How Geography Professors Select Materials for Classroom Lectures: Implications for the Design of Digital Libraries

Christine L. Borgman
Dept. of Information Studies
University of California, Los Angeles
Los Angeles, CA 951520
borgman@gseis.ucla.edu

Gregory H. Leazer
Dept. of Information Studies
University of California, Los Angeles
Los Angeles, CA 951520
gleazer@ucla.edu

Anne Gilliland-Swetland
Dept. of Information Studies
University of California, Los Angeles
Los Angeles, CA 951520
swetland@gseis.ucla.edu

Kelli Millwood
Dept. of Education
University of California, Los Angeles
Los Angeles, CA 951520
millwood@ucla.edu

Leslie Champeny
Dept. of Information Studies
University of California, Los Angeles
Los Angeles, CA 951520
lchampen@ucla.edu

Jason Finley
Dept. of Psychology
University of California, Los Angeles
Los Angeles, CA 951563
jfinley@gseis.ucla.edu

Laura J. Smart
California State Polytechnic University, Pomona
Pomona, CA 91768
ljsmart@csupomona.edu

ABSTRACT
A goal of the Alexandria Digital Earth Prototype (ADEPT) project is to make primary resources in geography useful for undergraduate instruction in ways that will promote inquiry learning. The ADEPT education and evaluation team interviewed professors about their use of geography information as they prepare for class lectures, as compared to their research activities. We found that professors desired the ability to search by concept (erosion, continental drift, etc.) as well as geographic location, and that personal research collections were an important source of instructional materials. Resources in geo-spatial digital libraries are typically described by location, but are rarely described by concept or educational application. This paper presents implications for the design of an educational digital library from our observations of the lecture preparation process. Findings include functionality requirements for digital libraries and implications for the notion of digital libraries as a shared information environment. The functional requirements include definitions and enhancements of searching capabilities, the ability to contribute and to share personal collections of resources, and the capability to manipulate data and images.

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INTRODUCTION
One aim of digital libraries is to support information seeking, creation, and use to support instruction, from elementary through graduate school. Digital libraries (DLs) hold great potential for educational applications, as they can provide access to a wide array of information resources that are essential for inquiry. Science teaching long has relied on methods and information resources that train students to follow directions with little connection to doing real science. Although students are accustomed to this approach, most do not form a deep conceptual understanding of science or its methods [21]. More recent science learning standards [22] promote inquiry teaching as a means to help students develop deeper conceptual understanding of science. When students learn science through inquiry they are imitating practicing scientists [9, 20, 23]. Inquiry learning approaches that bring scientific or scholarly experiences to the classroom are central to integrating teaching and research at the undergraduate level [7, 8, 13]. A prerequisite for inquiry learning is to make resources collected by and for researchers available to students.

In an effort to explore the value of digital libraries for inquiry learning, we are developing a geo-spatial DL to support undergraduate education. The Alexandria Digital Earth Prototype Project (ADEPT) is a 5-year (1999-2004) effort based at the University of California, Santa Barbara (UCSB), with multiple partners. The ADEPT project is a part of the Digital Libraries Initiative Phase 2 (http://dli2.nsf.gov), whose goal is to develop effective digital library models. Earlier research by the ADEPT Education and Evaluation Team has explored geographic education, digital library design, and the practices and goals of faculty, teaching assistants, and students [5, 6, 12, 14].

Primary sources are the area of greatest potential for digital libraries in teaching. This is particularly true in areas such as geography for which rich collections of primary sources exist, but which lack tools or infrastructure for teaching applications. Access to primary sources is a pre-requisite for inquiry learning at the undergraduate level. If students are to learn to "think like" or "work like" scholars, they need opportunities to explore the same primary sources used by scholars [20, 23]. The greatest promise of ADEPT appears to be in facilitating access to primary source content for teaching. At present, the ADEPT collections consist only of resources contributed by the instructors who have used the successive prototypes in teaching. Development efforts have focused on capabilities to ingest data from the Alexandria Digital Library and other sources (including personal collections) rather than collection building, per se. As the volume and variety of resources in ADEPT expands toward critical mass, we hope that the value of the system will increase accordingly. This has been the experience of the Perseus Project (http://www.perseus.tufts.edu), which has collections in the classics, US history, and British history (1,696 texts, 65,177 images as of July, 2003). Characteristics of Perseus' use have evolved over time, as users find ways to combine and adapt resources from an ever-larger collection [11, 16, 18, 24].

