

EXPANDING THE SCOPE OF COMMUNITY-BASED DIGITAL LIBRARIES: THE DIGITAL LIBRARY FOR EARTH SYSTEM EDUCATION AS A TEST CASE

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The emergence of world-wide “electronic communities” [1-3] provides ample testimony to the importance and potential impact of digital libraries, or digital information systems, in the daily lives of all global citizens. As digital libraries worldwide became more stable and mature, and as “libraries of librar-

ies” such as Renardus (the EU-funded academic subject gateway service) [4], the UK Resource Discovery Network initiative [5] and the National Science Digital Library [6] initiative in the United States emerge, the promise of creating a worldwide network of scholarly and educational digital libraries with the potential to transform teaching and learning practices across the full spectrum of academic disciplines comes closer to a reality. Global efforts to develop an international digital library community, such as those underway in Europe and Russia, reflect these same needs, interests, and primacy.

Digital libraries are a means for disciplinary or other kinds of communities to share, organize, and assess their intellectual holdings. As community digital libraries, they are “...distinct through having a community of potential users define and guide the development of the library” [7]. This paper will present some of the critical issues to date in the development of one such community-based digital library effort—the Digital Library for Earth System Education (DLESE). With these issues in mind, we offer a framework for examining the development and possibilities for community-based digital libraries.

The Digital Library for Earth System Education

DLESE (www.dlese.org) is a community-owned and governed digital library offering easy access to high quality electronic resources about the Earth system at all educational levels [8]. Such resources include maps, lesson plans, lab exercises, datasets, virtual field trips, and interactive demonstrations. Numerous individual faculty members, agencies, and institutions maintain local storage of these resources on their own servers, which are then accessed via the DLESE database of searchable metadata records that describe them. Currently in its third year of development and operation, DLESE resources are designed to support systemic educational reform, and include web-based teaching resources, tools and services for the inclusion of data in classroom activities, and a “virtual community center” that supports community goals and growth. “Community-owned” and “community-governed” embody the singularity of DLESE through its unique participatory approach to both library building and governance. DLESE users include learners and instructors in all venues, many of whom are also resource contributors, developing educational materials, providing scientific knowledge, and evaluating DLESE holdings. To date, DLESE has developed community and governance structures, a strategic plan, a useful collection of 2000+ resources, and a working version of the library, which was formally released as Version 1.0 at the DLESE Annual Meeting in August of 2001. DLESE features include:

- Resource discovery that will integrate the U.S. National Science Education Standards, geography standards, Earth system science vocabulary, georeferenced discovery

- The DLESE Catalog System, a catalog management tool allowing discovery, contribution, management, and sharing of records

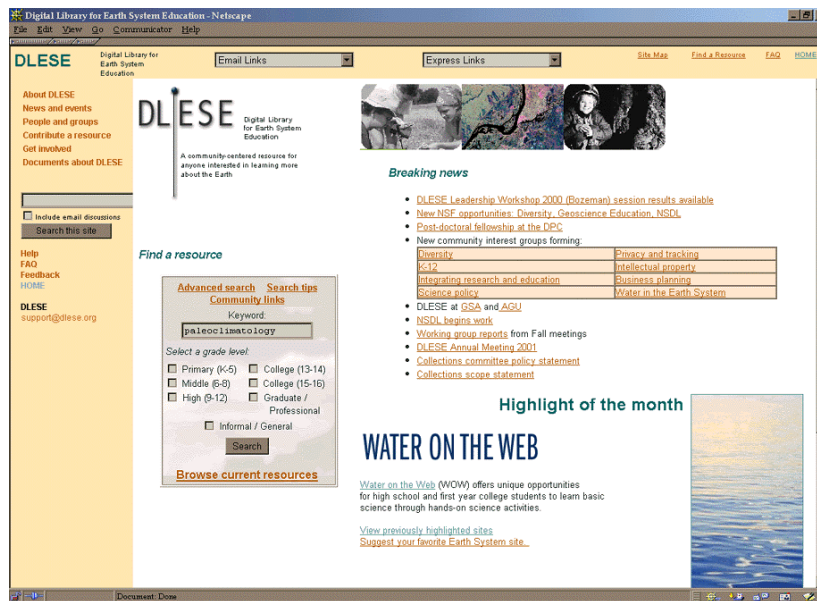


Figure 1. Version 1.0 of DLESE (www.dlese.org) was released at the Annual Meeting in August 2001. It enables educators and learners to search and browse for educational resources by grade level, keyword, and educational resource type. Every month an educational resource created by a community member is featured.

