Chapter 4
Library Space and Technology

Robert P. Holley

Introduction

Libraries have dealt with the impact of technology on space for decades. This chapter will first provide a historical perspective before focusing on current trends. While developments have overlapped, it is proposed that there are three main periods of technological innovation. The first is the use of technology to automate backroom processes such as cataloguing, acquisitions, and serials control. This period extends roughly from 1960–1980 for the initial applications with further, though often less important, developments since then. The second period is the arrival of the online catalogue in the period from 1980–1994, as well as the efforts at retrospective conversion that allowed the disappearance of the card catalogue. The third and principal period starts with the arrival of the Internet and extends to the present. The full implications of the Internet on library space have yet to be seen, but substantive changes have already occurred. In general, larger academic libraries in the developed world have been the first to embrace new technology, while smaller libraries everywhere and libraries in the developing countries have mostly introduced technology more slowly, most often due to budget constraints.

This chapter is written from an American perspective, and is based upon over 40 years' experiences as a librarian and library educator since 1971. The context will be provided by documentation and literature from many sources and the focus will be on academic libraries. Before this focus, the changing use of physical space in special, public, and school libraries will be considered. Special libraries have often been in the forefront of adapting to technological change for several reasons. First, for-profit corporations are more likely to introduce new technology that ultimately reduces the cost of providing services or that makes it possible to generate additional revenue as these changes benefit the bottom line. Second, space is often at a premium in the corporate environment, especially in large, expensive cities such as New York, London, Paris, and Zurich. Third, the Internet has permitted the consolidation of library services for companies with multiple locations so that a library at corporate headquarters has often replaced multiple physical libraries.

> Technology often permits special libraries to reduce the size of the collection and allows library space to be reallocated … As digital information has become ubiquitous, the role of the physical library space as the repository of information,

and the role of the librarian in maintaining the order and accessibility of the information resources, has been replaced by networked access from anywhere. (Shumaker 2009)

Public libraries will initially benefit less from technology in reclaiming space. Since, at least in the United States, they receive their funding from local communities, they must satisfy the needs of both technologically advanced and technologically limited users. Meeting the needs of both types of user may put additional pressures on their space requirements and budget (Holley 2010). Finally, school libraries benefit greatly from technology, especially with the great increase of available resources; but most school libraries are so small that even the systematic introduction of technology will not have a great impact upon their space requirements. A contrary view does, however, emphasize the benefits of repurposing even the limited space freed up by removing print collections (Corbett 2011).

Automation of Internal Processes, 1960–1980

Not all technology depends upon computers. The equipment needed to read microformats had the greatest impact upon space needs during much of this period. The library needed to provide machines for reading the various formats both in technical services for processing and in public areas for reading. In addition, the library had to purchase storage space for the physical copies of the microformats. Libraries purchased microform versions of some materials, especially newspapers, because preserving the paper original was difficult. During much of this period, libraries were expanding. Many academic libraries were new and wished to create depth in their collections. Since they had the money to do so, many microform publishers created major microform sets such as *Early English Books* and *Landmarks of Science*. These collections required some space but much less than if these expanding libraries had been able to purchase even a small percentage of the materials contained within these collections. While the two most common formats were microfilm and microfiche, some publishers also used specialized formats such as microopaques, requiring libraries to provide multiple types of reader and to devote space for their use. 'In the 1970s the information explosion forced libraries and institutions and their users to microforms as an alternative to bulky expensive print materials. Improved film, readers, viewers, reader-printers, and the advent of portable lap readers made this money-saving choice more acceptable' (Heritage Microfilm 2010).

While libraries began experimenting with computers from the late 1950s, the first efforts were mostly batch processing that had little effect upon the space needs of the academic library. Most of these systems used punched cards and would require at the most one or perhaps several keypunch machines in the library. A separate computer centre would most likely process the punch cards and then

return any final product to the library. Some products were in a microformat and were read on the microform readers described above or had their own dedicated readers.