Following efforts to address issues such as what should be in the collection, how should collection items be described, and what searching and manipulation capabilities are required, we decided to take a step back to address some fundamental questions about faculty information seeking and use to inform our design of the ADEPT digital library. The research reported here explores the information-seeking behaviors of geography faculty in support of teaching and research, with the especial goal of applying the results to the design of ADEPT. An upcoming paper (Borgman et al forthcoming) reports in detail on the method and findings of our information seeking study of geography professors; a summary of those findings are provided in this paper. This paper focuses primarily on the implications of that study for the design of a digital library for geographic education.

EDUCATION AND EVALUATION RESEARCH ON THE ALEXANDRIA DIGITAL EARTH PROTOTYPE (ADEPT)

The Education and Evaluation (E&E) Team of ADEPT consists of faculty and student researchers at UCLA and UCSB. We began work on the iterative design of the system when the ADEPT project was launched in 1999. Tasks have included observing undergraduate introductory courses in geography, assembling teaching materials from these courses, creating initial software specifications and a simple prototype, interviewing faculty and students, and analyzing the instructional content of physical and human geography courses taught at these two University of California campuses.

The evaluation of digital libraries is an area of emerging interest, as DLs move from research to practice. Particularly notable of earlier efforts is the multi-year, multi-method evaluation of the Perseus Project [18]. Evaluation is also a key area of the National Science Digital Library effort [17]. In 2002, the European Union DELOS initiative and the U.S. National Science Foundation jointly organized a workshop on evaluation of digital libraries [4], which concluded that research is needed on metrics and methods that can be applied in local contexts and on testbeds to allow comparisons between digital libraries.

Our initial evaluation efforts addressed *instructional delivery* in the lecture hall and in laboratory sessions; our UCSB partners on the Education and Evaluation team are focusing on student learning. In observing instructors in introductory courses, we found that they rarely cited specific sources of primary scientific evidence and spent little time relating scientific method to the development of geographic knowledge during lectures. However, these instructors indicated their desire to teach with primary observational data and images, which ADEPT could provide [6]. To do so would require a shift in the instructional design practices of faculty members. Thus we recognized that to understand how instructors might select, gather, organize, and present their lectures using a digital library, we would need a model of their behavior during *instructional preparation*. To understand how digital libraries might support instructional preparation, we needed to learn more about information seeking in support of teaching. We also wanted to know how these faculty define primary and secondary sources, and how those definitions might vary from definitions used by librarians (e.g., http://www.lib.berkeley.edu/teachinglib/guides/primarysources.html).

One finding from our first studies was that geo-spatial databases are organized better for research than for instructional applications [5]. Geo-spatial databases and digital libraries are typically organized, not surprisingly, by geo-spatial coordinates and by place names. Geographers are largely oriented toward the physical location of phenomena, whether rocks, climate, people, events, or social activities. Questions such as "what is known about X at this location (latitude, longitude)?" are readily answered. Questions about a geographic event or process are less readily answered, such as "find good examples of adiabatic processes," especially if qualified by pedagogical concepts such as "suitable for a freshman level course." Yet more complex are questions about people's everyday experiences in a particular place, which is a core topic in the area of human (or cultural) geography. Another finding of our research to date is that generalizing DLs for use across the diverse array of geo-spatial disciplines is not a trivial challenge: Building collections and tools that would be of value to such a diverse audience was a key challenge.

