THE NATIONAL SCIENCE DIGITAL LIBRARY (NSDL): AN EXAMINATION OF ITS ROLE AS A DIGITAL ENGINEERING EDUCATION LIBRARY

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1. BACKGROUND

In the Division of Undergraduate Education of the National Science Foundation (NSF) an initial conceptualization for the creation of a national digital library for the sciences was initiated in 1995. By 1998, through the Digital Library Initiative - Phase 2, an early prototype was developed ("DLI2 Projects," 2003).

The National Science Digital Library (NSDL) is an NSF program. Its central administrative body is the Core Integration Team formed by three principal investigators, ten project leaders, and three audience liaisons.

The NSDL Policy Committee is elected by representatives of the projects and it has five standing committees: Community Services, Content, Educational Impact, Sustainability, and Technology. The first year of NSF NSDL funding cycle was in FY 2000. The NSDL.org initial release was in December 2002 ("Organization," 2005).

2. PROJECT AREAS

Since its inception in year 2000 the NSDL has funded over 217 projects for several main tracks: core integration system, collections, services, targeted research, and pathways. In addition other funding agencies that have provided significant co-funding of these projects, particularly during the beginning years, are the Directorate for Geosciences (GEO) and the Directorate for Mathematical and Physical Sciences (MPS). Definitions of each of the main tracks follows and the years in parentheses are the years when these tracks were funded.

Core Integration (2000-2004).
"Projects are expected to focus on the coordination and management of the library's core collections and services and to develop the library's central portal" (Zia, 2001).

Collections (2000-2003).
"Projects are expected to aggregate and manage a subset of the library's content within a coherent theme or specialty" (*ibid.*).

Services (2000-2005).
"Projects are expected to develop services that support users, collection providers, and the Core Integration System and which enhance the impact, efficiency, and value of the library" (*ibid.*).

Targeted Research, TR (2000-2005).
"Projects supported in this track should have direct applicability to one or both of the other two tracks or to the Core Integration activity. Additionally, they may explore other aspects of NSDL including its impact on educational practice, changes in user behavior, and development of new learning environments" ("Program Solicitation," 2005).

Pathways (2004-2005).
"A project supported in this track will coordinate its work with the Core Integration activity so as to assume a stewardship role on behalf of NSDL for the educational content and/or the services needed by a broad community of learners. Projects will typically aggregate the efforts of existing resource providers that fall within the needs of the community that is targeted" (*ibid.*).

3. FUNDED PROJECTS

From 2000 to 2004 the NSF has fully or partially funded 194 projects for a total of US$ 107,565,715. Funding has been provided to projects in the aforementioned six tracks: Core Integration; Pathways; Collections; Services; and Research. There is also allocated funding for subcontracts; 20 subcontracts were awarded during this period.

Table 1: Distribution of projects funded by track areas.

FY	Core Integration	Subcon-tracts	Pathways	Collections	Services	Research	Total
2000	6	0	0	13	9	1	29
2001	3	4	0	18	14	4	39
2002	3	5	0	35	11	6	55
2003	3	5	0	22	11	8	44
2004	3	6	4	0	14	6	27
2005							
Total projects	18	20	4	88	59	25	214
Total Funding	21071323	3893461	2668473	48996961	22701429	8234068	107565715
Total Percentage of Funding	19.59	3.62	2.48	45.55	21.10	7.65	99.99

This table does not include awards given for FY2005.

According to the list of total funded projects (2000 – 2005) and information taken from the 2005 Solicitation Informational Sheet (2), in FY2005 23 new projects were awarded for nearly US$ 9,000,000. These new projects in FY2005 are from three tacks: Targeted Research, 3; Services,

10; and Pathways, 10. Therefore, the total amount of funding allocated by the National Science Foundation for the development of the National Science Digital Library is nearly US$ 117,000,000. ("Funded Projects," 2005).

3.1 Recipients of the awards.

Colleges and universities, professional organizations, and private businesses totaling 107 have received funding in the last five years.

