NMC

Horizon Report > 2017 Library Edition

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The *NMC Horizon Report: 2017 Library Edition*
is a collaboration between The NEW MEDIA CONSORTIUM, UNIVERSITY OF APPLIED SCIENCES (HTW) CHUR, TECHNISCHE INFORMATIONSBIBLIOTHEK (TIB), and ETH LIBRARY.

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Front Cover Photograph
Students check out anatomical models at Lied Library, University of Nevada Las Vegas. UNLV Photo Services/Aaron Mayes.

Inside Cover Photograph
The innovative learning spaces at Reid Library, The University of Western Australia. Photo: Peter Bennetts

Back Cover Photograph
Innovation Space at the Health Sciences and Human Services Library (HS/HSL) of University of Maryland, Baltimore. Photo: HS/HSL

Executive Summary

What is on the five-year horizon for academic and research libraries? Which trends and technology developments will drive transformation? What are the critical challenges and how can we strategize solutions? These questions regarding technology adoption and educational change steered the discussions of 77 experts to produce the *NMC Horizon Report: 2017 Library Edition*, in partnership with the University of Applied Sciences (HTW) Chur, Technische Informationsbibliothek (TIB), ETH Library, and the Association of College & Research Libraries (ACRL). This *NMC Horizon Report* series charts the five-year impact of innovative practices and technologies for academic and research libraries across the globe. With more than 15 years of research and publications, the NMC Horizon Project can be regarded as education's longest-running exploration of emerging technology trends and uptake.

Six key trends, six significant challenges, and six developments in technology profiled in this report are poised to impact library strategies, operations, and services with regards to learning, creative inquiry, research, and information management. The three sections of this report constitute a reference and technology planning guide for librarians, library leaders, library staff, policymakers, and technologists. These top 10 highlights capture the big picture themes of organizational change that underpin the 18 topics:

1 **Libraries remain the gatekeepers to rich tapestries of information and knowledge.** As the volume of web resources increases, libraries are charged with finding new ways to organize and disseminate research to make it easier to discover, digest, and track.

2 **Incorporating new media and technologies in strategic planning is essential.** Libraries must keep pace with evolving formats for storing and publishing data, scholarly records, and publications in order to match larger societal consumption trends favoring video, visualizations, virtual reality, and more.

3 **In the face of financial constraints, open access is a potential solution.** Open resources and publishing models can combat the rising costs of paid journal subscriptions and expand research accessibility. Although this idea is not new, current approaches and implementations have not yet achieved peak efficacy.

4 **Libraries must balance their roles as places for both independent study and collaboration.** Flexibility of physical spaces is becoming paramount for libraries to serve as campus hubs that nurture cross-disciplinary work and maker activities — without eschewing their reputations as refuges for quiet reflection.

5 **Catering to patrons effectively requires user-centric design and a focus on accessibility.** Adopting universal design principles and establishing programs that continuously collect data on patron needs will make libraries the ultimate destination for learning support and productivity.

6 **Spreading digital fluency is a core responsibility.** Libraries are well-positioned to lead efforts that develop patrons' digital citizenship, ensuring mastery of responsible and creative technology use, including online identity, communication etiquette, and rights and responsibilities.

7 **Libraries must actively defend their fundamental values.** In times of economic and political unrest, libraries will be challenged to uphold information privacy and intellectual freedom while advocating against policies that undermine public interests and net neutrality.

8 **Advancing innovative services and operations requires a reimagining of organizational structures.** Rigid hierarchies are no longer effective. To meet patrons' needs, libraries must draw from different functional areas and expertise, adopting agile, matrix-like paradigms.

9 **Enabled by digital scholarship technologies, the research landscape is evolving.** GIS data, data visualization, and big data are expanding how information is collected and shared. These tools are helping libraries preserve and mine their collections while illuminating collaborative opportunities.

10 **Artificial intelligence and the Internet of Things are poised to amplify the utility and reach of library services.** These emerging technologies can personalize the library experience for patrons, connecting them more efficiently to resources that best align with their goals.

It is our hope that this analysis will help to inform the choices that academic and research libraries are making to improve, support, or extend learning and research. Education leaders worldwide look to NMC Horizon Project publications as strategic technology planning references, and it is for that purpose that the *NMC Horizon Report: 2017 Library Edition* is presented.

