
Building a digital library for the health sciences: information space complementing information place

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In 1990, the University of California, San Francisco, dedicated a new library to serve the faculty, staff, and students and to meet their academic information needs for several decades to come. Major environmental changes present new and additional information management challenges, which can effectively be handled only through the widespread use of computing and computing technologies. Over the next five years, a three-pronged strategy will be followed. We are refining the current physical, paper-based library through the continuous application of technology for modernization and functional improvement. At the same time, we have begun the planning, design, and implementation of a "free-standing" Digital Library of the Health Sciences, focusing on the innovative application of technology. To ensure complementarity and product integrity where the two libraries interface, we will look to technology to transform these separate entities into an eventual, integral whole.

INTRODUCTION AND BACKGROUND

The University of California, San Francisco (UCSF), is one of nine campuses of the University of California (UC) system. Although there are five medical schools and various other programs in the health sciences spread throughout UC, UCSF is the only UC campus that can be characterized as a health sciences university. UCSF has professional schools of medicine, pharmacy, dentistry, and nursing; a Graduate School of Behavioral and Social Sciences; several independent research units and institutes in the biomedical sciences; and a medical center, consisting of numerous inpatient and ambulatory care facilities. With a city campus greatly constrained by available real estate at its main site on Parnassus Heights, UCSF has distributed its 12,000 faculty, staff, and students across more than 140 separate locations in the San Francisco Bay Area. The UCSF Library is responsible for all academic information needs across this functional and geographic spectrum. It is considered one of the nine university libraries of the UC system, whereas the other health sciences libraries within UC are a subcomponent of a campus university library.

The UCSF Library acts as an equal partner with UC's large academic research libraries, such as those at Berkeley and Los Angeles, in the interpretation and implementation of the "one university, one library" concept that guides universitywide library development, policy, and governance. In this context, UCSF planned and built a new library, which opened in September 1990 [1].

The UCSF Library is widely acknowledged as a building of great and lasting beauty. An exquisite design was superbly executed. Complementing the beauty of the "bricks and mortar" are the incomparable grandeur of the Pacific Ocean, the San Francisco Bay, the Golden Gate Bridge, and the Marin Headlands, which are incorporated into the library through the creative interplay of space, glass, and light.

Regarding functionality, the original planning objectives were to

- house print collections optimally;
- allow for ten years of paper collection growth;
- permit flexible future reconfiguration;
- support present and future technologies;
- provide beautiful space; and
- serve as a legacy.

At this point, the planners, designers, and builders have met these objectives. Although staff and patrons may identify design limitations that compromise their work, these are relatively few. The overall sense is one of a high degree of success.

That the campus dedicated its only remaining available space to the construction of this new library is significant. The new library was viewed as essential. It is a clear statement by campus administration and faculty as well as a constant visual reminder of the importance of academic information resources and their management to progress and success in biomedical research, scholarship, and professional training and practice.

NEW CHALLENGES

Since the late 1970s, when planning began for the new UCSF Library, there have been numerous environmental changes.

- The University of California, as a result of the most severe budget cuts in its history, was permanently downsized by more than 20%. Fewer resources are available at each campus to support libraries, yet the libraries individually and collectively need increasing levels of resources simply to maintain the status quo.

- Along with other academic health sciences centers, UCSF finds itself in the midst of health care reform. To persevere in its long-standing commitment to research, education, and patient care, UCSF must transform itself and its clinical training and practice to survive in a highly competitive managed-care environment [2].

- UCSF is completing a long-range development plan that will identify two new major satellite campuses and a future development site that will equal the Parnassus Heights campus in size and programmatic significance.

- Medical education continues to evolve, albeit slowly. Problem-based learning and evidence-based medicine both are increasingly important at UCSF.

- Information technologies continue to emerge at an ever-increasing pace. An important convergence of computing, communications, and content available in electronic form is occurring.

- Traditional forms of scholarly and scientific communication are in flux. This ambiguity is likely to continue for several years.