Most of these institutions were recipients of one single grant. However in this five year period the following institutions have received more that three grants: Cornell U./ Cornell U. – Endowed/ Cornell U. - State 12; U. of Wisconsin, Madison 7; Syracuse U. 6; Columbia U. 5; U. of California, Berkeley 5; Carnegie Mellon U. 4; Drexel U. 4; Eastern Michigan U. 4; Kent State U. 4; Texas A&M 4; U. of Arizona 4; U. of Colorado 4; WGBH Educational Foundation 4; California State U. 3; Education Development Center 3; New Jersey Institute of Technology/ Foundation @ NJIT NJ 3; New Media Studio 3; The Ohio State U. 3; UCAR 3; University Corporation for Atmospheric Res. 3; Utah State University 4; Virginia Polytechnic Institute and State University 3; Washington & Lee U. 3; and Worcester Polytechnic Institute 3.

The distribution of the states where all these 107 institutions are located follows:

Table 2: Distributions of funding by states.

Number of Grants received	States
26	NY; CA
18	MA
15	VA
14	CO
10	PA
9	OH; MI
8	DC
7	TX: WI
6	MD; NC; UT
5	AZ
4	IL; OR
3	KS; TN
2	FL; GA; IN; MN; NH; NJ; OK; RI; WA
1	HI; IA; ME; MT; ND; NM

From Table 2 it can be concluded that institutions from the remaining seventeen states have not beneficiated from this NSF project (AL, AK, AR, CT, DE, ID, KY, LA, MO, MS, NE, NV, VT, SC, SD, WV, WY).

According to the NSF's report on funded projects (Funded Projects, 2005) not every grant has been included yet; from 2000 to 2004 194 awards were distributed. With the additional 23

awards approved for 2005, the total number of awards is 217 and they represent the major portion of the program. Subcontracts which are still more difficult to determine are a small part of the total funds. Nevertheless, even without a complete number of awards accounted for it is possible to say that approximately fifty percent of all awards were given to institutions located in six states (NY, CA, MA, VA, CO, PA) and institutions from two states combined (NY, CA) have received nearly twenty five percent of all the grants.

If we take into consideration the number schools with an accredited ABET engineering program it does appear that a much wider distribution of grants would be beneficial to the whole community of engineering education in this nation. There are 358 engineering schools with accredited engineering programs in the United States including the District of Columbia and Puerto Rico (ABET, 2006). The six states mentioned above have thirty one percentage of those schools and accredited institutions in CA and NY represent only a sixteen percentage of the total.

4. ORGANIZATION OF THE NSDL PORTAL

Users have access to the NSDL through its main portal (NSDL, 2006). Search, Browse, Resources, News, and Publications are some of the components of this portal.

The Search function allows for keyword searching of resources about a topic by grade level and by resource format.

The Resources page provides access to key areas of the portal for four types of users: K-12 Teachers; Librarians; University Faculty; and First Time Users. There is also a section on information about the NSDL community.

News features current events about the NSDL in three components: New collections; Newsfeed of interest to the NSDL community; and Press releases about people, projects or scientific discoveries.

Finally, the Browse function leads the user to the Browse by Topic page where five major subjects are listed: Education, Health, Mathematics, Science, Social Studies, and Technology. The Engineering component of the Library is a sub-section of the Science area.

5. NSDL COLLECTIONS

One of the major objectives of NSDL is the creation of collections and the selection of high quality external resources all available under a common metadata infrastructure. By using the Browse by Topic search it is easy to determine that there are 619 unique collections.

The collection resources of the NSDL are both multidisciplinary in coverage and multi-user oriented. This fits accordingly with the NSDL collection policy statement: "The mission of NSDL is to enhance science, technology, engineering and mathematics education through a partnership of digital libraries joined by common technical and organizational frameworks."

Further it says: "NSDL is intended to meet the educational and informational needs of a wide variety of users, from pre-school children to self-directed adults, in both formal and informal education settings." Therefore, the purpose of NSDL is to create a digital library for the sciences with the participation of multiple organizations, with multiple subject oriented resources for a multiple audiences, and presented in an array of different formats. It is a very significant goal to be accomplished ("NSDL Collection Policy," 2005). The table below summarizes the current status of NSDL collections.

Table 3: Distribution of collections by subjects.