Services and tools enabling community interaction and collaboration; usability analysis and design application enabling user-friendly interface development combined with effective functionality

A grass-roots participation structure enabling DLESE to serve as a model for community interaction and governance for the NSF-funded National Science Digital Library (NSDL) and others

Further staged development of the library is planned for two-year and five-year benchmarks as detailed in the DLESE Strategic Plan [9]. Version 2.0 will offer search across multiple peer-reviewed collections, collections development services, and extension of resource discovery through support for science education literacy standards and an Earth system science controlled vocabulary. Version 3.0 will enable spatial and temporal search of resources such as data, maps and images. Gazetteer services will support user-centered, geo-referenced discovery, integrated tools and services for data exploration, and the creation of personalized collections. Many of these features will be carried out by the distributed community, and coordinated with the DLESE Program Center in Boulder, Colorado, USA [http://www.dlese.org].

Community libraries such as DLESE also constitute examples of unique socio-technological innovation and impact. The early development of a strong community governance structure and the principle of “user as contributor” have been integral to DLESE development from its inception. A steering committee and standing committees (collections, services, technology, users) informed by topical working groups and email discussion lists, enables a dynamic transference of ideas, needs, collaborations, and policy development, all dedicated to the

idea of collaborative participation. A series of working groups, workshops, collaborative funded projects, and annual community meetings has enabled the DLESE community to take active roles in policy development, collections, and peer reviewing services.

A Community-Based Digital Library Framework

DLESE is now a widely recognized resource for Earth system education in the United States, and increasingly, in Europe and Asia. Based on our past three years of development and operation, we offer a framework in which to consider the development and operation of community-based digital libraries. This framework encompasses the variety and the complexity of people and institutions, relationships and processes, and technical and social artifacts that are integral to the development and study of community-based digital libraries. Although we acknowledge that there are many models that can be considered, we believe that healthy community-based digital libraries display, at least to some degree, elements of the following characteristics:

1. A collective vision for library goals and values
2. Equitable and representative community-based governance processes
3. The employment of user-centered design methodologies
4. Opportunities for meaningful community-wide engagement
5. Distributed and contextually-based evaluation efforts.

Each of these characteristics will now be considered in light of our experience.

1. A collective vision for library goals and values

A necessary characteristic of community-based digital libraries is a high degree of synergy and cohesion surrounding the library's vision. Over the past three years, this vision has been articulated and refined through community discussions, technical developments, and evolving needs. In the case of DLESE, the library was conceived as a community response to calls for educational reform in the United States. Over the past decade, a series of key national documents has recommended a variety of systemic reforms in geosciences education. These reforms call for an emphasis on an Earth system perspective, inquiry-based and "hands-on" discovery learning, and a recognition of the importance of emerging pedagogies and new educational technologies [10-12]. At the same time, there has been increasingly visible public demand for improved science education across the national, state, and local levels [13], and a call for greater access to quality science education-for all [14].

A significant body of research indicates that systemic educational change at any level cannot be mandated; instead it requires large-scale, long-term community participation in and ownership of the process of change [15-17]. In the

United States, the National Science Foundation has made substantial contributions to a wide variety of science education reform projects in recent years. Although there have been many notable pockets of success, more often than not these innovations have remained localized and not widely adopted. There is an explicit need to maximize existing investments in science education by providing the necessary integration services and community support to promote synergy across these otherwise disparate projects.