Most of our efforts have focused on physical geography, as that is the topic on which we have the richest collections in the Alexandria Digital Library (on which ADEPT is based) (see http://alexandria.ucsb.edu/adl/about_adl.html), and it is the primary research area of the geographers who are members of the ADEPT design team. The first full-course deployment of an operational version of ADEPT took place in fall term, 2002, and spring term, 2003, in an introductory physical geography course taught by the same instructor both times. The current ADEPT software client has a rich set of tools and services to support course preparation and

presentation. It gives instructors the ability to create, search and display a variety of learning materials, including collections of DL information objects (e.g., images, data sets, maps, animations), knowledge bases of course concepts and concept maps of the relationships among concepts, and presentation materials (e.g., lectures, lab exercises, self-guided presentations). ADEPT further allows instructors to integrate the didactic, relational, and illustrative information in these collections into multiscreen, multimedia presentation formats in the classroom, laboratory, or on the Web. Resources assembled for the course are held in the instructor's "personal digital library (PDL)" within ADEPT. Under this architecture, the instructor can share some or all of his PDL with other users of ADEPT (this instructor is willing to share all the resources he has assembled). The assembled course resources, including the relational concept knowledge base, lecture and lab modules, and DL collection items, are available to students on the course website, although minimal effort has been devoted to functionality for student use as yet.

The overarching goal of the ADEPT project is to deploy digital libraries for undergraduate instruction in ways that will promote inquiry learning. Our previous research sought to study the ways that geography is currently taught in undergraduate classrooms. However, this previous work did not carefully examine the process by which professors prepared for class. To understand the educational setting, we need to have a closer understanding of the processes by which faculty search for and use information in support of their teaching. The processes used by instructors to locate useful material will inform the design of digital libraries for use in undergraduate settings. Such interviews would help shed light on the characteristics of resources selected for class and the process of their arrangement so that we could better understand the design of the ADEPT system to support professors in their instructional activities.

RESEARCH METHOD

This study is based on interviews with nine professors in a department of geography at a large research university. Six respondents are physical geographers and three are human geographers, and represented a wide range of research interests. In physical geography these include climatology, geomorphology, ecosystems, environmental change, historical geography, and desertification. Research areas of the human geographers in our study include privacy, environmental change, and the culture of specific regions. Eight are male, one is female. They represent the ranks of assistant, associate, and full professors.

Interview questions were intended to address the following research objectives:

1. identify and describe faculty information needs and information seeking in support of instruction,
2. compare and contrast information needs and seeking in support of instruction with information needs and seeking in support of research,
3. identify and describe tools used when searching for instructional materials,
4. identify and describe content chosen for instruction and the process by which they are selected and evaluated by faculty,
5. analyze how instructional media is arranged prior to presentation, and
6. compare the arrangement of instructional information with the presentation of geography concepts in the classroom.

Faculty members were interviewed during a quarter when they were teaching a lower-division undergraduate class to ensure their description of their experience was current. The interviews were conducted and tape-recorded in each faculty member's office so we could observe them in their working environment. Interviews lasted from about 30 minutes to almost two hours, with the average length being about 1 hour.

SUMMARY OF INTERVIEW RESULTS

Our interviews revealed significant differences between physical and human geographers in their use of information resources for teaching. All of the physical geographers appear to assign textbooks for their introductory courses, although the choice of text varies by instructor. They also vary in the degree of reliance on the text. A younger physical geographer follows the text very closely and uses minimal supplemental materials, while the others actively seek complementary images, maps, data, and examples. The human geographers are less likely to assign texts in introductory courses, instead assigning multiple scholarly monographs or constructing course readers from journal articles and other sources. The latter courses are built more around case examples, which require a wider array of supplementary materials for classrooms and laboratory sessions.

Seeking information is a frequent and regular activity of the geographers in our study. They are continually scanning their environment for documents, images, datasets, ideas, people, and resources that may be useful for research or teaching. They are active information seekers, deliberately searching for items of interest. They also are passive information seekers, grabbing an interesting image or tidbit spotted in the process of other reading, browsing, or leisure behavior. Most of the behaviors these geographers reported are typical of prior studies of information seeking for scholarly research, such as browsing library and personal collections, following citation references in articles, asking colleagues, and attending conferences. All of our subjects use online sources, and many continue to be heavy users of campus libraries and print sources.