- The library's customers are changing their expectations not only of the library but also of information technologies in general. They expect technology to provide more information and service with less cost and effort on their part.

These changes challenge the library's ability to meet the academic information needs of our faculty and students primarily through the technologies of li-

brary buildings, paper-based collections, automated systems, and specialized software tools, which provide access to paper collections. Although these technologies will continue to be important into the early twenty-first century, we are at a critical juncture where we must consider creating an entirely new entity. The critical task of creating a physical, paper-based library, which will last and be useful for decades to come, is behind UCSF. This library will need to go through a normal evolution. New systems and technologies will be integrated; services will change with needs and resources. However, the UCSF Library, along with a few other academic health sciences libraries, is in a unique position to move on to a new challenge: the planning, design, and construction of a parallel and complementary structure, a digital library of the health sciences (DLHS).

A DIGITAL LIBRARY OF THE HEALTH SCIENCES

Describing a DLHS is both easy and difficult. It is easy, because we still know so little about the shape, contents, services, staff, and functions of a DLHS. At the same time and for the same reason, it is difficult to paint a picture that is useful to us and that will be a beacon to move from where we are to where we need to go. Having said that, what follows is my personal view, rooted in more than a decade of thought and experimentation with the concept of the digital library [3-4].

Three primary ideas drive the author's conception of a digital library: unexpected service, knowledge-based innovation, and product integrity. Unexpected service is more than consistently excellent or outstanding service: it is surprising DLHS users with a positive memorable experience that they had not anticipated [5]. In moving from information place, the paper-based library, to information space, the DLHS, we will need to reorient our efforts to a new infrastructure and context for service, adding value to the DLHS's content [6]. A significant part of this new service infrastructure will be partnerships with others. Innovation is the middle of three stages of technology diffusion, between modernization and transformation. The DLHS is a knowledge-based innovation [7]. It provides customers with new opportunities beyond those provided by the automation of a paper-based library for generating, accessing, analyzing, and synthesizing information. These opportunities subsequently suggest new ways of doing work that may ultimately result in transforming how DLHS customers conduct science, practice medicine, or teach students. Innovation is the seed of transformation. Finally, product integrity can be described as completeness, adherence to coherent ideas and values, and a unity between concept and realization. The true test

of product integrity is in its "look and feel"—how it meets customer expectations on practical and intuitive levels [8]. The new UCSF Library has product integrity. Our goal for our complementary DLHS can be no less.

The DLHS has three primary roles: information storage, retrieval, and preservation; information access and delivery; and the online publishing of biomedical knowledge, referred to as "knowledge management." These roles encompass all activities in the information transfer cycle, including knowledge generation, organization, representation, dissemination, and use. The DLHS is not the exclusive performer of these roles. In many functions, the DLHS may play a minor role, while other collaborators, such as publishers and individual scientists, make more significant contributions. However, the DLHS adds value in partnership with others through every step of this cycle.

The DLHS is content based. Technology, whether the computer or the book, is only the tool for the librarian and customer. Describing content in terms of today's context, DLHS will contain or provide access to electronic versions of the current published literature, new literature created solely in electronic form, specialized databases, primary source data, and informal network communications. It is highly likely that new, unknown content forms will emerge as well. The content will also be quality filtered. This DLHS will not contain material simply because it is available in electronic format. Much of the content will not be owned; some will be licensed.

The DLHS is also centered on the customer. This is evidenced by the online productivity tools available. With consistency in design and use, these tools include ones for browsing, information retrieval, visualization, statistical analysis, authoring, and communication. User customization of the tool set and content base is possible.

Services in the DLHS information space are integrated with the content and tools. Interactive and distributed services support electronic publishing, personal information management, distance learning, and instructional development. The DLHS is network based rather than place based.