NMC Horizon Report > 2017 Library Edition at a Glance

Trends Accelerating Technology Adoption in Academic and Research Libraries

2017 2018 2019 2020 2021

Short-Term
Driving technology adoption in academic and research libraries over the next one to two years

Research Data Management
Valuing the User Experience

Mid-Term
Driving technology adoption in academic and research libraries over the next three to five years

Patrons as Creators
Rethinking Library Spaces

Long-Term
Driving technology adoption in academic and research libraries for five or more years

Cross-Institution Collaboration
Evolving Nature of the Scholarly Record

Challenges Impeding Technology Adoption in Academic and Research Libraries

Solvable
Those that we understand and know how to solve

Accessibility of Library Services and Resources
Improving Digital Literacy

Difficult
Those that we understand but for which solutions are elusive

Adapting Organizational Designs to the Future of Work
Maintaining Ongoing Integration, Interoperability, and Collaborative Projects

Wicked
Those that are complex to even define, much less address

Economic and Political Pressures
Embracing the Need for Radical Change

Important Developments in Technology for Academic and Research Libraries

2017 2018 2019 2020 2021

Time-to-Adoption Horizon: One Year or Less

Big Data
Digital Scholarship Technologies

Time-to-Adoption Horizon: Two to Three Years

Library Services Platforms
Online Identity

Time-to-Adoption Horizon: Four to Five Years

Artificial Intelligence
The Internet of Things

Introduction

The *NMC Horizon Report: 2017 Library Edition* was produced by the NMC in collaboration with the University of Applied Sciences (HTW) Chur, Technische Informationsbibliothek (TIB), ETH Library, and the Association of College & Research Libraries (ACRL). The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlook* series are part of the NMC Horizon Project, a comprehensive effort established in 2002 that identifies and describes important developments in technology poised to have a large impact on technology planning and decision-making in education around the world. Each of the four global editions of the *NMC Horizon Report* — higher education, primary and secondary education (K-12), museum, and academic and research library — highlights six trends, six challenges, and six developments in technology or practices that are likely to enter mainstream use within their focus sectors over the next five years (2017-2021).

In the pages that follow, 18 topics selected by the 2017 Library Expert Panel related to applications of technology for learning, research, and information management are examined. The topics are placed directly in the context of their likely impact on the core missions of academic and research libraries, and detailed in succinct, non-technical, and unbiased presentations. Each has been tied to essential questions of relevance or policy, leadership, and practice.

To plan for the future, it is important to look back. In reflecting on the three library-focused editions of the *NMC Horizon Report*, larger themes have emerged. Certain topics such as research data management and embracing the need for radical change reappear, regularly voted into the report by a now vast body of education leaders and technologists. The tables below show the findings from the past two library editions as well as the 2017 edition. (In some cases, for consistency, the topic names have been slightly modified from the report where they originally appeared.)

In observing the numerous overlaps from edition to edition, it is important to note that while topics may repeatedly appear, they only represent the broad strokes of library transformation; each trend, challenge, and technology development evolves over time, with fresh perspectives and new dimensions revealed every year. For example, scholarly records today are not what they were yesterday. Progress in open access and new research formats have expanded the spectrum of possibilities for how information is stored, accessed, and communicated.

Also noteworthy are topics that were almost included in the report. Because the expert panel votes on which topics they believe are poised for the deepest impact, some received many votes, but not enough to be featured among the 18 here.

Three Library Editions of the *NMC Horizon Report*

Key Trends	2014	2015	2017
Continual Progress in Technology, Standards, and Infrastructure	■		
Cross-Institution Collaboration			■
Evolving Nature of the Scholarly Record	■	■	■
Increasing Accessibility of Research Content	■	■	
Patrons as Creators			■
Prioritization of Mobile Content and Delivery	■	■	
Research Data Management	■	■	■
Rethinking Library Spaces		■	■
Rise of New Forms of Multidisciplinary Research	■		
Valuing the User Experience		■	■

Significant Challenges	2014	2015	2017
Accessibility of Library Services and Resources			■
Adapting Organizational Designs to the Future of Work			■
Capturing and Archiving the Digital Outputs of Research as Collection Material	■		
Competition from Alternative Avenues of Discovery	■	■	
Economic and Political Pressures			■
Embedding Academic and Research Libraries in the Curriculum	■	■	
Embracing the Need for Radical Change	■	■	■
Improving Digital Literacy		■	■
Maintaining Ongoing Integration, Interoperability, and Collaborative Projects	■		■
Managing Knowledge Obsolescence		■	
Rethinking the Roles and Skills of Librarians	■	■	

Important Developments in Technology	2014	2015	2017
Artificial Intelligence			■
Bibliometrics and Citation Technologies	■		
Big Data			■
Digital Scholarship Technologies			■
Electronic Publishing	■		
Information Visualization		■	
Library Services Platforms			■
Location Intelligence		■	
Machine Learning		■	
Makerspaces		■	
Mobile Apps	■		
Online Identity			■
Online Learning		■	
Open Content	■		
Semantic Web and Linked Data	■	■	
The Internet of Things	■		■

The next page contains a synopsis of topics not profiled here that are still deemed worthy of following in the coming years. Definitions and panel discussions of these topics can be viewed at library.wiki.nmc.org. Wherever relevant, important aspects of them have been integrated into the 18 topics represented in this report.