	Jan. 20, 2006		March 10, 2006	
Total Collections (A-Z) unique sites included	554		619	
EDUCATION	237	10.92	368	10.88
HEALTH	101	4.65	165	4.88
MATHEMATICS	239	11.00	417	12.33
SCIENCE (Engineering = 91&139)	1204	55.46	1809	53.5
SOCIAL SCIENCES	201	9.26	337	9.97
TECHNOLOGY	189	8.70	285	8.43
GRANT TOTAL of sites listed	2171	99.99	3381	99.99

Because of the multidisciplinary aspect of each resource they appear in several different subject areas. According to Table 3 each collection is on the average listed 3.92 times (2171/554= 3.92) for the results obtained in January 20th and for March 10th the duplication on the average is 5.46 (3381/619=5.46). This is due to the subject assignments given to each collection.

As noted in Table 3, a significant increase in collections has occurred from January to march of this year. The total number of unique collections jumped from 554 to 619, this is a 11.73 percent increase. The total number of sites included in the subject lists jumped from 2171 to 3381 which represents an increase of 55.73 percent.

In March 16, 2006 the total number of sites in the Science component of the NSDL is 1809. Within this set of resources and not based on the total number of original sites (619) but in the total of sites listed (1809); the Science section represents 53.5 percent of the NDSL resources.

Table 4 shows the subject components of the Science cluster and the number of collections found both in January 20th and March 10th of 2006. Considering the most recent data collected, as of March 10, 2006 the Engineering area - a subsection of the Science cluster - has 139 collections listed which represents only 7.68 percent (139/1809-7.68) of the Science cluster. It also represents 4.11 percent (139/3381=4.11) of the total number of resources listed in the NSDL. A much better picture of the volume of engineering resources contained in the NSDL is found when considering only the 619 unique collections selected as resources for this digital library, in this case, the Engineering portion of the library is 22.46 percent (139/619=22.46).

Table 4: Science Cluster, Distribution of Subjects

	Jan. 20, 2006	March 10, 2006
Science	283	417
Agriculture	42	57
Astronomy	38	63
Biological and Life Sciences	57	78
Biology	101	152
Botany	47	57
Chemistry	53	77
Computer Science	18	40
Earth Science	54	80
Ecology	44	69
Embryology	5	7
Engineering	91	139
Entomology	12	19
General Science	31	48
Geography	29	47
Geology	42	57
Histology	4	6
History of Science	17	25
Metallurgy	3	4
Meteorology	16	22
Natural History	46	63
Oceanography	21	38
Paleontology	14	22
Pharmacology	5	9
Physical Sciences	27	39
Physics	84	137
Space Science	20	37
Total of SCIENCE sites listed	1204	1809

6. THE ENGINEERING COLLECTION

As mentioned before, the Engineering collection of the NSDL is a subset of the Science cluster, and as of March 10, 2006 it has 139 listed sites. In order to get this list of collections the Browse by Topic search was used ("NSDL Search Results," 2006).

These resources came from a variety of sources, most of which are external resources; the actual number of external resources is 132. The other 7 collections were obtained through grants given by the NSDL to several institutions. The following seven sites are resources created for the NSDL from awards provided by the NSF:

Electronic Encyclopedia of Earthquakes (E3).
Digital Library Network for Engineering and Technology (DLNET).
Materials Digital Library: MatDL.org.
Kinematic Models for Design Digital Library (K-MODDL).
Computing and Information Technology Interactive Digital Educational Library (CITIDEL).
Geotechnical, Rock & Water Digital Library (GROW).
Computer Vision Education Resource.

Additional engineering related funded projects in FY 2005 but not included yet as Engineering resources are:

Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education (2005).
Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education (3 awards, 2005).
NSDL Materials Digital Library Pathway: Hub for Materials Education and Research (2005).

It is assumed that these projects will be included within the next two or three years as they are completed.

The following project funded by the NSDL is not listed in the engineering page apparently because is has not been completed:

Annals of Research on Engineering Education, AREE (2004). AREE is scheduled for completion by 2008, but a Web site for this project is already operational (AREE , 2005).

