to find for some participants (i.e., one participant reported finding it on the last trial).
- The search menu did not allow participants to look at more than one drop down within the Resource Type tab at a time.
- The search box did not correct misspelled words (e.g., Google provides “did you mean...?” option for misspelled search terms).
- DLESE lacked information (or tabs to narrow search) to look for research or history.
- DLESE provides valuable information; however, it required time to mold it into what was needed to present to students.
- Some of the images were too advanced and perhaps not geared at the appropriate grade level indicated in the search field.
- Some of the searches reportedly ended up producing searches that repeatedly led back to the same site.

F.4.5.12 Perceived Conditions Under Which DLESE Would Not Meet User Needs

- DLESE lacked adequate links to information on the history of plate tectonics.
- They would still have to do a lot of work to mold the lessons.
- There was not enough information to link the lessons to information they found or already had.
- It lacked a section with material for middle school teachers by middle school teachers.

- Though it was a valuable tool, if student resources were needed “in a pinch” (e.g., time was short), they would have trouble finding what they needed quickly.

F.4.5.13 Discussion from MSP2 Users

Participants found MSP2 easy to use once they gained initial familiarity with the user interface design, and viewed it as a great resource for finding text-based material. Additionally, participants reported that the website seemed to direct them to relevant links. They also mentioned that MSP2 provided “blurbs” beneath the links that described the link content.

At the same time, participants described the site as linking largely to text-heavy sites and felt it did not provide sufficient links to video and animation material. There was also concern that much of the material to which MSP2 linked might not be grade-level appropriate and the teacher would likely have to put in extra work preparing it for students. Additionally, there were complaints among participants that many of the links were dead and there did not seem to be any effort to ensure that links were up to date. Overall, two of the six (33 percent) participants stated that the site would likely meet their needs for gathering information for class preparation and delivery.

F.4.5.14 Perceived MSP2 Strengths

- Very easy to use after learning the user interface design.
- Great place for finding text.
- Site gave the user a little blurb below the link so you knew what you were clicking (2).
- Site made material easily accessible—took participants to what they needed.
- Participants liked that the links were specific to the user search: It wasn’t like Google that would find a site that just had the words somewhere on the site.
- The site was fast.

F.4.5.15 Perceived MSP2 Weaknesses

- MSP2 was reportedly text-heavy.
- Content did not always seem targeted for eighth grade use, even after filter.
- Great place for finding text, but the sources are not always “trusted” names in science.
- MSP2 presented a lot of inactive sites (dead links).

- Users should be able to search directly from the home page.
- Material does not seem to come ready-made. Users have to break it down as a teacher.
- Animations were reportedly not up to the participants' standards.
- The search box does not have spell-check or word completion suggestions.
- The home page could be simpler with a streamlined design.
- The website was big on science but short on science history.
- Users found it hard to find material that was grade-level appropriate without having to do some preparatory work with the material.
- The site did not provide enough videos and animations.

We did not ask participants about the particular circumstances in which MSP2 would or would not meet their needs.

APPENDIX G. SAMPLE FIND, IDENTIFY, SELECT, AND OBTAIN INSTRUMENT

Appendix G provides a sample of the type of instrument used to evaluate NSDL metadata. Each of the four instruments that was developed had four parts. The first part explains the purpose of the study, asks about the course of study at Rutgers, and provides information about participants' rights in the study, particularly privacy of identity and confidentiality of answers. The second part engages participants in a FISO evaluation of the NSDL portal, while the third part engages them in a FISO evaluation of a selected Pathway. The final section asks participants to evaluate the instrument itself, particularly whether any part of the instrument was confusing, used unfamiliar jargon, or took too long to complete.

1. NSDL Collection Evaluation - Introduction

You are invited to participate in a web survey being conducted by Grace Agnew, Associate University Librarian at the Rutgers University Libraries. The purpose of this research is to evaluate the searching and resource description practices of two digital collections: The National Science Digital Library (NSDL), an NSF-funded portal to digital information resources useful for teaching and learning in mathematics and the sciences, and one of the NSDL pathways portals, which are gateways to information specific to a broad topic (e.g., mathematics) or type of audience (e.g., middle school).

This survey is not evaluating your ability to search but rather the ability of the portals to present search options and information about resources effectively.

This study is also a test of the survey you are completing, so you will be asked questions specifically about the survey in the last section.