The final topics are published here as two-page spreads to make them useful as standalone essays and guides, but generating a more holistic vision of how they all coalesce is becoming increasingly important. In some instances, the challenges represent the obstacles hindering positive trends from scaling and the technologies are accelerators, revealing a convergence between all three sections.

Taken together, the topics featured in the library report from year to year tell a larger story about the overarching themes driving progress in — or impeding — learning, research, and information management. Each topic can be placed into one or more of six meta-categories that reflect movements in academic and research libraries, especially in the context of higher education as a whole.

NMC Horizon Report > 2017 Library Edition Semi-Finalists

Key Trends	Significant Challenges	Important Developments in Technology
Advancing Cultures of Innovation	Addressing Societal Challenges	Adaptive Learning Technologies
Collaborative Learning Approaches	Competition from Alternative Avenues of Discovery	Information Visualization
Increasing Accessibility of Research Content	Embedding Academic and Research Libraries in the Curriculum	Makerspaces
Prioritization of Mobile Content and Delivery	Managing Knowledge Obsolescence	Mixed Reality
Proliferation of Open Educational Resources	Marketing/Promoting Library Services	Virtual Assistants
Shift Away from Books	Rethinking the Roles and Skills of Librarians	Wearable Technology

Six Meta-categories for *NMC Horizon Report* Topics

Expanding Access and Convenience
People expect to be able to learn and work anywhere, with constant access to learning materials, as well as each other. Academic and research libraries have made great strides in generating more methods and platforms for students, faculty, and researchers to collaborate and be productive wherever they are. The advent of always-connected devices has provided more flexibility in how, when, and where people learn and conduct research, and many libraries have updated their IT infrastructures accordingly. Further, libraries must continuously update their policies and services to accommodate all patrons, regardless of disabilities.

Spurring Innovation
To spread progressive practices and develop 21st century services, libraries must be structured in ways that allow for flexibility while spurring creativity and entrepreneurial thinking. Libraries are positioned at the threshold of new frontiers in digital scholarship, though the culture often stems from academic leadership. In order to continuously stimulate fresh ideas and incubate improved services and operations, there is a need for libraries to adopt more agile organizational structures.

Fostering Authentic Learning and Discovery
Pedagogical trends in higher education are decidedly more student-centered in service of creating richer and more hands-on, real-world experiences. As vital hubs for campus activities, libraries have a responsibility to promote these active approaches by revamping their physical spaces and rethinking the kinds of events and training they offer. Similarly, research is increasingly becoming a collaborative activity that involves cross-disciplinary teams who work with and record data in technology-enabled formats. Libraries are well-positioned to cater to these activities by providing access to new digital tools and establishing the processes to store and disseminate an ever-expanding range of data and research outputs.

Balancing Societal Shifts
Though they are often viewed as steady, historic beacons that are vital to local and global communities, libraries are not immune to the pressures brought about by changes in national economies, governments, consumer behaviors and expectations, and education paradigms. Responding to every challenge or shift in a timely manner is nearly impossible, so libraries are devising long-term strategies that prioritize agility and cost-effective practices while anticipating and planning for emerging technologies to come.

Tracking Research and Patron Data
As scholarly records proliferate online in different formats, libraries play a major role in understanding their impact in the greater research community. This has been traditionally evaluated by where and how prominently a work is published. However, more libraries are measuring the impact through altmetrics — examining the influence of research in various mediums outside of formal publications and citations. Just as research can be tracked and measured, libraries are becoming more adept at integrating analytics and feedback

loops into their services and operations to gain a better understanding of patron behaviors and needs — and make subsequent adjustments accordingly.

Spreading Digital Fluency

Technology and digital tools have become ubiquitous, but they can be ineffective when they are not integrated into learning and research processes in meaningful ways. The contemporary workforce and academia increasingly call for digitally-savvy individuals who can seamlessly work with different media and new technologies as they emerge. A major element of fostering this fluency is recognizing that simply understanding how to use a device or certain software is not enough; people must be able to make connections between the tools and the intended outcomes, leveraging technology in creative ways that allow them to more intuitively adapt from one context to another. As hubs of information literacy and discovery, libraries are integral in advancing this mission, working with campus leaders, faculty, and staff to embed digital fluency more deeply in teaching and learning.