Most of the geographers in our study use images or maps as part of their own research, whether via cameras (film or digital), or via computer generation from data sets (e.g., weather patterns). By mid-career, many have built substantial image collections of their own, and searching them is part of their information seeking activity.

When we asked these geographers how they sought information in support of their research, all had ready answers. They could tell us how often they went to the library, what they did there, and which web sites and databases they searched most often. They demonstrated some of their search methods to us in their offices – the use of online resources, stacks of manila folders, and slides arranged on light tables. They generated long lists of favorite resources and common practices.

In contrast, the answers were less forthright when we asked about their information seeking in support of their teaching. All had answers, but few appeared to have articulated this behavior before, and the responses were more rambling than those for research topics. Often we needed several follow up probes to elicit explanations of how they gathered resources to use in reading lists, lectures, labs, and assignments.

When asked to compare their information-seeking activities for their research and teaching, five of the nine geographers stated some specific differences. Even the four who initially said these were a common activity pointed out a few differences in their own practices. Upon analyzing the transcripts of the nine interviews, it appears that seeking information for research and teaching are mutually reinforcing activities. Geographers spot useful images or examples for teaching while searching for research materials. Conversely, some try out research ideas in class, such that resources initially used in teaching may become research documentation. Overall, research influences teaching more than vice versa.

As prospective users of digital libraries, our participants wanted more access to useful images and maps, and they wanted them described more fully. Geographers of all specializations mentioned the need for more conceptual or thematic searching capabilities on maps. Asked to provide further definition of thematic search, one interviewee replied maps could be organized to "represent certain kinds of economic concepts. Or certain kinds of economic geographical concept. Or a certain kind of physical geographic concept. So more concept organized knowledge."

Participants indicated that they are interested in teaching materials created by others. They also want to be able to manipulate the maps and images once they obtain them.

The information-seeking activities of geographers for their research tracked closely with behaviors typical of physical scientists and social scientists, respectively [10, 19]. Faculty in this study follow the new literature in their fields, browse familiar sections of the library, bookmark favorite web sites, follow citation links, attend professional conferences, and receive sources and references from their scholarly peers. All of the geographers seek maps, images, and illustrations for their research and their teaching. The specifics of what they seek vary by research area and course content, as would be expected.

Faculty in research universities have dual work roles of research and teaching. While often viewed as complementary, these roles also can be competitive, especially in demands for faculty time [13]. In the case of information-seeking activities, the roles do appear to be complementary. Most of the geography faculty interviewed report that the activities are mutually reinforcing. They often find useful items for teaching in the process of searching for research topics, and may also find research ideas or resources while gathering information for teaching. Their personal collections of research data, maps, and images are mined for teaching examples. Several professors also mentioned that research insights might arise from teaching.

IMPLICATIONS FOR DIGITAL LIBRARY DESIGN

The results of these interviews have a variety of implications for the design of ADEPT, as a digital library for undergraduate education in geo-spatial disciplines, plus some general implications for the design of other digital libraries. The most general implication is the importance of basing design decisions on studies of users, as their concerns can be diverse and counter-intuitive. We highlight four issues of functionality and architecture for ADEPT that arise from this study: (1) Searching for maps or images by concept; (2) creation and management of personal digital libraries; (3) digital libraries as shared spaces; and (4) capabilities to manipulate data and images.

6.1 Searching for maps or images by concept

Geographic information systems (GIS) and other forms of geo-spatial digital libraries are typically organized by location on the earth, both by coordinates (latitude, longitude) and by place name, with a gazetteer to reconcile variant names. The full name of ADEPT, the Alexandria Digital Earth Prototype, incorporates the location-based model in the "digital earth" metaphor. Maps and ideas associated with a physical place are the organizing principle of the field of geography. And yet the faculty in our study consistently spoke of the need to search for maps, images, and data by concept or theme. They find that the lack of adequate searching capability by concept is the weakest aspect of most geo-spatial information systems.