The use of technology for online cataloguing had the greatest space implications during this period. OCLC was incorporated on 6 July 1967 (Kilgour 1969). OCLC provided the opportunity to make use of cataloguing records stored on the OCLC computers in Dublin, Ohio in the MARC record format that was developed at the Library of Congress under the supervision of Henriette Avram. OCLC soon began to offer its services beyond Ohio to all types of library, and quickly attracted a large number of members. The Research Libraries Group, founded in 1974, emerged later as a competitor with an emphasis upon providing shared cataloguing and other services to large research libraries (OCLC n.d.).

During this period, libraries mostly used cathode-ray terminals (CRTs) and dedicated access lines for online cataloguing. The CRTs and dedicated access were expensive enough that cataloguers shared the CRTs. The cataloguing departments needed to allocate some space, depending upon the number of CRTs, for online cataloguing. Since each library employee still needed personal space to work, catalogue units needed to find additional space for online cataloguing. The OCLC and RLG databases soon proved themselves to be valuable resources for other library activities. Acquisitions and serials staff could use the online databases for verification, though specific subsystems for these two areas appeared later: 1978 for acquisitions (Schreiner 1978) and 1977 for serials (1977). In 1976, Joe A. Hewitt (1976) published an excellent summary of how libraries used OCLC in its early years, including a photograph of a communal work space with its cluster of CRTs.

Online cataloguing initially did not have much effect upon public space in libraries. Libraries initially used the OCLC online system to print catalogue cards that continued to be filed in public and other specialized catalogues. Only after libraries believed that they had a sufficient number of online records did they offer online OCLC access to their patrons. This public access started to occur around 1984, and online public access to OCLC had little effect upon the use of space in public areas during this period (Bills 1984).

Arrival of the Online Catalogue, 1980–1994

The major event during the next period, 1980–1994, was the general adoption of the online catalogue. According to Christine Borgman (1996: 499),

> … it is generally acknowledged that the first large scale implementations were at Ohio State University in 1975 (Miller,1979) and the Dallas Public Library in 1978 (Borgman, 1978; Borgman and Kaske, 1980). By the early 1980s, a sufficient number of online catalogs were in place in the United States for the

Council on Library Resources to commission a major study of online catalog usage. (Matthews et al., 1983)

Almost all libraries embarked upon retrospective conversion projects to increase the coverage and number of records in the online catalogue (Schottlaender 1992). (This volume includes an extensive bibliographical article that lists publications on retrospective conversion from 1980–1990 by Daphne C. Hsueh (1992).) While larger libraries had more resources, they almost always had large, older collections whose records needed to be converted to machine-readable records. When they made the online catalogue available, they often had to retain the card catalogue, usually without adding cards for any acquisitions since the arrival of the online version. As with the initial internal automation, the online catalogue required more space because the card catalogue remained while a location had to be found for the new online terminals. Once the library 'closed' the card catalogue, some libraries compacted the catalogue to save space and sometimes reclaimed the prime location that it occupied by moving it to a less visible spot. As libraries completed retrospective conversion, they most often removed the card catalogue to discourage patrons from using an obsolete tool (Bausser 1988).

The online catalogue also offered the possibility of saving space in technical services. With the improvements in technology, some library employees began to get their own computers on their desks, though they were quite primitive by today's standards. Many libraries networked these computers and even provided access to BITNET and other systems that were precursors of the Internet. The bibliographic utilities also offered online modules for acquisitions and serials, as did most online catalogue vendors, who started to call their online catalogues 'integrated library systems' (ILS). The space formerly used for shared computer clusters became available for other uses, as did the space given over to specialized files that could now be discarded. A 1999 publication, *Planning Academic and Research Library Buildings* by Leighton and Weber, includes a section on space planning for technical services areas and specifically mentions the removal of old card files like the shelf list and the possible decentralization of serials check in (Leighton and Weber 1999).

The increased productivity of shared online cataloguing, coupled with a decrease in the purchase of monographic materials by many libraries, led to significant reductions in cataloguing staff and somewhat lesser reductions in acquisitions and serials staff. At a practical level, this space was often difficult to convert to public use because of its normal location behind the scenes, often away from existing public services areas, but could be used for internal library activities or for storage.

