*White Paper*

# The State of DLESE: Collections

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This white paper surveys the state of collections of the Digital Library for Earth System Education (DLESE) after 5 years of planning and implementation, and describes remaining collection-building challenges as we see them. This document attempts to take stock on the eve of a new round of reforms and revisions driven by the 2004-2005 Quality review.

## *Goal of the DLESE Collection-building Effort:*

DLESE's Collection Building goal is "To assemble and foster the creation of educational materials from the community that are rich in science content; diverse in format, content, and topics covered; fresh, dynamic, and interactive; instructor-ready; and integrative across traditional disciplines".[2]

## *What's in the DLESE Collection and how is the Collection subdivided?*

DLESE does not hold or disseminate actual educational resources. DLESE's content is pointers to, and information about, web-accessible materials. A "resource," in the DLESE context, is "any web-accessible teaching or learning material."[3]

DLESE resources may be lesson plans, computer activities, data sets, audio files, reference materials, syllabi, tutorials, assessment instruments, or any other material of use for teaching or learning about the Earth and environment. Early in DLESE's history, there was considerable discussion about the desirable "granularity" (coarseness or fineness) of individual resources appropriate for cataloging into DLESE. This controversy has been settled in favor of creating separate catalog records for each entity that has distinctive educational, technical or pedagogical information.[4]

A "collection," in the DLESE context, is defined as a set of metadata records for "a group of related resources that reflect a coherent, focused theme"[5]. All educational resources accessible through the DLESE Discovery System are collectively known as "The DLESE Collection." The DLESE Collection can be subdivided along two axes (figure1): according to degree of review scrutiny (i.e. Broad vs Reviewed) and according to the means by which the resources entered DLESE (i.e. Themed vs Community).

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[1] With input from Susan Buhr, Ed Geary, Shelley Olds, and Barbara DeFelice. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

[2] DLESE (2001). DLESE Strategic Plan

[3] from the on-line overview of DLESE: www.dlese.org/resources/index.html

[4] "Granularity" page of DLESE metadata website: www.dlese.org/Metadata/collections/granularity.htm

[5] Educational Resources overview: www.dlese.org/resources/index.html

The *DLESE Reviewed Collection* consists of resources that have been rigorously reviewed against seven selection criteria: scientific accuracy, pedagogical effectiveness, completeness of documentation, ease of use for teachers and learners, ability to inspire or motivate learners, importance or significance of the content, and robustness as a digital resource. There are multiple pathways to the Reviewed Collection (Table 1), but all pathways use these same selection criteria. The meaning of these selection criteria is further spelled out in the DLESE Reviewed Collection (DRC) Best Practices[6]. The rationale for maintaining the Reviewed Collection is to help library users find exemplary teaching and learning materials, and to help resource creators achieve academic career recognition. Inclusion in the Reviewed Collection of DLESE is intended to be analogous to publication in a peer-reviewed journal.

The *DLESE Broad Collection* comprises resources that are relevant to Earth System Education and function reasonably well, but have not been scrutinized against the seven selection criteria of the Reviewed Collection. Since April of 2003, new resources being considered for the DLESE Broad Collection have been assessed against additional guidelines: attribution as to origin, sound scientific principles and current scientific knowledge, obvious and intended utility for teaching or learning, lack of distracting advertising, and free or low cost to educational users.[7] The rationale for maintaining the Broad Collection is to provide an extensive variety of resources, and to provide a forum in which resource users can provide feedback to help creators iteratively improve the quality of individual resources.

The *DLESE Community Collection* comprises resources that have been individually contributed and cataloged, either as part of funded comprehensive gathering/cataloging efforts or as voluntary contributions from individuals in the DLESE Community.

*DLESE Themed Collections* are distinct named subcollections within the DLESE Collection, with an organizing principle such as a topic, audience, teaching strategy or some other criteria that can be clearly articulated[8]. The DLESE Discovery System permits a user to confine his or her search to specific themed collections. A themed collection may be part of the DLESE Reviewed Collection or part of the DLESE Broad Collection.

As of March 5, 2005, the distribution of resources in the DLESE Collection is as follows:

- Broad Collection (9178) versus Reviewed Collection (561 resources)
- Themed Collections (3997) versus Community Collection (5742)
- Grand total: 9739 resources

The DLESE Themed Collections currently comprise slightly more than a third of the total DLESE Collection. They include a balance of contributions from universities, government agencies, a K-12 collaborative, and the private sector (Table 2).

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[6] Best Practices for the DLESE Reviewed Collection: www.dlese.org/Metadata/collections/drc-best-practices.htm

[7] DLESE Resource Quality Guidelines: http://www.dlese.org/Metadata/collections/resource-quality.htm

[8] DLESE, 2004a, Accessioning and Deaccessioning Policy: www.dlese.org/documents/policy/collections_accession.html

Everything discussed so far is a resource collection, i.e. a collection of resource metadata records, each of which directly describes what is contained in a web-based educational resource. DLESE also contains several other non-resource collection types. *The DLESE News & Opportunities Collection* contains metadata to describe events or time-sensitive resources that have specific start and end dates, for example, grants, scholarships, conferences, etc. An *Annotation Collection* contains annotation metadata records, which provide information about an educational resource that is not directly found in the educational resource itself, for example comments by users. The Community Review System (CRS) is currently DLESE's only annotation collection, serving annotations that point to teaching tips, comments, editor's summary, tally of scores on review rubrics, and recommendations for use of the resource with specific audiences.[9] Annotations have been suggested for several other uses in DLESE, including calling attention to critical thinking resources or history of science resources[10].

***Growth, Scope & Balance of the DLESE Collections:***

The scope of resources that are appropriate for inclusion in DLESE is given in the DLESE Scope statement. The crucial wording is "…the DLESE collection provides access to Earth system education materials with particular emphasis on interdisciplinary areas. The collection offers access to materials that bring the Earth System into the classroom or learning site, and that demonstrate the application of science to solving real world problems. All geographic areas on Earth are included in the scope of the collection, as well as the atmosphere and the solar system. DLESE users include educators, learners, and researchers, at all educational levels, in both formal and informal education settings"[11]. In practice, DLESE has welcomed resources that deal with constituent disciplines of Earth Science, resources that deal with interactions between natural systems and humanity, and resources that deal with educational matters of concern to educators in the DLESE community (figure 2). In other words, DLESE has welcomed resources that can be aggregated to craft an interdisciplinary education, not just resources that are interdisciplinary when considered in isolation.