This finding does not imply that they reject the need to search by location or place name. Rather, it is more likely that they find those capabilities to be adequate. A search might start with a location or place, but then they want to know more about concepts, structures, or processes associated with that place. Alternatively, a search may be primarily about a concept, whether a geo-morphological structure or process or a social concept such as privacy or public spaces. Distinguishing between searching by place and by concept risks obscuring the depth of expertise of these geographers, however. Their scholarly expertise may include encyclopedic knowledge about what features or activities are associated with particular places. What appears to be a search for a place may be a search for a concept or process, and vice versa. Undergraduate students (and other novices) lack this form of knowledge. Thus, providing capabilities to search by concept in a geographic digital library will help to manifest scientific knowledge and to assist students in inquiry learning.

The emphasis on concept over place also follows from our first round of ADEPT prototyping in 1999-2000, where instructors' preferences ran counter to our expectations [5]. We first offered images of a well-known local stream (Ballona Creek) for use in a class session on streams, as the instructor expressed a preference for locations that would resonate with students. These images were rejected in favor of more vivid photos of the River Nile. In this case, clarity of representation of the particular geo-morphological structure being taught was a higher criterion than familiarity of place.

In principle, it would appear that concept searches in physical geography may be easier to index, as users may describe a known structure (e.g., a certain type of stream or cloud formation), or process (e.g., a type of erosion or wind pattern). However, these interviews and other conversations with physical geographers suggest that indexing and metadata for physical geography are more complex than they might appear, as any image, photo, map, or diagram can have many interpretations. The geographer who deployed the fullest version of ADEPT this year noted that he often uses the same image to illustrate different concepts in different classes, and that he may emphasize different aspects or describe an image in different ways in each of several class sessions.

The examples of maps and images given by human geographers are even more abstract, and one image can have many meanings. How does one represent privacy, public spaces, or historical ideas in maps and images? How can images be indexed and represented so they can be located by future users? These are questions addressed by librarians and archivists in the fields of images, photo, and film, as noted in the literature review. Exploration of the relationship between image retrieval in the visual arts and in geo-spatial

disciplines is likely to be fruitful, for the challenges appear to be similar.

To support research and teaching in any of the geography specialties studied here, more image searching and management capabilities will be required. Support for browsing and scanning will be essential. Subjects repeatedly described the difficulty of articulating descriptions of images, the importance of "knowing it when I see it," and the value of serendipity. Browsing relies on recognition memory, and facilitates "knowing it when I see it." Techniques that facilitate recognition should be useful, such as "thumbnails" of candidate images from which the user may select. Allowing users to label images with their own metadata also will facilitate browsing, particularly within personal collections.

6.2 Creation and management of personal digital libraries

Personal digital libraries have emerged as a core design principle for ADEPT, and this study confirms the value of this approach. All of the geographers studied are gathering information in support of their research and teaching from a wide variety of print and electronic sources. They also mine their personal research collections in support of their teaching. No single digital library collection could begin to meet their needs. Each geographer has his or her own idiosyncratic ways of organizing lectures and class materials, whether stacks of manila folders, stacks of overhead displays, web sites, MS PowerPoint files, or CD-ROMs. No single thesaurus or metadata structure will meet their diverse set of needs either.

ADEPT will need the capability to import, or ingest, information sources in standard formats, including text, images, numeric data, and files from common office products such as MS Word, PowerPoint, and Excel. The ingest capability is under development and is being refined continuously. Until faculty can easily and quickly import the resources they are currently using into ADEPT, they are not likely to find the system attractive. The value gained has to exceed the effort expended.

ADEPT should be able to capture whatever metadata already exists on files and images as they are imported. Faculty users of ADEPT also must be able to add metadata to their resources quickly and easily. One of the key developments in the current implementation of ADEPT is a concept database that allows instructors to create concept nodes, link them to each other in hierarchical relationships, and to populate them with digital objects. The instructor who deployed this version of ADEPT in fall, 2002, and spring, 2003, constructed a rich concept database for teaching this course. One of the research questions for the evaluation of ADEPT in 2003-2004 is how much use other instructors will make of his concept database and how much modification they are willing to do for their own courses and research materials. We are attempting to make the concept creation and linking tasks as simple as possible.