Beyond the online catalogue, the advances in technology had little effect upon public services. While Dialog was available as an online search tool, this service was expensive enough that librarians often did the searches for patrons. The one or two workstations used for this searching did not require much extra space.

The Internet and Massive Change, 1994–

After a long period of relative stability in libraries, the Internet caused massive changes. While precursors to the Internet had existed since the first ARPANET connections in 1969 (Guice 1998), the appearance of graphical browsers led to the rapid growth of the World Wide Web. While the exact date of the birth of the Web is subject to debate, 1994 would appear to be the pivotal year, with growing public interest in the Internet. Few initially imagined the broad changes that the Internet would bring to all aspects of our lives, including significant changes in the use of library space. Various themes emerged that are interconnected in their effects upon libraries and their space needs.

Advances in Connectivity

The increase in connection speeds and connectivity has had a profound effect upon all aspects of Internet use. At the beginning of this period, most users still used modems that connected at extremely slow speeds over telephone lines. These slow transmission speeds inhibited the use of graphic-rich Web pages and made use of some Internet resources a frustrating experience. By 2011, in contrast, many users had multiple high speed options including cable, DSL, and satellite that could be delivered in a variety of ways, including fibre optics. Many research libraries had access to Internet2, with some providing speeds approaching 100 Mbps. This means that the bottle neck is most often no longer the Web connection but the processing speed of the Web site. In comparison, 'slow' home access in this area is rated from around 1.5 to 18 Mbps.

Users also have greatly increased options for accessing the Internet. At the beginning of this period, the standard access tool was a desktop computer with either Windows or Macintosh software, with some still using DOS or Linux. By 2011, users could access the Internet through a broad array of devices including the traditional desktop computer, laptops, netbooks, and smartphones of all types, as well as specific purpose devices such as game consoles and eReaders with added Internet connectivity. Prices have also plummeted for these devices. An entry level netbook can cost a little over $200, while desktop PCs and laptops start around $400 but can sometimes be bought for less. A smartphone often costs very little as long as the users purchase bundled access. (On 16 September 2011, according to Google Shopping, the cheapest new netbook cost $125; a laptop cost $198; and a desktop $178. All these devices would be considered underpowered by most users so the prices above more accurately reflect the standard models.)

A third factor was that most of the devices above had the capability for wireless access. Students, faculty, and staff had laptops, phones, and eReaders that could connect to the Internet with this wireless access. Even staff could get by with wireless access, though most libraries still had wired access at staff desks from the pre-wireless period.

These two technological advances have had extensive implications for space needs in academic libraries, either directly or indirectly. The increase in connection speeds has allowed libraries to provide remote access for large files, including documents with extensive graphics. The document or file that would have taken a frustratingly long time to download or display now appears almost instantaneously. Many users no longer have any need to come to the physical library to access digital resources. This is because of the increased connection speeds made available by the various Internet service providers at a reasonable cost and the availability of cheaper devices to make these connections. Furthermore, many colleges and universities have implemented or increased their distance education offerings. While many provide some access to physical resources, the vast majority of these students rely upon digital resources and do not make use of library services other than those provided remotely. To give some statistics, 'in 2007–2008, about 4.3 million undergraduates, or 20 per cent of all undergraduates took at least one distance education course' (IES National Center for Education Statistics n.d.), while in 2009, *The Chronicle of Higher Education* estimated that 2.14 million students were taking only online courses (2010).

The availability of higher speed Internet connections for users, coupled with the drop in cost for ways to access the Internet, has meant that many more users are able to access the Internet remotely. At the beginning of this period, users most often had to come to the physical library to use library resources because online connections were too slow or too expensive outside the library. In addition, many academic libraries took responsibility for providing Internet access and sometimes other capabilities such as word processing, spreadsheets, presentation software, and other tools needed by students to complete their coursework. Many provided the space and funding for computer labs that were almost indistinguishable from those in non-library locations, though some libraries made attempts to limit at least some terminals to library use. Some academic libraries, especially publicly funded institutions and community colleges, provided Internet access for the surrounding community as an outreach initiative. In a recent paper, an experimental two-year programme at the University of Arkansas at Little Rock is described (Dole and Hill 2011).