In recognition of the urgency of the need and the timeliness of the opportunity, the Earth system science community came together in the summer of 1999 to begin construction of the Digital Library for Earth System Education. The Portal to the Future grant funded a workshop for geoscience educators and community leaders to articulate a vision for the library and to develop a governance structure. The first slate of community representatives, comprised of the DLESE Steering and Standing Committees, was generated from this workshop. A second important outcome was the articulation of the DLESE Community Plan [18], which laid out the community's vision for the first stages of library development.

Concurrent with the Portal grant was the NSF award for Collaborative Research for a Geoscience Digital Library. This effort resulted in a library prototype, demonstrating educational discovery features and the initial formulation of the DLESE metadata framework. The DLESE Program Center was established at the University Corporation for Atmospheric Research in Boulder, Colorado, in order to provide continuity and coordination for the distributed library building process. As a result of outreach activities funded by this effort, a set of five coordinated proposals were forwarded to and funded by the first NSF-sponsored National Science Digital Library solicitation. These proposals contributed critical services to DLESE, including collections development, peer-review design, business models, and interoperability research. The First DLESE Annual Meeting (DLESE 2000) was held in the summer of 2000 in Bozeman, MT. It was attended by 120 broadly representative community members and engaged the community in the distributed library building process. As a direct result of this meeting, a K-12 Working Group was formed, which was successful in obtaining NSDL funding for a K-12 collections effort: the Digital Water Education Library (DWEL).

The result of the subsequent grant, Digital Library for Earth System Education: Implementing the DLESE Community Plan, was Version 1.0 of DLESE. This operational library was released in August 2001, with approximately 1000 carefully selected resources in its initial collection. Version 1.0 provides educational discovery features that enable users to search by grade level, educational resource type, and keyword. This version also contains a Resource Cataloger, and community oriented services such as discussion forums for working groups and a community posting tool. During this period, two working groups were formed and convened: the Diversity Working Group [19], and

the Dataset Working Group [DAWG] [20]. As a result of the second round of NSDL solicitations, the NSDL Central Office was established at UCAR and several community members received NSDL funds to develop data services, data collections, and K-12 collections for DLESE. The Second DLESE Annual Meeting was attended by over 140 educators, researchers, and representatives from allied fields and expanded the scope of the previous meeting to include library users as well as library builders. The DLESE Strategic Plan, which outlines the five-year vision for the next stage of library development, was formally approved in November 2001. This plan, which was crafted by the DLESE Steering Committee with broad community input, provides the basis for the project goals outlined in this proposal.

These community input mechanisms, along with subsequent meetings, grant proposals, working groups, and governance structures have all contributed to the development of an evolving collective vision for DLESE. They insure that the diversity of community interests are represented, and provide a voice for the constantly evolving DLESE vision, as new members are brought into the community, and as new technologies are developed.

2. Equitable and representative community-based governance processes

A second characteristic of community-based digital libraries is the establishment of a governance process that can represent the broad range of interests across the community. The uniqueness of DLESE lies in its strong community roots and active community governance. Community-building and technical development always have been tightly integrated [8]. Our experience to date demonstrates the viability of distributed library building and governance. Through workshops, working groups, and funded projects, the community is actively participating in the development of library policies, collections, and peer reviewing services. This participation was facilitated by coordinated outreach efforts and a great deal of face-to-face community contact. In the future, these efforts will be funded through an independent NSF-sponsored community solicitation.

Program Governance. As detailed in the Strategic Plan, DLESE is governed in ways that sustain the program's community-oriented character. The DLESE Steering Committee, whose composition reflects the full range of DLESE institutions (from K-12 to large universities), provides policy and direction for the overall effort. Steering Committee members are nominated and elected by the community for 3-year terms. Representatives from NSF and NASA also join in the Committee's discussions. Four Standing Committees (Users, Technology, Services, and Collections) report to and inform the Steering Committee. Together, they have helped to build collective agreement on the purpose and vision for DLESE. These committees are also instrumental in providing input on mid-course program corrections when necessary.

