Via the Internet, two ambitious projects are helping to organize educational communities and improve access to learning materials in the geosciences and other scientific realms. Behind these scenes is an unusual blend of educators, librarians, technical innovators, and subject experts—all working to put interactive tools, animations, data sets, and other digital resources at the fingertips of users.
You're a middle school science teacher, gathering resources for an upcoming sequence on volcanism. You type “lava” into one of the leading search engines on the World Wide Web. At the top of the hundreds of thousands of links that result, you might find anything from a software company to a home-decorating icon of the sixties. Chances are, you won't encounter—without a lot of digging—the kind of accessible, focused, easy-to-navigate material you and your students need.

Thousands of teachers and students replay this scenario each day. Although the Internet's roots lie firmly in the academic and research world, the kudzu-like growth of Web commerce threatens to block out the vibrant network of education-oriented sites growing more quietly in the background. And even when those sites can be reached, the value of their best materials may not be evident at first glance.

Building on over two decades of expertise going back to the Internet's earliest days, UCAR is now part of two broad-based efforts, both funded by NSF, that will help science educators and learners of all types find what they need on the Internet. It’s not a moment too soon for those frustrated at how difficult it can be to leverage the immense power of the Web.

“The vision of the geoscience education community was the driver for this effort,” says Mary Marlino, director of the Digital Library for Earth System Education Program Center, housed at UCAR. Over the past three years, DLESE has pulled together a wide-ranging array of software experts, instructional designers, librarians, and other specialists.

The program center houses 18 staff, but in line with DLESE’s distributed-development approach, many others are at work at K–12 schools and universities nationwide. The Boulder-based staff serve as facilitators—providing the technical infrastructure, support, and continuity so that science teachers and other users can evaluate and annotate materials in the ways most useful to them. Over the past several years, says Marlino, “we have developed a community-based digital library that is being used by thousands of educators and learners every month.” Critical to this effort, she adds, has been “an extraordinary level of community involvement in all aspects of library building.”

As of mid-2002, DLESE was providing access to more than 2,000 user-contributed resources, ranging from a single Web page to sites with hundreds of pages. Each resource stays at the location where it was created. Through DLESE, users can get to each resource through a simple but powerful search engine (one that won’t take you to a hockey team if you type “avalanche”). The resources are identified by audience, resource type, discipline, and other variables.

What distinguishes DLESE from related efforts (many of them research-based) is its participatory community. Dozens of universities take part in annual meetings and other activities, all guided by a user-driven strategic plan. Collaborating partners, working groups, standing committees, and a steering committee are all stakeholders in the development process—a nationwide
Climate output for all

The output from global circulation models is front and center when climate change is debated. Until now, it’s been difficult for geoscience students (much less ordinary citizens) to access the original output and see for themselves what the experiments are saying. A Consortium for the Application of Climate Impact Assessments, based at NCAR and cosponsored by the Electric Power Research Institute, is opening the model doors to a broader audience. In 2002 a test version of the ACACIA Regional Climate Data Access System came online. The Web-based interface (http://dataserver.ucar.edu/arcas/main.html) allows users to plot data on the fly from any of five simulations produced by two different models. Two of the simulations assume business as usual (greenhouse gas emissions that rise unabated), while two others project a stabilization scenario (emissions gradually leveling off). All four of these runs extend to the year 2100, while a fifth simulation covers the past 125 years of climate. The output variables from each model range from average temperature and precipitation to cloud amounts. Users can examine the entire globe, pick a continent, or zoom in to a specified region. The displays make use of LiveAccess technology developed at NOAA’s Pacific Marine Environmental Laboratory. The system assumes some basic knowledge of how climate models work. However, ACACIA director Tom Wigley and software designer Maarten de Koning plan to devise a simpler interface so that an even wider range of people can scrutinize model output.

A global-scale reading room

Next door to the DLESE program center in Boulder, a different yet complementary approach is taking shape at the National Science Digital Library (NSDL). With a mission encompassing the full range of science, engineering, and related activities, NSDL may become one of the world’s largest digital libraries of its type by the end of the decade.