Many things can be mistaken for digital libraries. A health sciences library with advanced online systems, including the new UCSF Library, is not a DLHS. Electronic versions of the current journal literature, such as UCSF's Red Sage Project, and specialized scientific databases, such as the Online *Mendelian Inheritance in Man*, the Genome Data Base, or Genbank do not themselves constitute a DLHS. Instead, these are logical and useful electronic extensions of present-day library and scientific computing activities. We must begin to think of a DLHS as an entirely new entity, not simply an evolutionary outgrowth of what

currently exists. In addition, we must direct considerable energies and resources to the conceptualization, prototyping, designing, and implementation of a digital library that complements paper-based libraries. Otherwise, we will simply continue to use technology for modernization when today's challenges call for innovative and transforming uses of information technologies.

INITIATING TRANSFORMATION

UCSF adopted a threefold strategy to reach its goal of creating an operational DLHS that complements its new physical structure:

1. refine the current physical, paper-based library through the continuous application of technology for modernization and functional improvement;
2. conceive, plan, design, and implement a free-standing DLHS, focusing on the innovative application of technology; and
3. ensure complementarity and product integrity where the two libraries interface, using technology to transform the separate entities into an integral whole within the next decade.

This threefold strategy has been supported through the (re)allocation of monies among the continued operation and refinement of the new paper-based library; investment in the future by developing our DLHS; and the development of educational and consulting services, which will serve as the bridge between the two libraries.

Evolution of the new UCSF library

Less than a year after moving into the new library, staff began reallocating and renovating space based on different principles and assumptions from those that guided the development of the new building. First, library space is campus space devoted to academic information management. It is not simply the housing and management of a state-of-the-art paper-based library. Second, as much library space as possible should be devoted to housing personnel involved in the use and management of academic information. Whenever possible, space allocated to information storage should be reduced. For instance, the library has systematically moved more materials than planned to UC's Northern Regional Library Facility. Third, collection development should be based on the critical information needs of faculty, staff, and students rather than the goal of collection comprehensiveness. This will slow the growth of one of the largest health sciences collections in the United States. Taken together, these principles freed some space now, with more to come in the future. This highly valuable space will leverage extending the library building's use as well as the library's functional roles.

As the basis of a campus Informatics Federation, alliances were created with the School of Medicine's departments of radiology, epidemiology, and biostatistics and the School of Pharmacy's Computer Graphics Laboratory. Approximately 4,000 square feet of stack and library staff space has been transformed into space for a Laboratory for Radiological Informatics, a Statistical Consulting Service, and a Sequence Analysis Consulting Service. Along with the Center for Knowledge Management (CKM), these new uses of library space have helped broaden the notion and reality of the library's role on campus to include health sciences informatics research and practice. The CKM is responsible for DLHS product development, management, and engineering. Resources Management (RM), replacing Technical Services, also occupies remodeled space contiguous to the CKM. This facilitates RM's database management role for the paper-based library as well as its emerging content management role for the DLHS. The Media Center with storage facilities was fashioned into an Interactive Learning Center (ILC), with a state-of-the-art computer classroom, a laboratory and consulting service for the faculty's creation of multimedia educational software, and public-access computing facilities. These changes helped the library fulfill its role in health sciences informatics education. As part of a recently dedicated Education Center, a second Interactive Learning Center housed in space released by the old library is enhancing and extending that role functionally and geographically.

Creation of the complementary digital library

It took fourteen years for the new UCSF Library to move from a recognized need and idea to reality. With current knowledge about library buildings and digital libraries, we should expect a similar time frame for the building of a sophisticated, functional digital library. Knowing that we face several years of challenges, we have begun the process of building the UCSF DLHS using a product development approach. This implies several important steps, including

1. the development of a strong product concept, such as unexpected service, knowledge-based innovation, integrity, and complementarity with our paper-based library;
2. copious market input to determine what the DLHS does, who it serves, what it means to them;
3. putting in place a development process or system for solving complex problems and decision making;
4. cost-effective software engineering, making use of and customizing free and commercial software as well as developing our own;
5. initial and ongoing education and marketing strategies for deployment; and
6. creating a support and service structure to ensure the product's success.