The positive news for library space needs is that many academic libraries can reduce the numbers of computers that they make available because fewer students and other patrons will need them. As early as 2009, it is reported that 'more than 11 per cent of colleges and universities are either phasing out public computer labs or planning to do so [and] at colleges that have not pulled the plug on their labs, nearly 20 per cent are reviewing the option' (Terris 2009). Interestingly enough, however, the same article states that many colleges and universities are repurposing computer labs as communal space. While the quote above refers to general purpose computer labs, the same general principles will apply to those in the library that are often used as general computer labs rather than for library-specific reasons.

On the other hand, libraries will need to make sure that they provide reliable remote access and also wireless access within the library, because many users will prefer to use their own devices even when they are within the physical library. With reliable and speedy wireless access, libraries should not need to worry as much about providing publicly accessible data ports. Another major space issue will be providing laptop owners with electrical outlets, since many will prefer not to drain their batteries while using the library's wireless connection. Providing enhanced electrical outlets could be a major issue in older libraries. The same rules should apply for meeting rooms within the library, since bringing a laptop to meetings has become a common occurrence. One stopgap measure is to provide extension cords with multiple outlets. Overall, '[u]se of all of this equipment has implications for the need for electrical outlets and network connectivity throughout the library facility since some users will do their work inhouse. In addition, students who bring their own devices need access to electrical outlets in order to recharge their own equipment' (Lippincott 2008: 3).

One major caveat before reducing the number of computers or closing public access computer labs is to consider digital divide issues that could affect some members, mostly students, of the library's user community. Libraries within colleges and universities that require students to own laptops will be much less affected by this issue, though some students may wish to complete computer tasks in the library at times when they do not wish to bring their computers with them. Terris (2009) states that 'the vast majority of students at four-year-colleges—83 per cent—own laptops, according to Student Monitor, a market-research company' and quotes Kenneth C. Green (founding director of the Campus Computing Project): 'It's amazing that labs haven't died out yet … It would seem like an obvious area to save money, but schools keep insisting they are finding value.' This decision to cut costs and reclaim space overlooks a substantial minority, 17 per cent of the students, who did not own a laptop. In addition, some of the 83 per cent may own computers that are too old to access library resources effectively, or may not have a high speed Internet connection at home. Furthermore, these students may be those more at risk for dropping out of college if financial constraints are the reason for not owning a laptop or having a high speed Internet connection. In fact, community colleges, whose mission is to provide affordable education at the local level, are most likely to have decided not to eliminate computer labs (88 per cent) compared with the other types of colleges and universities (48–69 per cent) (2011c).

Collections – General Considerations

Since the arrival of the Internet, the changing patterns in collection building have had the most effect upon library space needs. As more digital resources have become available, academic libraries are collecting fewer physical materials and are often discarding parts of their physical collections. According to the most recent Association of Research Libraries' statistics, published for the years 2008–

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2009, the 113 largest academic libraries are spending a median of $5,870,147 on electronic resources. The percentages of the collection development budget range from a high of 85.40 per cent to a low of 14.33 per cent, with a median of 58.29 per cent (Kyrillidou and Shaneka 2011).

The reduction in budgets for almost all academic libraries has exacerbated the decline in the purchase of print materials. Especially when coupled with inflation, libraries have lost purchasing power. Some academic libraries have even experienced declines in absolute funding (2009). These cuts have had a disproportionate effect upon space needs because most libraries have focused the cuts on physical book purchases for reasons that will be discussed shortly.

Before a discussion of various types of library material, some general comments are in order. Digital resources are popular with users for many reasons. They are available 24/7, unlike the unavailability of physical resources when the library is closed. Users can access them remotely with many different devices. In most cases, users can download the items for later use and can often annotate them digitally. They can also print them out, albeit at a cost, if print is the preferred format. Digital resources can feed data into documentation software such as Endnote and RefWorks. Finally, online students prefer digital resources because they cannot easily come to the physical library if they live a significant distance from the campus. As for negatives, users may have to deal with multiple searching conventions that can vary subtly from platform to platform so that what works in one digital universe may not work in another.