Approximately 40 participants in engaged in graduate study in science education, math education or library science will participate in the study, which is a pre-test for a larger study. Each individual's participation will last approximately 15-20 minutes.

This survey requires the ability to open Adobe PDF files to complete. If you do not have Adobe reader, please [click here](#) to download.

This research is anonymous. Your name is never requested and no other identifiable information, such as IP address, will be collected or used. There will be no way to link your responses back to you. Therefore, data collection is anonymous.

***1. Please indicate that you understand that you cannot be identified as a participant in this survey. If you select "no," you cannot participate further in the survey.**

- Yes, I understand that my participation is anonymous
- No, I don't understand. (this response concludes your participation)

***2. Some questions provide opportunities for open ended comments that may be used in the report to the National Science Foundation and its consultants, Guardians of Honor and the RAND Corporation, or in scholarly papers or presentations. Please indicate how quotes from your individual survey may be used. These quotes will be anonymous since participants cannot be identified.**

- Please quote verbatim, using quotation marks at the beginning and ending of the quotation.
- Please paraphrase my response(s) rather than quoting my response(s) directly.

***3. You need to be eighteen years of age or older to participate in the survey. Please indicate your broad age range. This information is used only to determine eligibility to participate in the survey and is not retained or analyzed.**

- 18 years of age or older.
- 17 years of age or younger (this response concludes your participation)

***4. Participants need to be engaged in a degree program that is relevant to the National Science Digital Library. Please select your degree program below. If more than one applies, please select your primary or most current degree program.**

- Master of Library and Information Science (SC&I MLIS)
- Ph.D. Library and Information Science (SC&I)
- Ed.M. Program in Biological Science Education
- Ed.M. Program in Mathematics Education
- 5-Year Teacher Education Program: Mathematics (K-12)
- Ed.M. program in Physical Science or Physics Education
- Ed.D. Program, Mathematics Education
- Ph.D. Program, Mathematics Education
- Ph.D. Program, Science Education
- I am not engaged in a current degree program (this response concludes your participation)

The results of this survey will be included in a final evaluation report to the National Science Foundation and its consultants, Guardians of Honor and the RAND Corporation. Results and conclusions drawn from this survey may also be used in scholarly articles and presentations.

Participation in this study is voluntary. You may choose not to participate by exiting the survey at any time. Incomplete surveys will not be retained or analyzed.

If you have any questions about the study or study procedures, you may contact Grace Agnew, the principal investigator at Library Technical Services Building, 47 Davidson Road, Piscataway, NJ 08854. gagnew@rci.rutgers.edu
732-445-5908

If you have any questions about your rights as a research subject, you may contact the IRB Administrator at Rutgers University at:
Rutgers University, the State University of New Jersey
Institutional Review Board for the Protection of Human Subjects
Office of Research and Sponsored Programs
3 Rutgers Plaza
New Brunswick, NJ 08901-8559
Tel: 732-932-0150 ext. 2104
Email: humansubjects@orsp.rutgers.edu

Please continue to the survey!

2. National Science Digital Library (NSDL)

The first eleven questions will ask you to complete some basic activities and interpret information about resources available at the National Science Digital Library.

1. You are an 8th grade science teacher looking for a web-based resource that can illustrate plate tectonics for your students. Please [click here](http://nsdl.org) (http://nsdl.org) and find a suitable resource. Be sure to open a new window so you do not close the survey. Please type or copy and paste the title of the resource here.

2. Did you do a simple keyword or "google" search

or did you do an advanced search and fill in multiple text boxes and/or limit your search by categories?

- Simple ("google") search
- Advanced Search
- Don't know / not sure

3. Did you limit your search by a criteria such as educational audience?

- Yes
- No
- Not sure

If you limited your search by one or more criteria, please indicate what limits you applied

4. Was the search box easy to find at the site?

- Yes
- No
- Not sure

If you answered "no" or "not sure," please explain your response

5. Are you able to open the resource you found directly from the results screen for your search?

- Yes
- No
- Not available/File not found
- Not sure

If you are unable to open the resource itself, please explain:

6. How easy is it to search for resources at the National Science Digital Library?

- Easy
- Somewhat easy
- Difficult
- Somewhat difficult
- No opinion
- Not sure

Please share any comments on searching the NSDL

Please close the NSDL and resource links before moving to the next question.

You have found a resource on plate tectonics to use in class. Please [click here](#), read the attached PDF containing a description of the resource, and then answer the following questions about it as you evaluate its usefulness.