The DLESE Collection opened for business with 845 resources at the Annual Meeting in 2001. Since that date, the Community Collection has grown steadily (figure 3). Most of the Community Collection resources have been gathered through three funded gathering and cataloging efforts: an initial testbed collection at the DLESE Program Center, followed by efforts at Montana State University, and through an NSDL-funded collection project (Foothill College, the American Geological Institute (AGI), Dartmouth College, Lamont-Doherty). These projects explicitly aimed to populate the library across its full scope.

In addition, a trickle of resources came into the Community Collection through the Community Cataloging page and the "Suggest a URL" site. The early Community Cataloging and "Suggest a URL" pages have been replaced by the more user-friendly

[9] Kastens, 2005.
[10] Kastens, 2004a
[11] DLESE, 2004b, Collection Scope and Policy Statement: www.dlese.org/documents/policy/CollectionsScope_final.html

"Suggest an Interesting Earth System Site,"[12] which is generating an increased stream of community-contributed sites. Each site coming in through the "Suggest…." page is cataloged by the metadata group at the American Geological Institute and serves as a nucleus for additional gathering; this is one mechanism for preventing the library from becoming unbalanced and "lumpy" (see Challenges below).

Themed Collections have been accessioned in bursts, prior to the 2003 and 2004 Annual Meeting respectively (figure 3).

Even though the collection has grown impressively, we have reason to think that we are far from reaching the point of diminishing returns in collecting. Collectors report no problems finding resources that fall within DLESE's scope and quality guidelines and are not yet in the collection. And users still encounter null results searches (i.e. no resource match their search or browse request) too frequently[13].

The scope and balance of the DLESE Collections have been monitored by an ongoing collections assessment program. "Collections Assessment" is a "systematic comparison between an actual collection of materials in a library and the collection of materials desired by the users, staff, funders and/or overseers of the same library as expressed in the collection policy, types of materials requested by the community, user feedback, and searches for material"[14]. The DLESE Collections have been methodically assessed along three dimensions based on attributes recorded in the metadata: topic, grade level, and resource type. Each quarter, the percentage of all requests (searches plus browses) that fall in a given category is compared against the percentage of resources in the collection in that same category (figure 4 top). If a category is receiving many requests but has few resources, we take that as an indicator that more collecting may be needed in that domain (figure 4 bottom). Early in the collection building effort, such analysis suggested that we were under-resourced in K-12 resources relative to the percentage of requests, so we directed collecting and cataloging effort in that direction. More recently, such analysis lead to a targeted campaign to collect and catalog audio resources[15].

A digital library is unlike a grocery store (or even a traditional library) in that "stock" taken by one user is still available for the next user. To dig deeper into what kind of requests are going unfilled, the collection assessment project has also investigated null results searches. This analysis showed that searches for pollution-oriented resources, geotechnical resources, earth system-focused resources, and very specific searches (e.g. for a specific geographic area, fossil name, or event) tended to yield no results.

[12] Suggest a Resource page: http://www.dlese.org/suggestor/index.jsp
[13] Apedoe 20004a, 2004b, and DeFelice, 2003
[14] DeFelice, 2003
[15] Kastens *et al*, 2004

### *Quality of the DLESE Collections: Metadata*

Quality of the DLESE Collections has two aspects: metadata quality and resource quality.

DLESE is a library of metadata. A library with poor metadata is a library in which users cannot find what they want, and library administrators cannot assess the scope and balance of their collection. Metadata quality also has two aspects[16]: the quality of the metadata framework(s), and the quality of the specific metadata associated with each resource.

DLESE's metadata frameworks[17] specify in detail what information must be provided ("required metadata fields") for DLESE resources, collections, annotations, and news & opportunities and additional desirable and suggested information ("robust metadata fields") (Table3). DLESE's metadata framework was originally based on the existing IMS metadata[18], but the DPC metadata group has greatly expanded and refined the framework with much iterative community input and in partnership with NASA's Joined Digital Library (JDL) and the Alexandria Digital Earth Prototype (ADEPT). Aspects of DLESE's metadata framework have been adopted by other libraries throughout the National Science Digital Library (NSDL). DLESE has developed an online tool, the DLESE Catalog System or DCS,[19] that embodies the DLESE metadata framework and the associated DLESE Cataloging Best Practices guidelines. The DLESE Catalog System is being expanded to accommodate additional metadata fields. The planning for this renovation has been a collaborative, distributed effort involving input from all current cataloging groups, with a record of discourse and supporting documents shared via a swiki[20].

Catalogers use the DLESE Catalog System to populate the resource metadata fields with specific information pertaining to a resource. Many hands and eyes have contributed to the item-level metadata of the resources in the DLESE collection, including information professionals (e.g. at the American Geological Institute), students hired and trained as part of funded collecting efforts (e.g. Montana State), resource creators cataloging their own resources (e.g. Atmospheric Visualization Collection), and educators (e.g. the DWEL collection).

To minimize problems of metadata quality, DLESE takes the following steps[21]: First, the Catalog System checks for duplicate and similar URL's before it allows cataloging to begin. Second, when the draft metadata of a Community Collection item is submitted, the record is reviewed by staff at the DLESE Program Center (DPC) and may be edited for completeness and quality. Next, come automated checks for completeness of the required metadata and conformity to controlled vocabularies. Only after these checks are passed successfully is a resource ingested into the Community Collection. For resources in themed collections, the first check on metadata quality is an automated check

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[16] Tahirkheli, 2004
[17] Metadata, collection building and cataloging: http://www.dlese.org/Metadata/
[18] DLESE-IMS framework: http://www.dlese.org/Metadata/dlese-ims/
[19] Launch DLESE Resource Cataloger: http://catalog.dlese.org/catalog/launch.html#
[20] Project-DCS swiki: http://swiki.dlese.org/Project-DCS/1
[21] Duval, 2004

by DPC staff, which tests every resource for the existence of required metadata. Then, the Collections Accessioning Task Force of the Collections Standing Committee manually reviews the metadata for a sample of resources. This check was added in spring of 2004[22] after the initial round of collection accessioning revealed problems with default placeholders and inconsistent metadata. If the metadata do not conform with DLESE Metadata Best Practices[23], the collection developer is notified and no resources from that collection are accessioned.