Digital resources also offer advantages to libraries. They cannot be lost, stolen, mutilated, or not returned at the end of the checkout period. Processing is simpler since the purchase of many items includes the needed bibliographic tools. The library no longer needs to check in physical serials, or to worry about claiming missing issues. Libraries can digitize their own resources to make them much more available to user communities around the world and to eliminate the majority of physical handling with its potential to damage rare or unique items. Digital resources also have some disadvantages. They require the necessary telecommunications, hardware, and software, and can be made unusable by malfunctions in any of these three components. The complex pricing and licensing agreements make them more difficult to purchase as publishers and vendors grapple with finding appropriate pricing strategies. Furthermore, the purchasing of bundles of materials, the 'big deal', makes budget reductions by cutting unwanted materials in the larger packages almost impossible. While not a scholarly resource, Wikipedia presents an excellent discussion of digital resources, including their advantages and disadvantages for both users and libraries (2011b).

While the subject of this chapter is space, it can be argued that space considerations did not factor all that much in the decision to go digital. The rationale presented for the increased focus on digital resources centre on better service to users. The realization that digital collections were reliable enough to allow libraries to modify their physical collections came relatively late in the period. Some librarians still worry about the permanence of digital records, the

ability for them to be modified without the permission of the owners or leasers, the quality of the illustration, and the changing content of packages as the copyright owners add or subtract resources. Perhaps the greatest concern has been the fact that libraries license rather than own many digital resources so that they disappear the first year the library cannot afford to pay for them, unlike physical resources that become part of the library's permanent stock (Currall and Moss 2009).

Collections – Reference Materials

The Internet has killed almost all need to collect print resources for ready reference. Librarians and users turn to Google, the other search engines, Wikipedia, and more specialized free resources for quick answers. The more definitive reference sources purchased by libraries for years have almost all gone digital and update their content continuously in a way that was impossible for print resources (Singer 2010). The library no longer needs to purchase the current resource and then later on purchase an expensive cumulation to save users from having to look through multiple volumes of the index. Some libraries feel the need to retain older reference sources. Furthermore, some reference resources are not available in digital format, such as the *Encyclopedia of the Israeli-Palestinian Conflict*, though print only is becoming much less common (Danford 2009). One complication for some libraries is the change in the pricing structure for digital reference resources so that large libraries pay more based upon the number of users in comparison with the fixed price for the print resource.

The digital world has allowed indexing and abstracting services to become content providers so that many of these former reference sources have blurred the line between access and content by providing full text for many of the resources that they index or abstract. Even when these resources do not provide full text, libraries use article linkers such as those provided by EBSCO, OCLC, and Serials Solutions to provide quick access to the digital and physical items in their collections. Many libraries have provided training materials on how to use article linkers, including this YouTube video from University Libraries, Wayne State University (University Libraries, Wayne State University 2011).

Most libraries have reclaimed significant space by eliminating or reducing their reference collections (Lampasone 2008, Singer 2008). Possibilities include discarding the materials, sending them to the circulating stacks, or putting them in a less valuable location. Some reference sources are retained only because professors of library science give assignments that require their use, but these reference tools are now located in low profile space.

Collections – Journals and Journal Articles

Libraries now have multiple ways to purchase journals and the articles they contain. They are available as individual purchases of the journal, as part of large or small packages of journals, as contents of various databases, and as packages of articles,

usually on a specific subject though this last option is quite recent. One negative of the multiplicity of possibilities is that the library may offer multiple options for the same item with different content, coverage, and access conventions.