DLESE Program Management. The Steering Committee has approved a management plan for the overall DLESE effort as part of the strategic planning activity. This plan includes a specification of the role of the DPC, mechanisms for significant community input into library management and operations, and a provision for a part-time Executive Director charged with overall coordination for DLESE. The Executive Director “ensures the integrity of the core functions in relation to the mission and goals of DLESE, facilitates linkages between DLESE core functions and DLESE-related efforts, and that the policies of the library are carried out” [9]. With direction from the Steering Committee, the Executive Director will oversee library implementation and ensure appropriate balance between DPC and community activities. The DLESE Management Council will include all lead Principal Investigators who are funded through the DPC or the NSF community solicitation and have core deliverables needed to ensure the success of the library.

3. Opportunities for meaningful community-wide engagement

The third characteristic of successful community-based digital libraries is the institutionalization and sustainability of opportunities for meaningful community-wide engagement. DLESE is a partnership among the NSF, the DLESE Steering Committee, the DLESE Program Center (DPC), and the DLESE community. The Strategic Plan articulates the many roles of the DLESE community as both builders and users of the library. The DPC supports the DLESE community by serving as an integrator for community efforts and by providing a basis for program continuity. These integrating and continuity functions are achieved through the provision of technical infrastructure and community support services, and are designed to encourage collaboration among DLESE’s diverse constituencies.

Core activities necessary for realizing Versions 2.0 and 3.0 will be carried out by both the DLESE Program Center and the DLESE community. This distributed building approach is essential to harness the community’s diverse educational and technical expertise, to enable greater participation, and to engender the commitment and social capital [21] necessary for long-term library success. Active community participation in library building will ensure that community needs are met and that the library is responsive both to changing demands and evolving technologies.

Stable funds are required for all core functionalities and services, both DPC- and community-led. These services must be designed and built to integrate with library policy and the library’s evolving technical infrastructure. These activities also must be held to a high level of accountability in order to deliver the caliber of service that the community expects. Toward this end, the DLESE Steering Committee has recommended a two-fold strategy for ensuring the success of this distributed approach: a central DLESE Program Center, cou-

pled with an independent NSF-sponsored community solicitation in the areas of collections, community, data services, and evaluation. Considerable thought and planning have been given to the coordination of central and decentralized library building activities. A coordination plan, Principles for Delineating DLESE Responsibilities [22], has been included in the formal DLESE management plan. Other library initiatives that are important, but not necessarily core, may be funded through other sources.

DLESE has established relationships with science and science education professional societies, including the American Association for the Advancement of Science (AAAS), the American Geological Institute (AGI), the American Geophysical Union (AGU), the Incorporated Research Institutions for Seismology (IRIS), the National Science Teachers Association (NSTA), and the emerging Center for Ocean Sciences Education Excellence (COSEE), and Earthscope efforts. These partners inform our library design and provide outreach opportunities for DLESE through their conferences and workshops. With AAAS we are developing library interfaces to enable users to discover resources via the AAAS strand maps. These maps depict the relations between Benchmarks in a graphical manner. AAAS has developed a mapping between the Benchmarks and the National Science Education Standards that we plan to integrate into DLESE. This will enable resources indexed via either the Benchmarks or the Standards to be queried and retrieved. AAAS intends to integrate DLESE into their professional development offering for educators. We also have a co-development partnership with NASA and plan to extend our partnerships to other federal and state agencies.

Our rapid technical progress to date can be attributed to a number of strategic relationships with key information technology efforts, allowing us to build upon a strong foundation of digital library technology research. Partnerships in this area include the University of California, Santa Barbara, (UCSB), the University of California, San Diego (UCSD), and Cornell University. Our partnership with UCSB has resulted in significant knowledge and technology sharing to date. With Santa Barbara and NASA, we are co-developing the ADN metadata framework. DLESE is providing the ADEPT project with resource cataloging tools and catalog management systems. ADEPT is providing DLESE with its search bucket middleware and expertise in geo-referenced material. We are working with UCSD to explore practical and cost effective solutions to the resource persistence problem. We will leverage the special expertise of Cornell in the area of metadata harvesting approaches to digital library interoperability (i.e., OAI), and in turn, we will assist Cornell with technical outreach to distributed library contributors.