The entire metadata collection is checked twice a day for broken links, and duplication of URL's or content. If links remain broken, the creator and/or collection builder is contacted. If the problem can't be resolved, the item is removed from the Discovery System. Less than 1% of the DLESE Collection is "broken" at any time.

In spite of these checks and balances, issues with DLESE metadata quality remain. The most common metadata-related user complaint is that the assigned grade level is inappropriate. There are several reasons for this: first, resources appropriate for the general public that were accessioned into DLESE in the first year were assigned to all grade levels. Second, many of the resources in DLESE are intended for use by teacher rather than students and are cataloged according to the grade level of the beneficiary of the resource (e.g. a primary school student); users then complain that students at that grade level cannot use the resource directly themselves. Third, assignment of grade level is inherently subjective; where the resource creator has not specified grade level, the cataloger must employ his or her own judgment to a degree not required in the other metadata fields.

Another set of metadata issues has to do with additional information that various constituencies would like to see included in the metadata. The most common user-complaint in this regard is that the education standards cover national standards only, whereas teachers need resources that align with state or local standards. Even within the national standards, education standards metadata are not broken down to the most detailed available level.

### *Quality of the DLESE Collections: Resources*

The second aspect of Collection quality concerns the quality of the actual resources that are pointed to by DLESE's resource metadata records.

The two subdivisions of DLESE, the DLESE Broad Collection and the DLESE Reviewed Collection, promise two different levels of quality control.

The Reviewed Collection offers a relatively small number of resources that have been reviewed by an approved, rigorous process against a challenging set of well-defined criteria. There have been few, if any, complaints about the quality of individual resources in the DLESE Reviewed Collection. Remaining issues with the DRC are that some users find the whole concept of multiple pathways to the Reviewed Collection confusing, and some users wonder why they can't read reviews of all Reviewed Collection resources.

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[22] Tahirkheli, 2004

[23] Cataloging Best Practices: http://catalog.dlese.org/catalog/cataloger/editor/best_practices.jsp

The Broad Collection promises a wide range of resources with the trade-off that quality may be more uneven. Over the history of DLESE[24], the level of scrutiny applied to resources entering the Broad Collection has ratcheted up. At DLESE's founding workshop (Coolfont, West Virginia, August 1999), some community members favored a completely open collection, incorporating all suggested resources from the community, with no censorship or judgment. When the library opened to the public, two accession threshold criteria were in place: relevance to Earth System education, and basic functionality. The catalogers and DPC Quality Assurance staff enforced these criteria. Following the 2003 Quality Workshop[25], one additional accession threshold criterion (attribution) and several additional guidelines (sound scientific principles, current scientific knowledge, obvious and intended utility for teaching or learning, lack of distracting advertising, and free or low cost to educational users) were implemented.

DLESE does hear formal and informal criticisms about individual Broad Collection resources. In keeping with original vision of the Broad Collection as a venue for constructive feedback by resource users, DLESE offers several self-correcting mechanisms that can lead to the improvement or removal of resources in which the community has found flaws. Next to the description of every resource in the DLESE Discovery System, is a link to "Submit a Comment or Teaching Tip." Comments submitted here are vetted by Community Review System staff for profanity, obscenity, and gratuitous insults, and then forwarded via an RT (Request Tracking) System to the resource creator, the DPC metadata staff, or the Collections Committee deaccessioning process for appropriate action. For most for-the-classroom resources, the Discovery System offers a second link to "Submit a Review." These detailed user reviews from Community Review System are forwarded directly, but anonymously, to the resource creator for use in revising the resource. Finally, if a user thinks that a resource should be removed entirely from the DLESE Broad Collection, he or she can invoke the DLESE Deaccessioning Policy[26], which calls for a review of the challenged resource by the Collections Standing Committee. Users can initiate a reconsideration of a resource either by checking a box on the "Comment" page for that resource, or via a webform[27] reached from the Educational Resources menu.

***Collections Challenges:***

Building a successful DLESE collection is a balancing act, which requires negotiating between conflicting priorities. DLESE is grappling with the following tensions and challenges:

*Balancing growth versus quality:* Every time a student or teacher searches in DLESE and finds no resource that matches his or her desired criteria, DLESE risks losing

[24] Kastens *et al*, 2003
[25] Quality Workshop Report and Recommendations: http://www.dlese.org/documents/reports/collections/quality_wkshop.html
[26] DLESE Accessioning and Deaccessioning Policy: http://www.dlese.org/documents/policy/collections_accession.html
[27] Request for Reconsideration of a DLESE Resource: http://www.dlese.org/resources/reconsideration.html

a user or potential user back to Google[28]. Every time a scientist finds an error of fact in a DLESE resource, DLESE's reputation for quality suffers. The former problem encourages us to continue to grow the library collection briskly; the latter problem encourages us to take the time to scrutinize every detail of every resource before ingestion. In a world with limited time and money, there is an inherent tension between these two desires. A partial solution to the former problem may be found in improvements to the search engine, so that users are less likely to confront a "false negative" null-return when there is, in fact, a suitable resource in the library. A partial solution to the latter problem may be found in the new "Reconsider a Resource" capability, whereby DLESE users can request that a resource be considered for deaccessioning. One difficulty in weighing the balance between growth and quality is that we don't have a good handle on the relative cost of bringing a resource into the Broad Collection versus bringing a resource into the Reviewed Collection.

*Seeking Educational + Scientific + Technical Quality:* The DLESE Reviewed Collection sets a high bar, requiring that resources be scientifically accurate, pedagogically effective, well-documented, easy to use for teachers and learners, inspirational or motivational for learners, robust as a digital resource, and important/significant in content. This is a daunting list for resource developers, but it is also a challenge for the designers of a review system. The seven review criteria span at least three different domains, which have historically been evaluated by different kinds of experts with drastically different procedures and values. The scientific community evaluates "Scientific accuracy" of a report or paper by anonymous peer review by other researchers working on the topic. The gold standard for summative evaluation of "pedagogical effectiveness" is review by an independent educational evaluator through classroom observation and assessments of student learning among multiple classes of students using and not using the resource.[29] The most stringent review for "Robustness as a digital resource" is the Quality Assurance system implemented by commercial educational software publishers, which involves testing the materials to failure on a wide range of hardware and operating systems, and methodical tracking of bugs and potential bugs through a data base. With thousands of resources and limited dollars, DLESE cannot replicate every aspect of these three intensive evaluation procedures.