The Red Sage Project (RSP) serves as an initial experiment. The RSP is a unique collaboration among the UCSF Library and Center for Knowledge Management; AT&T Bell Laboratories; and twenty commercial, society, and university publishers, including Springer-Verlag, Academic Press, the American Medical Association, the Massachusetts Medical Society, Nature Publishing Company, Oxford and Rockefeller University Presses, and the National Academy of Sciences. Collaboratively, we developed methods and standards for creating electronic content. We built a database of more than seventy journals of molecular biology, radiology, and high-impact titles dating back to 1993. These journals are available to UCSF faculty, staff, and students using Bell Labs' RightPages software. Library and CKM staff have worked with Bell Labs in refining, extending, and testing. This software includes personal tools for information retrieval and browsing. In addition, it integrates unexpected services such as content alerting and new-issue notification. Through this experiment, which continues until December 31, 1996, we are identifying the technical, legal, economic, business, infrastructure, human resource, and social issues involved in building and managing a DLHS. We are developing working solutions. Many of these issues have long-term strategic implications. For example, could the UCSF DLHS serve the entire Bay Area? To answer this question, we provide RSP journal access to Genentech, a major biotechnology firm in south San Francisco, under a special grant from Pacific Bell's CalREN (California Research and Education Network) Foundation. Could this UCSF DLHS serve the other four UC biomedical campuses? By extending RSP access to UCLA, we hope to provide a laboratory for UC to address questions important to the system-wide effort of creating a UC Digital Library. By putting journals online in the RSP, we put ourselves in a unique, advantageous position to understand, create, and build the UCSF DLHS.

Our GALEN II initiative logically follows the RSP. The original GALEN (General Access Library Electronic Network) consists of all the components that compose the state-of-the-art library systems in the new UCSF Library. GALEN II is the project name given to a set of online tools for the UCSF DLHS. With knowledge gathered from the RSP experience, a special faculty focus group, and the experiences of other pioneers in this area, GALEN II, version 0.1, became available in January 1995. Version 1.0 is expected in August 1995. Following the product development process outlined above, we will continue to refine our product concept through several prototypes. The World Wide Web, customized Web browsers, and special tools, such as multidimensional data-visualization applications, serve as our technical base for these early DLHS prototypes [9]. At some level, they actually contain all the features described

earlier in the personal vision of a DLHS. In addition to technology and content issues, the organizational structures necessary for product development, deployment, and support are of great interest. The organization that effectively supported the paper-based library is insufficient and dysfunctional for the digital library. We have turned to the five disciplines of learning organizations: personal mastery, systems thinking, mental models, shared vision making, and team learning as a framework [10]. These disciplines form the basis for developing a completely new organizational structure that empowers the team guiding GALEN II.

Education, consultation, and evaluation

In 2010, it should be possible to see three phases of library development occurring over a thirty-year period. From 1980 to 1990, the new library building was created. Between 1991 and 2001, UCSF built the first full-scale digital library serving the health sciences. Between 2002 and 2010, phase 1, information place, was integrated with phase 2, information space, into a new entity greater than the sum of its two components. Until this occurs, the task of integrating paper and electronic resource discovery, retrieval, and use is significant and challenging. Interoperation between the paper and digital libraries will not be handled to total satisfaction through design and construction. Innovative education and consulting programs will be critical. Groundwork has been laid with the development of a personal information management consulting service, database and software development consulting services, multimedia instructional development services, electronic publishing services, and a growing health sciences informatics curriculum.

SUMMARY

The new UCSF Library, dedicated in March 1991, took more than a decade of concentrated planning and

work by UCSF senior executives, librarians, faculty, staff, donors, and others. UCSF is proceeding with planning and developing a prototype for a new UCSF DLHS. The UCSF DLHS deserves and needs no less the effort if it is to serve biomedical research, clinical care, and professional health sciences education into the twenty-first century.

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