If DLESE is the rough equivalent of a specialized, community-based library, offering hand-picked materials with employee and patron recommendations, then NSDL is more akin to a vast, eclectic main branch. NSDL’s goal is inclusiveness: if an item is online and it’s related to science, it will likely have a place in the holdings. “We’ll rely on our partners, like DLESE, to vet their specialized collections,” says Kaye Howe.

Howe—a former college president, university vice chancellor, and professor of comparative literature—is now deputy director of the NSDL “core integration” office in Boulder. Howe’s office is charged with constructing the software and hardware that will pull this national library together. Other major partners in this $100 million NSF-funded project include Cornell University and Compaq Computer, which are overseeing the library’s catalog and its multifaceted entry portals, and Columbia University, where fiscal and intellectual-property issues are being handled.

NSDL is also seeding and supporting efforts to make digital collections more available and accessible. UCAR’s Unidata Program Center is teaming with more than ten geoscience data centers in one such NSDL-funded project, Thematic Realtime Environmental Data Distributed Services. The primary goal of THREDDS is to integrate a variety of scientific data collections—as well as tools for accessing, analyzing, and displaying the data—into the digital libraries.

Diane Hillmann, a librarian at Cornell, where the seeds of NSDL were first sown, has worked with electronic cataloguing since the 1970s. What’s different today, she says, is that computer scientists and librarians are learning together how to “scale up” to handle online collections that grow far more rapidly than hard-copy stacks ever could.
“We’re trying to apply a lot of the digital library research of the last decade or so. You don’t always need the most sophisticated technology. The initial goal is providing a large data base and making it work for the users.”

David Fulker concurs. After managing Unidata for almost two decades, Fulker took the reins of the NSDL core integration effort. His experience at Unidata—which furnishes geoscience data, software, and support to over 100 universities—convinced him that NSDL had to do far more than simply collect and index Web pages. “In a modern library,” says Fulker, “data sets are useless without tools.”

NSDL’s tools will be among the best. Experts at the University of Massachusetts–Amherst are building advanced search methods to help users zero in on the content they need. The library will also make it easy to build customized portals. For example, a teacher might combine astronomy and mathematics resources into a focused yet extensive home page from which her students could find source material for term projects without trawling the entire Web.

As it gathers material, NSDL is following the model of the traditional library rather than that of peer-reviewed journals. While individual collections may be reviewed, with annotation helping to guide users, “NSDL reflects the open intellectual commons of the academic library,” according to Howe.

**Financing a 21st-century library**

The effects of DLESE, NSDL, and other digital libraries on the business side of scholarly publishing are only beginning to take shape. “Many groups have developed their [digital] resources at lower cost than is possible in a traditional publishing model,” says Kate Wittenberg (Columbia), who is monitoring the world of “transformational publishing” for NSDL and other digital libraries. Increasingly, users might pay for publications indirectly—through fees for digital access—rather than buying hard copies directly. As for NSDL, some costs may be shifted to user institutions as the current funding winds down in 2006.

The NSDL principals were working at full throttle during 2002 to produce the library’s initial release by year’s end. In the driver’s seat were some of the world’s leading thinkers on how to move scientific resources on line. Among them are Cornell computer scientist William Arms, author of the 2001 overview *Digital Libraries*. In it, he envisions the hope of digital libraries that combine “everything that we most prize about traditional methods with the best that online information can offer. In some nightmares, the worst aspects of each are combined.”

However the digital future unfolds, surprises are bound to arise as new resources emerge. “The forms they will take,” says Arms, “are almost impossible to anticipate.”

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**On the Web**

- **DLESE**
  [http://www.dlese.org](http://www.dlese.org)
- **NSDL**
  [http://www.nsdl.org](http://www.nsdl.org)
- **NSF Digital Libraries Initiative, Phase 2**
- **Cornell Digital Libraries Research Group**
  [http://www.cs.cornell.edu/cdlrg](http://www.cs.cornell.edu/cdlrg)