*Reviewing Resources Fairly, Accurately and Affordably:* DLESE's multiple pathways to the Reviewed Collection (Table 1) can be viewed as a series of parallel experiments in how to obtain the most essential insights about a resource in a way that is fair, transparent, accurate, affordable and scalable. All groups found that great care must be invested in articulating clear guidance for reviewers in the form of rubrics or questions; simply stating the seven selection criteria is insufficient. The Journal of Earth System Education (JESSE) adopted a set of innovative procedures called "partnership reviewing," or "open peer review." Although this process offers several theoretical advantages over traditional peer review, JESSE was not able to build a constituency for this unfamiliar model among either reviewers or authors during the limited time they had available for their experiment. The DWEL group discovered that two reviewers sitting side-by-side looking at the same criteria and the same resource can rate the resource very

[28] Apedoe 2004a, 2004b
[29] Stevens, 1993; Fletchling, 2002.

differently. They were able to develop a calibration/training process, involving a face-to-face workshop and ongoing email discussion, which lead to much higher inter-rater reliability. DWEL chose to use K-12 master teachers as reviewers. This worked well for the pedagogically oriented criteria, but their review for scientific accuracy was uneven.[30] The NASA review process for educational materials uses multiple kinds of experts: classroom teachers, education specialists, informal educators, and scientists, coordinated by teleconference. NASA found they had to differentiate the questions according to reviewer and audience, with separate review forms for K-8, 5-12, college-level resources, and for scientist-reviewers. Unique among the DLESE review pathways, NASA expects that the products should have been field tested before being submitted for review.[31] The NASA process developed independently of DLESE, and NASA's review criteria were "cross-walked" onto DLESE's criteria. This crosswalk is not a good fit in all cases; for example DLESE's "importance or significance" maps onto NASA's "Relevance to NASA's Earth Science Enterprise." The Community Review System (CRS) does explicitly test for all seven of the Reviewed Collection selection criteria, and does incorporate observations of how well the resource worked in the hands of actual users. It also generates insights about the resource that are shared as annotations for other users and potential users. But the distribution of incoming community reviews is heavily skewed, with a handful of resources receiving dozens of reviews and passing easily into the specialist review phase, while the vast majority of resources languish with one or two or no reviews. On balance, much has been learned about reviewing of educational resources, but the perfect system has not been found.

*Avoiding a "lumpy" library:* The ideal DLESE collection would be well-populated across all areas of DLESE's scope, with respect to topic, grade level, and learning resource type. The early DLESE collection-building efforts aimed to populate the initially-empty library across its full scope. The current strategy of relying increasingly on accessioning of themed collections assembled by groups interested in a specific topic, audience, data type, or other theme, tends in the opposite direction: towards a library that is rich in resources of interest to well-organized interest groups, and relatively impoverished in resources not so favored. DLESE should certainly continue to tap into the energy and expertise of collection-building groups. But at the same time, we need to continuously monitor the scope and balance of the overall collection, and develop mechanisms to fill gaps and thin spots in the collection.

*Identifying appropriate and effective incentives:* To fulfill DLESE's vision of a library built by the users for the users, we need to mobilize educators, learners and scientists across the country to suggest resources for accessioning, to build themed resource collections and annotation collections, to contribute reviews, teaching tips and comments, and to alert the library staff of flawed resources that should be considered for deaccessioning. Within NSDL, DLESE is admired for its success in building a community of user-contributors, but we need to do much more. We need to figure out what combination of peer-expectation, professional recognition, awards, rewards,

[30] Ed Geary, personal communication, March 2005.
[31] NASA Earth Science Education Product Review website : http://science.hq.nasa.gov/education/ed_product_review.html

community-building events, stipends and grant-funding opportunities will lure passive users of DLESE into active participation in the collection-building process.

*Coping with resource instability:* Because control of each resource remains with the resource creator or publisher, resources can disappear or change without notice. When a resource changes, its metadata, review status or annotations may no longer be accurate. DLESE has taken one step to cope with resource instability, by implementing twice-daily checks for dead-end links. We have not addressed the more subtle problem of resources that have deteriorated, or merely changed, behind an unchanged URL. Archiving some or all of the resources in the DLESE Collection has been discussed. A substantial obstacle seems to be that DLESE would then be liable for intellectual property violations within individual resources, a liability we currently avoid by merely linking to resources. A system for keeping track of changes (version control), accompanied by a re-examination of drastically-altered resources, has been discussed, but no cost-effective path towards such a system has been identified. Neither archiving nor version-control can cope gracefully with a web site on which change is a constant and intentional feature, for example a site with frequently updated real-time data.

*Nurturing distributed collection-building efforts:* DLESE's strategy of accessioning themed collections has the potential to tap into the expertise and experience of motivated groups of people with vast knowledge of, and passion for, a specific topic or audience. By devolving responsibility to distributed collection-building groups for identifying valuable resources within a theme-domain and documenting those resources in metadata, DLESE-central inevitably gives up some control over what ends up in the library. DLESE is struggling to find the right balance of procedures and policies that respect and reward the effort and professional expertise of distributed collection-building groups, while maintaining a requisite level of consistency and quality-control over library resources and metadata.

*Providing appropriate resources across a wide range of ages, abilities and knowledge-levels:* DLESE aspires to provide resources for everyone "from K to gray." In practice, DLESE does not put much effort into providing resources suitable for professional scientists or advanced graduate students seeking information in their area of research specialization, feeling that such needs are well-served by GeoRef and other indices into the scientific literature. Even allowing for this exception, DLESE is still aspiring to serve a very wide audience, in terms of developmental stage, reading level, prior knowledge of science, and prior knowledge of earth systems. As a consequence, DLESE must, and does, provide multiple resources on the same topic, and then permits the user to search by grade level. The grade level coding is inherently imperfect, in that developmental stage, reading level, and prior knowledge of earth systems don't advance in lockstep; some middle school students know far more about dinosaurs, for example, than most college students. Different constituencies within DLESE pull in different directions when setting priorities for collection development: if tradeoffs have to be made, K-12 educators vote for a collection with "high quality resources but gaps and thin spots," whereas many college educators and developers vote for a "comprehensive library with variable quality resources"[32]. DLESE has barely begun to grapple with the problem

[32] Buhr, 2004

of how to identify and provide access to resources suited for learners with abilities or background very different from that of the middle-class, college-educated, environment-loving people who typically develop DLESE resources. The "challenging audience" capability of the DLESE Community Review System provides some empirical recommendation-engine data about the suitability of DLESE resources for specific audiences such as those with limited English or hearing impairment[33].