Initially, online access to journals was considered an add-on to the physical print subscription, normally at only a slight additional cost, if any. In the author's opinion, the tipping point was somewhere around 2002 when the increased use of digital resources made the online version more important than the print one. Online-only journals have become increasingly important, though they have little effect upon space need. Libraries were initially uncomfortable in cancelling print subscriptions, even with the direct and indirect savings that such cancellations would bring. Libraries worried about the loss of access to important journals. The publisher might go out of business, and no one would be willing to support continued digital access. The library might have 'leased' the digital content and did not want to be locked into purchasing the content each year to obtain access to past purchases. They also worried about the issues covered in the introduction to this section (Walters 2004). The increased realization that digital journals were here to stay has allayed some of these concerns. Some additional options for guaranteed access included storing physical or digital copies in a secure location beyond the control of the publisher (Luther et al. 2010).

Academic libraries have reduced, often significantly, their print holdings of journals. They continue to receive some popular materials in print format for recreational reading or for the importance of the graphics, though they have most likely stopped binding these issues. Whalen (2009) discusses the importance of the quality of graphics for art historians. The first effect of the reduction in print subscription is reclaiming the space that was used to make current issues available. A more important consideration has been what to do with back files, especially for those journals where the publisher has digitized the complete run. Some libraries have simply discarded the back files on the assumption that they can get copies through interlibrary loan or by paying a fee for digital access to select articles (Zambare et al. 2009). Other libraries have put the back files in institutional or cooperative storage. Removing back runs most often results in considerable space saving.

Collections – Books

While digital books (eBooks) have been available since 1971 with the creation of Project Gutenberg (Zakon 2010), this format was the last to be extensively collected by libraries. Various reasons can be established for this delay. Unlike journals, where one decision to purchase usually meant continuing revenue for many years for the publisher and the aggregator, libraries normally purchased books individually at a lower unit cost without any continuing obligation. For the publisher, the sale of one book produced less revenue while still requiring the overhead costs of digitization and acquiring copyright. In addition, both libraries and their users faced the complexity of proprietary formats. While some are more

open than others, the Wikipedia article on the *Comparison of Ebook Formats* lists around 30 different formats (2011a). While users seldom subscribed to digital journals or even bought individual articles, many wished to have digital books that they could read on their proprietary devices. Finally, many publishers hindered the growth of digital books by requiring libraries to follow the rules for physical collections including allowing only one copy in circulation, a rule that made little practical sense in the digital age but may have increased publisher revenues if the library required multiple copies.

It could be proposed that the tipping point for digital books occurred as recently as 2009–2010. Various aggregators such as NetLibrary (http://www.netlibrary.net) and Ebrary (http://www.ebrary.com) now provide extensive collections. Libraries can enter into agreements whose terms allow adding the complete collection of eBooks into the ILS with purchase occurring only when a patron uses a digital book for a defined amount of time or number of accesses. Some vendors also allow multiple circulations of the same item. Finally, some vendors provide static collections where the library will own in perpetuity all purchased items while others offer dynamic collections, especially in areas such as computer science where older materials are less useful.

Before considering library space needs and books, two more factors enabled by the Internet must be considered. Google Books, if the legal issues can ever be resolved, offers the enormous benefit of offering access to millions of books in digital formats or as print-on-demand. Other resources for digital books are the Internet Archive and the Hathi Trust (Dougherty 2010). The second factor is the possibility of purchasing books in the out-of-print book market, where the availability of materials approaches 95 per cent (Holley and Ankem 2005). Many libraries, even research libraries, no longer need to build large collections 'just in case' but have a reasonable assurance of meeting patron needs for research materials 'just in time'. The whole concept of patron-driven acquisitions is built upon this model of probable reliable access to the monograph publications of the last two centuries (Hodges et al. 2010).

Purchasing current eBooks does not provide additional space but makes it possible to avoid finding new space for current purchases. Digital books may, in fact, help solve the problem of finding funds for expensive new construction. Furthermore, except for popular materials, libraries may defer purchase of more advanced research materials on the expectation of being able to find these items if needed in print format from the out-of-print market or in digital format from the eBook vendors or from Google Books. Furthermore, some libraries are reclaiming space by weeding their monograph collections. As with journals, some libraries are storing these books either on site in less prime space or at individual or cooperative remote locations. Other libraries are discarding many items on the reasonable assumption of being able to acquire them again in the ways indicated above or through interlibrary loan. It may be that most libraries will reclaim less space from books than from journals. Digital journal access will remain more

reliable, and also identifying individual book titles is more labour intensive for the space reclaimed than doing the same for journal titles (Soma and Sjoberg 2010).