In addition, the following awards definitively related to engineering topics are not included on the Engineering page:

Geotechnical, Rock and Water Resources Library (GRAWRL) - Towards a National Civil Engineering Education Resource Library (2001).
Collaborative Research: TeachEngineering - Hands-on Engineering (several awards, 2003).
Collaborative Research: TeachEngineering - Hands-on Resources for K-12 (several awards, 2003).
Teachers' Domain - Physical Science and Engineering (2002).
Fire Science Multimedia Library (2004).
A Digital Library of Ceramic Microstructures (2002).
An Active Mathematical Software Collection for Inquiry-based Computational Science and Engineering Education (2001).

The year when these awards were given are indicated in parentheses. Two possible things could have happened: These projects are overdue or were never completed; or the metadata identifying these projects do not contain the proper information that will allow them to be accessed as engineering resources. Therefore, some corrections need to be made.

The 19 collections listed above which are funded by awards given by the NSDL represent approximately 20 percent of all the awards given in the Collections track since funding started in year 2000.

Credit should be given to the NSDL collection team for the inclusion on the Engineering page of a non funded NSDL project such as: NEEDS - National Engineering Education Delivery System: A Digital Library of Engineering Courseware ("NEEDS Digital Library," 2005).

In Summary, the Engineering collection of the National Science Digital Library after five years of funding, six years of development and three years since its initial release to users, is still a project with relatively small coverage. But it appears that the engineering collection is between 20 to 25 percent of the total number of collections.

7. EVALUATION OF THE NSDL

Extensive database searching in the literature published about the National Science Digital Library was conducted. These searches had two purposes: First, to identify documents about NSDL, history, projects, current developments and its future. In this case the literature is significant in numbers; secondly, to determine up to what extent the NSDL has been evaluated. Here only a very few number of independent articles were found.

Most articles were found either in journals or in conference proceedings, although quite positive about the role of NSDL and the quality of the projects, these articles did not contain adequate assessments made by independent experts. There are numerous literature entries about NSDL but most of it is of a descriptive nature. These types of publications are important informational and educational tools and their value can not be misinterpreted. Thus, there is need for more evaluation.

NSDL has also made an effort to evaluate their programs. For this purpose the Educational Impact and Evaluation Committee was created. Some of the work done by this group is included in the NSDL Annual Report (2005). In addition, the results of several surveys of different types have been presented at workshops and conferences. Still, the extent to which these studies include assessment data is limited. Therefore, much work needs to be done in evaluating NSDL, its programs and the projects that have been funded. These assessments should be done by independent parties.

From the Engineering collection point of view, the same situation regarding assessments also occurs. For example, critical evaluations of the seven collections included on the Engineering page of the NSDL and funded by NSDL have not been done. Without this type of process that is characteristic in the academic and research world it is at least premature to make conjectures about the value of these collections. Therefore, a more extended program of peer evaluation is highly recommended.

8. FUTURE PARTICIPATION

Continuous and appropriate levels of funding either from the public or private sector is the engine that can move an intense project of this kind. It is not clear whether allocations from the National Science Foundation will be available for FY2006; at least an announcement for solicitation of grants has not been disclosed yet.

The success of this digital library is really in the hands of the professors of engineering and technology programs at the college level and of science teachers at the K-12 level. It is extremely important that, for example, at the university level and using professional organizations such as ASEE as a forum, the participation of engineering and technology instructors be utilized. In order to accomplish this it is necessary to understand how a digital library can be a positive tool for the improvement of the curriculum. Second, there is a need to identify projects of significant value to be incorporated into the NSDL that would be beneficial to the improvement of the engineering curriculum. It appears that since its inception, NSDL has had problems making the linkage between the development of the digital library and the direct usage of the resources harvested in the digital library for the benefit of an enhanced curriculum. More effort is needed to facilitate that linkage.

9. CONCLUSION

The National Science Digital Library has a very broad set of objectives and the people directly involved in this venture have worked diligently to achieve these objectives. The support received from The National Science Foundation and other funding agencies in the last five years has been outstanding.

The Engineering and Technology component of the NSDL is nearly 25 percent of the library both in collections and in the percentage of resources allocated but still its coverage is limited. It is possible to say that the Engineering portion of this library has not yet achieved maturity and much more needs to be done in order to achieve the goals that NSDL has put forward.

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