*Balancing the pros and cons of increasingly information-rich metadata:* DLESE's diverse audiences each wish to be able to search for resources in the DLESE collection according to parameters that matter to them personally. Over time, new fields have been added to the DLESE metadata framework to capture information of interest to specific audiences. This trend towards increasingly information-rich metadata is good in that it allows discovery for specific purposes of interest to users. But the same trend is problematic in that the cost and difficulty of cataloging increases, which in turn means that fewer resources can be cataloged by either funded cataloging groups or by the community. Beyond a certain point, the complexity of information in metadata exceeds that which can be exposed in an easily-navigated Discovery System. Even with the currently-available Discovery System parameters, the likelihood of a failed search (null-return) increases for more highly-qualified searches[34].

*Finding, catalyzing, and cataloging pedagogical content knowledge resources:* Most of the resources in DLESE are aimed at helping learners understand the Earth system--in other words resources designed to foster content knowledge about the Earth. DLESE should also provide resources explicitly aimed at helping educators understand how to teach more effectively about the Earth system--in other words, resources designed to foster pedagogical content knowledge pertaining to the Earth[35]. Pedagogical content knowledge (PCK) is knowledge needed to teach effectively in a discipline, as opposed to knowledge of the discipline itself[36]. PCK includes such things as what ideas about or understandings of a concept students are likely to have before instruction, typical difficulties students tend to have learning a given concept or topic, and how to assess what students have learned about a given topic. DLESE can provide PCK either embedded within other resources (e.g. in a teachers' guide section of the instructions for a lab) or as free-standing resources designed for educators. Examples of the latter include: Teaching Quantitative Skills in the Geosciences[37] and The Private Universe Project[38]. DLESE would serve education well if it were to seek out those PCK-rich resources about the Earth and environment that do exist, and catalyze the creation of such resources where none exist. In addition, DLESE needs to find ways to make it easier for educators to find PCK-rich resources, once they are in the collection. Useful steps may include extending DLESE's metadata framework to include pedagogical information,[39] or

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[33] Kastens et al, 2004, Kastens 2005
[34] DeFelice, 2003
[35] Kastens, 2004b
[36] Shulman, 1986; Shulman, 1987; Hassard, 2005
[37] Teaching Quantitative Skills in the Geosciences: http://serc.carleton.edu/quantskills
[38] A Private Universe Project: http://www.learner.org/teacherslab/pup/index.html
[39] Recommendations from 2004 Quality Workshop: http://www.scieds.com/research/dlese/pdf/qp_recommendations.final.pdf

developing an annotation service to point out pedagogical resources that are related to specific earth system resources.[40]

*Understanding what users want:* A profound difference between a digital library and a traditional bricks & mortar library is that the traditional library begins with a defined and more-or-less captive constituency (the inhabitants of X village, the students and faculty of Y school or university), whereas a digital library must build its constituency through a spiraling, iterative process. A first-cut collection is assembled, which attracts some early-adopter users, who feed back to the library builders their desires about what they would like to see in the library, and the library broadens and deepens in those directions, and the broader/deeper library attracts new users with interests in those areas, who in turn feed back their desires about what they would like to see in the library, and so on. DLESE's feedback mechanisms, our mechanisms for knowing what users want in the collection and responding to those desires, are imperfect. The DLESE Collections Assessment effort, under the direction of Barbara DeFelice, has pulled valuable insights out of analysis of users' requests via the Discovery System, but this effort ended with the December 2004 data set.[41] The strand group reports at annual meetings are another valuable source of user-desire information, as are focused usage studies by the Evaluation core services and Community core services groups, but these efforts reach small numbers. DLESE needs to continue to foster mechanisms to understand what users want in the Collection, and to pay attention to those desires. If we fail to attend to users' desires, people will simply not come to our library in influential numbers. We need to acknowledge that there is an inherent tension between a user-centered philosophy, which values the distributed wisdom of practice in the education community, and a reform agenda, which holds that much of what is being done in science education today is ineffective or misguided. Both of these values are deeply embedded in DLESE, and both are of high value, and both can be held simultaneously and acted on in parallel if we recognize the complexity of the educational enterprise—but it's not easy.

[40] Kastens, 2004a.
[41] DLESE Collections Assessment Website: http://www.ldeo.columbia.edu/edu/DLESE/assessment/index.html

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## Table1: Pathways to the DLESE Reviewed Collections

There are multiple "pathways" by which a resource can enter the DLESE Reviewed Collection. All pathways are supposed to evaluate resources against the same seven selection criteria, plus they may add additional criteria. In addition, the review process should be an arms-length process in which the reviews are conducted by individuals not connected to a resource's creation or publication (DLESE, 2004).

**DWEL (dwel.dlese.org)**

*Description:* a resource collection seeking exemplary resources for K-12 and informal education focusing on the science, economics and policy issues of water.

*Criteria:* Standard DRC criteria minus "Importance/significance," plus "Alignment with identified core water concepts in national and state science and geography education standards, " and "Applicable to K-12 or informal learning environments."

*Review Procedure:* DWEL resources are identified and cataloged by practicing teachers from K-12 schools and science educators from informal setting organizations. Four working groups represent the teachers and learners in grades K-4, 5-8, 9-12 and the informal education setting. Gathering and cataloging of resources was clustered into topical "campaigns" to facilitate comparison of resources on the same topics. Resources are reviewed against a set of 25 questions by the educator who found the resource and at least one other educator. If multiple resources are found for the same audience on the same topic, only the highest scoring (most "exemplary") resource is included.

*Documentation:* http://www.csmate.colostate.edu/dwel/scopestatement.html; http://www.csmate.colostate.edu/dwel/Pathway.htm

**GLOBE Program Collection**

*Description:* a resource collection comprising the Teachers' kit and other materials that support teaching and learning in the GLOBE program (an international program in which K-12 students collect, share and analyze environmental data.)

*Review Criteria:* Seven standard DRC selection criteria

*Review Procedures:* The GLOBE program as a whole has passed NASA's Earth Science Education Product Review (see below under NASA-ESE Reviewed Collection). The individual resources in the GLOBE Program Collection within DLESE have not been independently reviewed.