You will use this PDF file to answer several questions so please keep it open in a separate window.

7. Was this resource published after 2005?

- Yes
- No
- Not sure

8. Who is the publisher of the resource?

9. Are scientific breakthroughs discussed in the resource?

- Yes
- No
- Not sure

Please close this PDF before moving to the next question.

10. You are looking for a resource that enables students to interact with the resource and to work together in class, using real time data. [Click here](#) and look at the descriptions for two possible resources, each of which is described on a separate page. Which resource would you choose?

- Plate tectonics animations
- Musical plates
- Not sure / can't decide

Please briefly explain your choice

11. Did the descriptive information about each resource provide enough information for selecting a resource to use?

- Yes, enough information was provided
- No, I needed additional information
- No opinion
- Not sure

Please share any comments on the information provided about each resource.

Please close this PDF before moving to the next section.

3. Engineering Pathway

This second set of questions will ask you to complete some basic activities and interpret information about resources available at the Engineering Pathway.

1. You are an 8th grade science teacher looking for a web-based resource that can illustrate plate tectonics for your students. Please [click here](http://www.engineeringpathway.com/ep/) (<http://www.engineeringpathway.com/ep/>) and find a suitable resource. Be sure to open a new window so you do not close the survey Please type or copy and paste the title of the resource here.

2. Did you do a simple keyword or "google" search

or did you do an advanced search and fill in multiple text boxes and/or limit your search by categories?

- Simple ("google") search
- Advanced Search
- Don't know / not sure

3. Did you limit your search by one or more criteria such as educational audience?

- Yes
- No
- Not sure

If you limited your search by one or more criteria, please indicate what limits you applied

4. Was the search box easy to find at the site?

- Yes
- No
- Not sure

If you answered "no" or "not sure," please explain your response

5. Are you able to open the resource you found directly from the results screen for your search?

- Yes
- No
- Not available / File not found
- Not sure

If you are unable to open the resource itself, please explain:

6. How easy is it to search for resources at the Engineering Pathway?

- Easy
- Somewhat easy
- Difficult
- Somewhat difficult
- No opinion
- Not sure

Please share any comments on searching the Engineering Pathway

Please close the Engineering Pathway and resource links before moving to the next question.

You have found a resource on plate tectonics to use in class. Please [click here](#), read the attached PDF containing a description of the resource, and then answer the following questions.

You will use this PDF file to answer several questions so please keep it open in a separate window.

7. What is the level of interactivity with the resource?

- High
- Medium
- Low
- Don't know

8. Is any software or browser plug in needed for for any activities contained within the resource?

- Yes
- No
- Not sure

If yes, what software or browser plug-in is needed?

9. Is the resource targeted to eighth grade students?

- Yes
- No
- Not sure

Please close this PDF before moving to the next question.

10. You are looking for a resource that enables students to work together in groups to learn about the impact of earthquakes on buildings. [Click here](#) and look at the descriptions for two possible resources, each of which is described on a separate page. Which resource would you choose?

- Not sure / can't decide
- Forces
- Build an earthquake city

Please briefly explain your choice

11. Did the descriptive information about each resource provide enough information for selecting a resource to use?

- Yes, enough information was provided
- No, I needed additional information
- No opinion
- Not sure

Please share any comments on the information provided about each resource.

4. Survey evaluation

This final set of questions will help us revise the survey to make it more useful for your colleagues nationally.

1. What is the purpose of this survey? Please select the answer that best applies.

- 1. To evaluate what I know about digital resources in specific subjects.
- 2. To evaluate how effectively digital resources can be discovered and selected in a digital collection
- 3. To determine whether a collection contains resources in a specific subject area
- 4. Not sure

Please add any comments on this question that you want to share

2. What collections were evaluated by this survey? If you don't remember, please say this.

3. Was it easy to navigate between the questions and the PDF files?

- Yes
- No

If you answered no, please explain

4. Did the survey include questions or jargon that you didn't completely understand?

- Yes
- No

If you answered yes, please identify as much as you remember of questions or terms that were confusing.

5. How long did it take you to complete the survey (in minutes)?

6. Was this length of time

- Too long
- About right
- No opinion

If you answered "too long" please provide the amount of time (in minutes) that you feel is "about right"

7. Please share any final thoughts about the survey.

5. Conclusion

You have completed your participation in this survey. Thank you for taking the time to assist us in this evaluation.

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