Collections – Special Areas

Libraries may reclaim some space in the microforms area from the availability of digital replacements for long microfilm runs such as the *New York Times* and *The Wall Street Journal*. While microfilm reader and copy technology have advanced considerably, most readers prefer digital content so that relatively few microform readers are needed in most libraries. Many media are now available on the Internet or can be streamed to computers for free or for a cost determined by the type of material. Most academic libraries have not extensively collected media, so space savings from this technological change will be slight.

More libraries are saving space by significantly reducing their collection of government documents. The first reason for this reduction is due to technology, as more government agencies are publishing their documents in digital form. Budget reductions provide the second reason, since staff cutbacks have made libraries less willing to process government documents and to comply with the stringent rules that the government imposes upon libraries with depository status. Finally, other digital resources may provide the information that was formerly available most expeditiously from government publications (Hernon and Saunders 2009).

The digitization of rare and archival materials in special collections and archives makes it possible for some patrons to use these digital versions to avoid travelling to the repository where they require work space for their research. Some scholars, however, continue to need access to the physical documents for their research. Furthermore, the number of scholars using rare materials may increase as their availability becomes better known through their Internet presence. Overall, however, digital copies are most likely a plus for the preservation of rare and archival materials since fewer users will need to handle the physical artefacts (Dooley 2009).

Library Services

As indicated above, the Internet has virtually eliminated the need for ready reference. While libraries continue to feel the need to provide an in-depth reference service in support of student and faculty research, many have made significant changes in the way this service is offered. These changes can have significant space implications beyond the reduction already described of the physical reference collection. Some libraries have combined the circulation desk, normally staffed by clerical employees, and the reference desk (Wang and Henson 2011). Librarians may sometimes be stationed at this combined service point, but often the clerical staff have instructions to call a librarian to the desk or to send the patron to the librarian. It is also possible to schedule an appointment with librarians when the patron question requires a sophisticated answer beyond simple directional or

service requests. While only slightly different conceptually, other libraries have eliminated the reference desk and have librarians who roam through the building and campus or who are embedded within the faculty and student spaces on campus and within course software (Tumbleson and Burke 2010). Other libraries think it sufficient to provide instructions to users on how to contact a reference librarian in case of need (Nunn and Ruane 2011).

A new, more comprehensive solution is to implement an information commons/ learning commons where the library not only consolidates its services but also includes computer support and perhaps even other college or university services. One of the chief goals behind this change is to allow students to have many of their needs met in the same physical space without having to travel to different parts of the institution. Overall, such an arrangement makes effective use of campus space globally but might require the library to prove additional space for units that were not traditionally housed within the library. A book entitled *Transforming Library Service Through Information Commons: Case Studies for the Digital Age* by D. Russell Bailey and Barbara Tierney (2008) provides 20 case studies that discuss space planning for the information commons.

Technology has less effect upon the space needs of other library services. Self-service circulation might provide some space saving. Interlibrary loan (ILL) might require even more space if the library depends upon ILL to meet patrons' needs caused by the library's having a smaller collection. The digital collection and scanning possibilities have eliminated much of the need for photocopying machines. Cell phones have done the same for pay phones.

Uses for Space Savings

The library may or may not be able to retain any space savings for its own use. Colleges and universities always have need for more space for meeting rooms, offices, and other uses. Some libraries welcome giving up the space for these other uses because having students and especially faculty use space within the library can help position the library as a core function within the campus community (Tooey 2010). This advantage obviously does not apply if the library gives up an entire building or the entire space allocated to a branch library. If the library retains the space, the most common use is increased study space. With crowded, noisy dorms and long commutes, many students seek out a quiet space to study, especially if it is wired with the latest technology (Bryant et al. 2009). Some academic libraries have experienced increased gate counts even as the use of traditional library resources and services has fallen. Some question whether a better alternative would be to provide quiet study halls at a lower cost rather than keeping the library open with its traditional services and staffing patterns.