*Documentation:* http://www.globe.gov/fsl/html/templ.cgi?dlesescope&lang=en&nav=0

**JESSE (http://jesse.usra.edu/)**

*Description:* an interdisciplinary electronic journal publishing resource on pedagogical, educational, historical, and cultural aspects of Earth system science [currently inactive].

*Review Criteria:* Seven standard DRC selection criteria.

*Review Procedures:* JESSE uses a peer commentary or open peer review system (also sometimes called "partnership reviewing") in which editors, reviewers and the resource author communicate openly through a review tool called the Digital Document Discourse Environment (D3E) to collectively critique and evaluate the resource.

*Documentation:* http://jesse.usra.edu/infoforreviewers.html; Weatherly et al (2002)

## Table1: Pathways to the DLESE Reviewed Collections (continued)

**NASA - Reviewed Collection**

*Description:* a resource collection emphasizing resources that support the NASA Earth Science Enterprise education mission.

*Criteria:* (1) relevance to NASA's Earth Science Enterprise, (2) Relevance to education, (3) Accuracy, (4) Appropriate, complete and effectively-presented material, (5) Production/design quality is high, (6) Easy to use and free from technical difficulties, (7) product includes good and relevant references, (8) accessibility, and (8) Conformance with Children's Online Privacy Protection Act (COPPA). The criteria differ slightly for different audiences. The collection scope statement provides a cross-walk between these criteria and the DRC selection criteria.

*Review Procedures:* Resources in this collection have passed through NASA's Earth Science Education Product Review. The review is performed by panels consisting of classroom teachers with experience at the appropriate level, education specialists who are familiar with the current trends and needs in science education and knowledge of national education standards , informal educators, and scientists with a relevant background in the science content of the materials being reviewed. The reviews are conducted for NASA by the Institute for Global Environmental Strategies (IGES), a non-profit education organization.

*Documentation:* http://www.dlese.org/Metadata/collections/scopes/nasa-eserev.htm#review; http://www.strategies.org/NASA_Reviews_Forms/EvaluationCriteria.html; http://science.hq.nasa.gov/education/ed_product_review.html

**Community Review System (crs.dlese.org)**

*Description:* (1) a pathway by which resources can move from the DLESE Broad Collection to the DRC without necessarily being part of a themed collection, (2) an annotation collection disseminating evaluation and feedback information from resource users.

*Review Criteria:* Seven standard DRC selection criteria

*Review Procedure:* The Community Review System (CRS) uses a two-phase review process. In the community review phase, people who have used a DLESE resource to teach or learn fill out a web-based questionnaire about the resource. When a resource has accumulated ten community reviews with high scores, it moves on to the specialist review phase. In the specialist review phase, an editorial review board recruits two specialists with expertise in the science content area of the resource plus two with pedagogy expertise for a second review phase. Finally, the CRS Editor examines the aggregated reviews and based on these, determines whether or not the resource qualifies for the Reviewed Collection.

*Documentation:* http://crs.dlese.org/contributors.html; http://crs.dlese.org/scope.html; Kastens (2005)

## Table 2: Themed Collections within DLESE

The DLESE Reviewed Collection contains the following Themed Collections:

- DWEL (Digital Water Education Library) [305]*[42]
- GLOBE (Global Learning & Observations to Benefit the Environment) [27]
- JESSE (Journal of Earth System Science Education) [1]
- NASA Reviewed [164]

The DLESE Broad Collection contains the following Themed Collections:

- ADL (Alexandria Digital Library) [6]
- AVC (The Atmospheric Visualization Collection) [29]
- COMET (Cooperative Program for Operational Meteorology, Education & Training) [77]
- CURL (Curricular Resource Library, from Weslyan University) [10]
- Cutting Edge Collection (from the Science Education Resource Center at Carleton College) [491]
- Discover our Earth (from Cornell Earth Information Systems Project) [7]
- EET (Earth Exploration Toolbook from TERC) [15]
- EMVC Geology Materials (Educational Multimedia Visualization Center at the University of California, Santa Barbara) [6]
- DLESE Evaluation Toolkit [70]
- NAP Earth & Life Sciences (National Academy Press) [157]
- NASA ED Mall Collection (from NASA Goddard Space Flight Center's Education Office) [72]
- NASA Scientific Vis [Visualization] Studio (from NASA Goddard Space Flight Center's Visualization Studio) [2089]
- Starting Point (from the Science Education Resource Center at Carleton College) [415]
- Visionlearning (from Visionlearning, Inc.) [47]

DLESE contains one annotation collection:

- The Community Review System collection (CRS)[43] [152 educational resources have at least one posted annotation; 163 educational resources have received at least one review]

[42] Numbers in square brackets indicate number of resources in that collection, as of November 2004. Note that the same resource may occur (and be counted) in more than one collection.

[43] The Community Review System is both an annotation collection and a pathway to the DLESE Reviewed Collection.

**Table 3**
**Required and Recommended Metadata for DLESE Educational Resources**
(source: http://www.dlese.org/Metadata/adn-item/0.6.50/index.htm)

| Required | Recommended |
|---|---|
| *Provided by Cataloger:*<br>• Title<br>• URL or access information<br>• Description<br>• Subject<br>• Technical<br>• Resource<br>• Audience<br>• Copyright<br>• Cost<br>• Resource creator<br>• Resource cataloger<br><br>*Provided by Collection Builder:*<br>• Language of the resource<br>• Language of the metadata<br>• Copyright of the metadata<br>• Terms of use<br>• Metadata framework<br>• Creation date<br>• Accession date<br>• Catalog name and number<br>• Record status | • Coverage (spatial and temporal)<br>• Science standard<br>• Geography standards<br>• Relationships between resources<br>• Keywords<br>• Additional technical information<br>• Interactivity type<br>• Interactivity level<br>• Typical learning time<br>• Duration of the resource<br>• Size of the resource<br>• Whom is the resource used by<br>• Whom does the resource benefit<br>• Instructional goal |