In the data arena, we have two important partnerships with the Unidata Program Center [<http://www.unidata.ucar.edu/>] and the emerging Geoinformatics effort [23]. Both are developing mechanisms for describing Earth system data for discovery and use in educational and research settings. In the

THREDDS project [24], the Unidata Program Center is developing services to enable users to create personalized and sharable collections of data and data analysis tools. Geoinformatics will create a database and a toolbox for the integration and discovery of Earth system data on a global scale, with a special emphasis on advanced Geographical Information System (GIS) capabilities. DLESE will build upon Geoinformatics' data collections and tool development efforts, and provide leadership with the educational metadata framework and project outreach.

DLESE is a large and complex undertaking. However, we have made significant progress in many key areas and have delivered an operational Version 1.0 library in a relatively short time. This rate of progress rests on the strength of community involvement, the development of strategic partners, and the interdisciplinary expertise provided by the DLESE Program Center. We believe that the progress we have made thus far would be impossible without the institutionalization of processes for meaningful community-wide engagement, as described above.

4. The employment of user-centered design methodologies

Our fourth characteristic, the employment of user-centered design methodologies, leverages and builds on the three previously cited. DLESE's experience in the past three years has demonstrated that the integration and involvement of distributed community members into the practices of "doing design and development" is not merely possible, but raises development itself to new levels through technological and social innovations that allow and foster dynamic interaction, social creativity, and the creation of intellectual capital [25, 26]. The participatory design approach [27] emphasizes the involvement of users as co-designers, i.e. users help determine the design, the processes, and the conditions of use of the technology employed. This early buy-in to the process of development is the essence of the designation "community digital library," providing a platform for the expertise of a distributed community to gain cohesion and creative critical mass.

We believe that because of the investment that the DLESE community has made in articulating a common vision, developing an equitable and representative community-based governance processes, and institutionalizing opportunities for meaningful community-wide engagement, our user-centered design methodologies are even more salient and powerful.

6. Distributed and contextually-based evaluation efforts

A final characteristic of community based digital libraries is a wide range of distributed and contextually based evaluation efforts. These efforts are carried out by researchers and university faculty, and K-12 teachers in class-

rooms across the country. Current efforts include the development of evaluation criteria by specific collections developers, and the development of a “DLESE Evaluation Toolkit” which will bring together a significant body of evaluation tools, theories, and implementation strategies for the DLESE user and research communities. Emerging efforts include qualitative and quantitative studies on DLESE use and impact. The DLESE community will carry out these evaluation and research efforts over the next several years, under the coordination of the new DLESE Evaluation Center. As DLESE evolves, it will be critically important to have ongoing measures of its success, so that the service provided to the community can be continually improved. This will involve use of formative evaluations methodologies to determine how efficiently and effectively DLESE services are being provided, as well as an analysis of the impact of DLESE on improving student learning in Earth system science and the degree to which DLESE is contributing to the important cause of educational reform

The DLESE Evaluation Plan (www.dlese.org under "Documents About DLESE/Plans") provides a strong platform for community member to build upon in their evaluation efforts.

Conclusion

This paper has outlined some of the key development highlights in DLESE’s short history, and has attempted to present a framework for others to consider in their development and research efforts on community-based digital libraries. DLESE will continue to refine and institutionalize processes that promote sustainable library growth through community capacity-building and community participation in library governance, development, and operations. In this way, we anticipate that DLESE will provide an indispensable service to the geoscience community of library developers, contributors, and users. It will serve as an incubator for leadership and innovation, and as a forum for social creativity. We believe that the value of DLESE lies in its potential to scale success on national and international levels, by promoting equitable access to quality resources, supporting literacy goals and Earth system perspectives, integrating research and education, and contributing to the body of evidence on the value and efficacy of digital libraries as a vehicle for educational change.

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