6.3 Digital libraries as shared spaces

The Perseus Project has had great success in providing content for use in teaching Greek and Roman classics and has expanded into other historical topics. However, they have focused on building collections rather than on building tools to use those collections in teaching, which is the goal of ADEPT. If we focus on the creation of personal digital libraries, will faculty have sufficient incentive to share their collections with others? The goals of ADEPT are to share primary sources as well as secondary sources such as teaching modules that incorporate primary sources.

Some scientific fields are making progress in sharing primary sources, particularly in biology and environmental sciences. Incentives appear to exist for sharing secondary sources such as teaching materials. Geographers in this study expressed interest in the use of teaching materials created by others, and many freely ask colleagues to share lectures and images. Posting lectures, notes, syllabi, and teaching resources on public web sites is becoming much more common. While the risk of borrowing without attribution exists, the academic ethos is to give credit where it is due. Furthermore, course materials posted online are often considered to be artifacts of a course, rather than the course itself. Reading the contents of a web site is no substitute for taking the course at a other leading university.

Content contributed to the shared space should include whatever metadata the instructor assigned. These metadata may be local and idiosyncratic, but the assumption is that messy metadata is better than no metadata. Some automatic indexing could be applied to the shared collection to improve consistency.

On the other hand, disincentives to share also exist. Faculty may use research data in a course prior to the time they publish those data, and do not wish to share them until post-publication. Even after publication, they may be reluctant to share them in raw form. Providing data to others often involves providing the field notes and codebooks that may be difficult for others to interpret adequately. Scientific data are not useful as disembodied numbers or facts; knowledge of the research method and instrumentation are essential for interpretation. Finding ways to reconcile data from multiple sources is continuing challenge in the construction of scientific digital libraries. Tackling this larger problem is presumably beyond the scope of ADEPT. However, ADEPT may have to incorporate means to share selected research outputs, such as charts and images, with sufficient explanation that others can interpret those outputs.

Studies of the adoption of ADEPT will focus on the necessary incentives for faculty to share their research resources and other primary sources, as well as their course materials, in return for use of the system.

An overarching disincentive to share course materials is the current intellectual property regime in the United States [15]. Instructors frequently clip articles and images from newspapers and magazines (print and digital), textbooks, scholarly journals, and even from film and video for use in teaching. As long as the use of copyrighted materials is restricted to the instructor's classroom, it generally is deemed fair use for educational purposes (regardless of whether it would pass a strict legal interpretation of "fair use"). However, if those same materials are posted on a web site, circulated electronically to students, or distributed to other instructors, the interpretation of fair use becomes far more restrictive. Explicit permissions may be required and may be difficult to obtain, in terms of both time and money. Use of copyrighted content so often falls into the "it depends" category that university lawyers are reluctant to offer advice.

The Creative Commons (http://www.creativecommons.org) offers some guidance in this area. Users can license their content via Creative Commons with varying degrees of rights. Others may be allowed to use the content only if left intact, only for non-profit purposes, or they might be allowed to manipulate it, provided the original source is acknowledged, for example. Creative Commons is

the most promising approach to the intellectual property problems, which are otherwise a roadblock to progress in the use of educational technology. An interim step for ADEPT is to rely on metadata to register copyright ownership (at least at the level of "ok to share" vs. unknown) and to use that field as a filter for providing access to materials. This is admittedly a provisional solution to an enduring problem. Other digital libraries, such as the Alsos Digital Library for Nuclear Issues [1] have made use of the Creative Commons license. ADEPT, as mentioned, contains resources of uncertain provenance, and professors who make course materials available online via ADEPT may not be willing or able to ascertain which portions of their personal collections they are able to share, even when the mechanics of that process (such as posting appropriate metadata) are quite simple.

6.4 Capabilities to manipulate data and images

Digital libraries are more than databases. Ideally, they should support the life cycle of information seeking, use, and creation [2, 3] by offering services that enable users to take full advantage of the collections. The geographers in this study desire capabilities to support the full cycle. Once they locate items of interest, they tend to manipulate them in various ways. They enlarge images, they shrink images, they select sections from them, and they annotate them. Sometimes they use computer-based tools and sometimes they use paper, plastic foils for overhead projectors, markers, and photocopy machines (one of our respondents is particularly facile with the enlargement capabilities on his department's photocopier). They recompute data to create new maps and new images. The ability to manipulate data and images is at the core of scholarship and teaching in the field of geography. Each individual adds his or her own perspective to the evidence available.