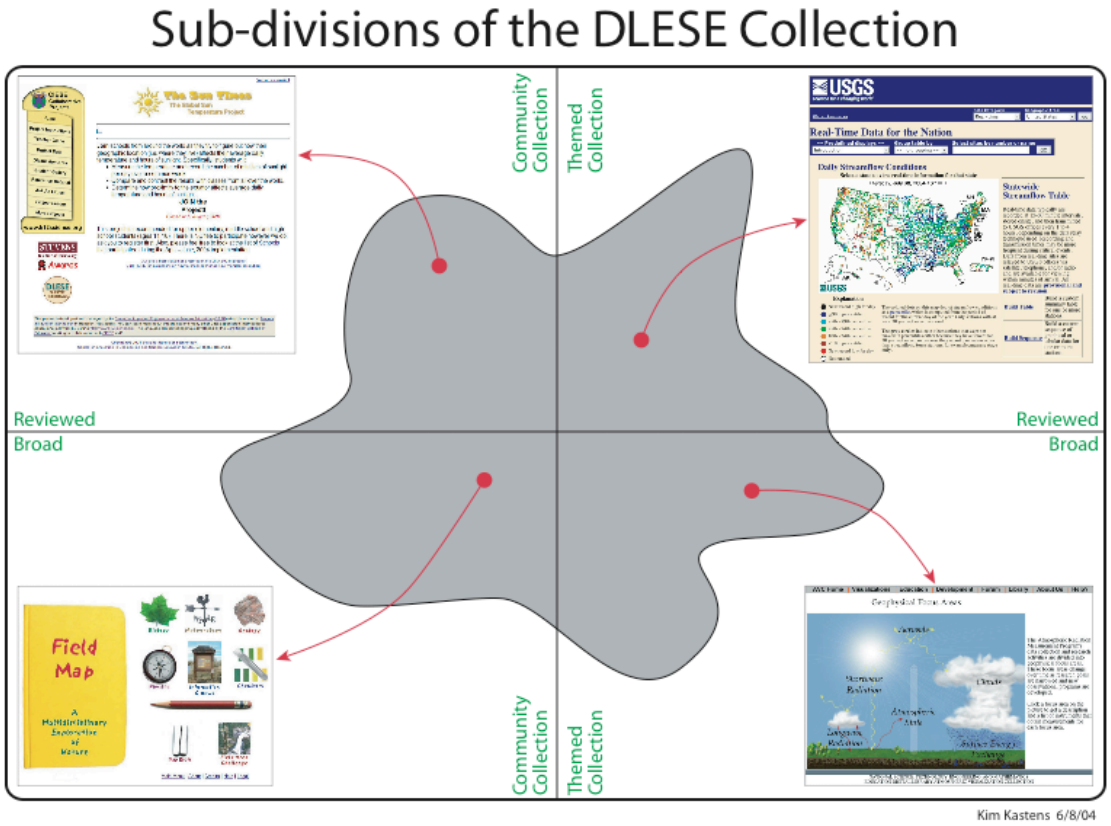



Figure 1: The DLESE collections (symbolized by the grey field) can be subdivided along two dimensions: according to degree of review scrutiny (the DLESE Broad Collection versus the DLESE Reviewed Collection), and according to the means by which the resources entered the collection (Community Collection versus Themed Collections).

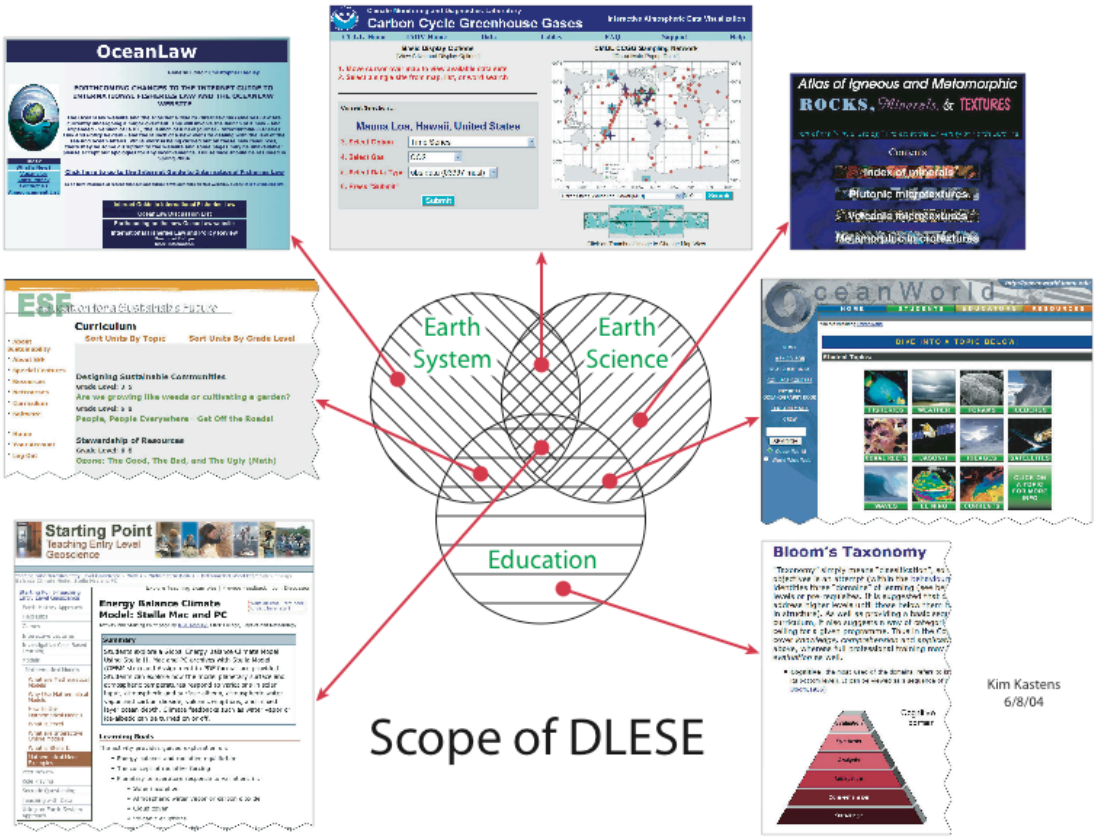



Figure 2: There has been much debate, and some disagreement, over the appropriate scope of DLESE's content domain. In this Venn diagram, the upper right circle represents resources in the classic science disciplines that deal with natural Earth processes. The upper left circle represents resources that deal with the Earth system, including interactions between humanity and the environment. Some of these are science resources (in the cross-hatched overlap), but others may focus on non-science aspects of the human-environment interactions, such as law, policy, or economics. The bottom circle represents educational resources, which may or may not pertain to the Earth explicitly. In practice, the DLESE Collection has welcomed resources in all of three fields--while seeking especially hard to find resources in the overlapping areas. An alternate view is that the DLESE collection should be restricted to resources that are educational in purpose and that deal with Earth System science (i.e. include only resources in the center overlap of the three circles), or that strictly educational resources with no Earth-content should be excluded (i.e. include only resources in the upper two circles.)