Current Status and Future Predictions

The space needs of academic libraries have been affected in various ways by the technological factors discussed above. They have choices in how they wish to implement the technologies and how radical they wish to be in rearranging their space. This concluding section looks at the status of space use today with some predictions for the future. The author moves from the most radical to the more conservative scenarios on a continuum.

Reclaiming Space by Eliminating or Drastically Reducing the Physical Library

Eliminating the library is most likely a possibility for branch campus libraries where a central library can still provide some library support. One example is the Medical Library at Johns Hopkins University that plans to shrink print holdings by 80 per cent by 2012. The librarians are now embedded in their departments and provide support through digital resources. The library has given the space back to the university to be used for other purposes and moved to a more remote location (Woodson 2010).

The Completely Digital Library

Another possibility is the completely digital library. In fact, the University of Texas at San Antonio (UTSA) recently announced the official opening of its new Applied Engineering and Technology (AET) Library, which, in a press release, it is calling 'the first completely bookless library on a university or college campus' (Rapp 2010). This new or remodelled library will provide access only to digital items but may have an Espresso Book Machine to provide on-demand print copies for patrons and may also have access to print collections from other libraries on campus. The optimal size of the library depends upon the number of patrons who wish to use the library and the willingness of the library to provide space for these users. As indicated above, many students seek a quiet space for study without extensive use of library services. The completely digital library may or may not provide a significant number of computers for patron use because mobile devices, wireless access for personal laptops, and checking out library laptops may eliminate much of the need for making desktop computers available.

Core Collection with Access to Research Materials as Needed

This scenario could extend from community and four-year undergraduate colleges to mid-size research libraries. These libraries will have a core collection of heavily used materials and provide access to research materials upon demand, 'just in time'. One issue will be the definition of heavy use, but the author would consider it to be at least one circulation every two years. The other chief factor is how many of these heavily used items will be digital and how many physical. As digital

availability extends to more and more items, this scenario may work out to be not much different from the completely digital library. Research materials will be acquired as needed from the storehouse of digital artefacts such as publisher offerings, Google Books, and institutional repositories, and from the print offerings in the out-of-print book market. Another decision will be whether the library provides a digital copy or a physical copy from the Espresso Book Machine when this is an option, and whether the library adds the digital or physical copy to the collection. Those libraries with special collections and archives will need to retain these physical collections as artefacts.

The Large Research Library

The large research library will most likely maintain larger collections of physical items with the space needs that these collections entail. First, the author hopes that some key libraries will take responsibility for current collecting in the disciplines where each library has the greatest strengths. The principle of 'just in case' relies upon someone somewhere having the copies to be shared. Second, the very large research libraries most likely will continue to collect to a depth that requires the acquisition of physical copies from countries where digital has not yet taken hold and from publishers elsewhere, mostly in the realm of grey literature, that see no need to make digital copies available and whose offerings do not have enough value for third party digitization. This prediction could prove wrong if these large research libraries decide to digitize these items on their own, but this decision brings up staffing issues and copyright considerations. Finally, some areas such as special collections where the original has intrinsic value and where details, important for at least some researchers, would be lost even with the best digitization will continue to require space for collection growth.

Conclusion

The advances in technology will at the very least slow the need for additional space in all academic libraries and may allow many academic libraries to shrink. While the availability of the Internet has led to some changes in services such as reference, the increased importance of digital collections is the main factor in the reduction of the need for space. Some libraries are already completely digital, while others will undoubtedly follow. Even the largest research libraries can reduce their journal holdings and substitute eBooks for a portion of their current acquisitions. Overall, the academic library no longer needs to define itself as a place where users go to access physical materials. Instead, the library has become a service point for providing users with the information resources and services that they seek even if they never set foot in the physical library.

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