If ADEPT or other digital libraries are to be truly useful for teaching, they must provide some capabilities to manipulate content in the collections. Providing such facilities as native functions in ADEPT is probably not feasible. Rather, it may be more an issue of interoperability whereby objects are maintained in a standard form such that they can be exported to common data management tools and then imported in revised form (and tagged accordingly). Better interoperability is likely to lead to more adoption.

The intersection between personal digital libraries and shared spaces may lie at the data manipulation function. Users could maintain their separate personal digital libraries while contributing some or all of the content to the shared space. Others could select from the shared space, manipulate it, and resubmit to the shared space with appropriate tags. Or perhaps they might be allowed to keep their manipulated versions in private spaces. As usual, the technology challenges are simpler than the policy challenges, and we will need to bear these issues in mind as we move forward with the design of ADEPT.

CONCLUSIONS

The overarching goal of the ADEPT project is to make primary sources in geography useful for undergraduate instruction in ways that will promote inquiry learning. If ADEPT is to be successful, the system must be easy to use and must provide sufficient value that faculty will choose to use it for teaching. The results reported here indicate that the greatest information needs of geography faculty are better access to primary source content, better ways of searching that content, and better ways to manipulate and present that content. Thus a system such as ADEPT that can provide tools for acquiring, managing, and presenting primary sources in geography is an important pre-requisite for inquiry learning.

The geographers we studied are active information seekers who concurrently pursue resources for their research and teaching, although their research activities influence teaching more than vice versa. Searching for teaching resources cannot easily be separated from research activities, which raises the question of whether faculty would use an independent digital library of teaching resources. We expect that they will, if the system provides sufficient value for managing, manipulating, annotating, and presenting teaching resources. The notion of "sufficient value" has several components: Faculty most often need maps, images, and other illustrations for use in research and teaching. They also want better ways to search for these resources. Another requirement is to import content from their own research files into ADEPT, quickly and easily, as personal collections are basic sources for teaching. Lastly, faculty need a simple facility to import content acquired from other sources. Our efforts in ADEPT are focused on building tools and services to support instruction rather than on building collections, per se.

While searching by location or place name is desired, such capabilities are already well developed in geo-spatial digital libraries. Our research indicates that it is concept searching that is lacking. The design of ADEPT, as a digital library to support teaching undergraduate education in geography, must incorporate robust capabilities to search for maps and images by concept or theme.

A digital library for teaching also must combine personal digital libraries with shared spaces. Individual users desire a private area to manage and manipulate their own resources in personalized ways. Some of this content they are likely to share; other parts of it may be kept private. If the digital library is to serve a larger community adequately, a critical mass of shared content will be required. A variety of incentives and disincentives exist for contributing to a shared collection. While faculty are likely to contribute some of their resources in return for access to the resources of others, barriers such as publication schedules and ownership of intellectual property are significant barriers to sharing. Geographers, and likely faculty in many other disciplines, wish not only to access information resources, but to manipulate them and to create new resources. Manipulating content contributed by others raises a host of interesting policy questions for which we can only suggest general answers. Principles established by the Creative Commons offer a promising framework for digital libraries.

The findings from this study provide guidance for the next phase of the ADEPT project. We plan more study of information seeking in support of teaching to identify other issues into the adoption of ADEPT by faculty. We will deploy the next iteration of ADEPT in multiple geography classrooms at both campuses to assess the generalizability of the current module and the adaptations required for different courses, specialties, and instructors. These findings also have implications for the technical design of the system, such as the importance of the personal digital library framework, ingest capabilities from personal collections, the ability to manipulate and annotate digital objects, and the need for searching by concept or theme. Librarians may find these results useful for collection development, cataloging, and access mechanisms, as they suggest the need for more primary sources for research and teaching and better ways to describe and retrieve them.

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