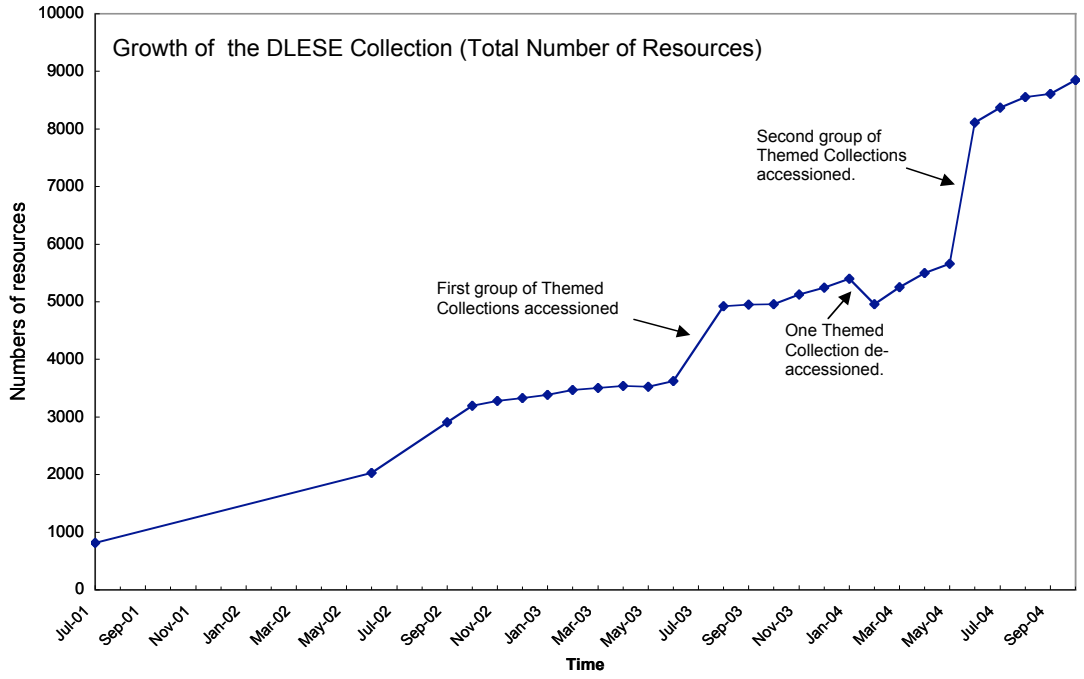
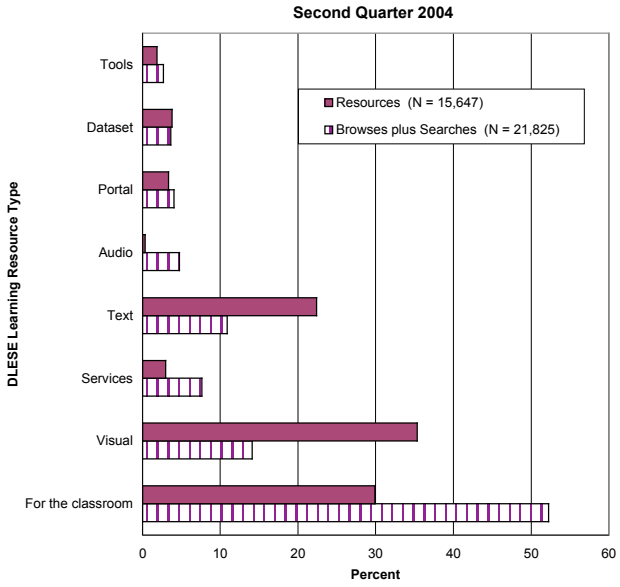



Figure 3: Growth of the DLESE Collection, in terms of total number of resources. When the collection opened to the public, at the 2001 annual meeting, it had 845 resources; by November 1, 2004, the collection had grown by more than an order of magnitude, to 8445 resources.



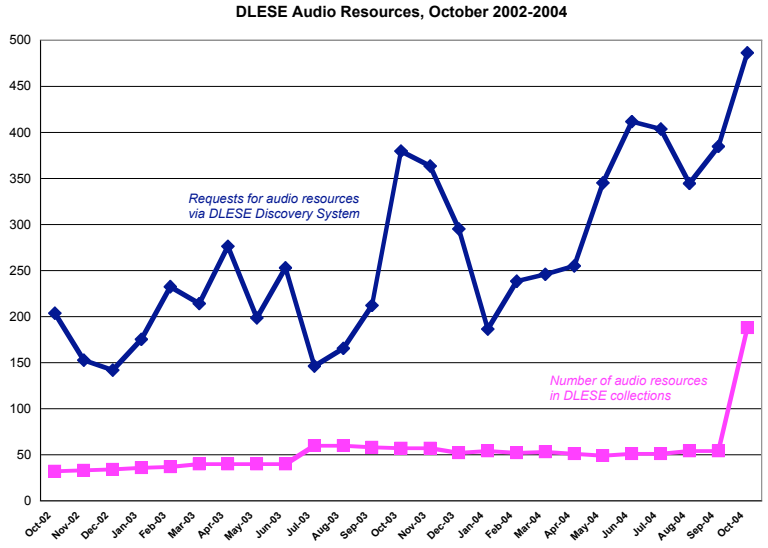




Figure 4: An example of the DLESE Collection Assessment and gap-filling process. (upper) Solid bars show what percentage of the resources in the DLESE Collection were cataloged in each major category of learning resource type. Striped bars show what percentage of the searches and browses coming in through the DLESE Discovery System asked for resources in those same categories. The relative size of the two bars in the various learning resource types is an indicator of whether the scope and balance of the actual DLESE collection matches the scope of and balance of the "desired collection" that users are asking for via search and browse. As of spring 2004, we noted an imbalance in the "audio" learning resource type: we were logging approximately 300 requests per month for audio resources, but had few such resources on offer. (lower) After two years of almost no growth in the audio resource category, we undertook a targeted effort to find and catalog audio resources in fall 2004 (from Kastens et al, 2004).