In the report that follows, each topic will have icons that appear next to it, indicating the above meta-categories where it belongs, in order to more clearly illuminate the connections between topics. The report's first two sections focus on an analysis of the trends driving technology decision-making and planning, and the challenges likely to impede the adoption of new technologies, respectively. Each includes an explicit discussion of the trend or challenge's implications for policy, leadership, and practice in academic and research libraries and library organizations. The inclusion of these three elements acknowledges that it takes a combination of governance, vision, and action to advance positive trends and surmount pressing challenges. Relevant examples and readings for further elaboration conclude each topic.

The report's third section focuses on important developments in technology — consumer technologies, digital strategies, enabling technologies, internet technologies, learning technologies, social media technologies, and visualization technologies — all positioned to impact libraries over the next five years. Each development contains a discussion of its relevance to academic and research libraries, and concludes with a set of project examples and further readings.

Taken together, the three sections constitute a straightforward guide for strategic planning and decision-making for academic and research library leaders across the world.

Trends Accelerating Technology Adoption in Academic and Research Libraries

The six trends described in the following pages were selected by the project's expert panel in a series of Delphi-based voting cycles, each accompanied by rounds of desktop research, discussions, and further refinements of the topics. These trends, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three movement-related categories — long-term trends that typically have already been impacting decision-making, and will continue to be important for more than five years; mid-term trends that will likely continue to be a factor in decision-making for the next three to five years; and short-term trends that are driving technology adoption now, but will likely remain important for only one to two years, becoming commonplace or fading away in that time.

While long-term trends have already been the topic of many academic and research library leaders' discussions and extensive research, short-term trends often do not have an abundance of concrete evidence pointing to their effectiveness and future directions. All of the trends listed here were explored for their implications for libraries in a series of online discussions that can be viewed at horizon.wiki.nmc.org/Trends.

The NMC Horizon Project model derived three meta-dimensions that were used to focus the discussions of each trend and challenge: policy, leadership, and practice. Policy, in this context, refers to the formal laws, regulations, rules, and guidelines that govern libraries; leadership is the product of experts' visions of the future of libraries, based on research and deep consideration; and practice is where new ideas and services take action, in libraries and related settings. Below are summaries of the six key trends that will be explored more in-depth in this section, with citations and resources included.

Long-Term Trends: Driving technology adoption in academic and research libraries for five or more years

Cross-Institution Collaboration. Collective action among institutions is growing in importance for the future of academic and research libraries. Today's global environment is allowing them to unite across international borders and work toward common goals concerning technology, research, and shared values. Within the current climate of shrinking budgets and increased focus on digital collections, collaborations enable libraries to improve access to scholarly materials and engage in mission-driven cooperative projects. More and more, libraries are joining consortia to combine resources or to align themselves strategically with innovation in higher education. Support behind technology-enabled learning has reinforced the trend toward open communities and consortia as library leaders, educators, and technologists come together to develop platforms and software that help institutions aggregate and store data, ensuring sustainable access and preservation.

Evolving Nature of the Scholarly Record. Once limited to print-based journals and monographic series, scholarly communications now reside in networked environments and can be accessed through an expansive array of publishing platforms. The internet is disrupting the traditional system of scholarship, which was founded on physical printing and distribution processes. Now scholarly records can be published as soon as peer review has taken place, allowing communication to happen more frequently and publicly. No longer limited to text-based products, scholarly work can include research datasets, interactive programs, complex visualizations, and other non-final outputs, as well as web-based exchanges via social media. There are profound implications for libraries, especially those that are seeking alternative routes to standard expensive publishing venues. As different kinds of scholarly communication are becoming more prevalent on the web, librarians are expected to discern the legitimacy of these innovative approaches and their impact in the greater research community through emerging altmetrics tools.

Mid-Term Trends: Driving technology adoption in academic and research libraries over the next three to five years

Patrons as Creators. A shift is taking place in the focus of pedagogical practice on university campuses worldwide as students, faculty, and researchers across disciplines are learning by making and creating rather than by simply consuming content. Creativity, as illustrated by the growth of user-generated videos, maker communities, and crowdfunded projects in the

past few years, is increasingly the means for active, hands-on learning. People now look to libraries to assist them and provide tools for skill-building and making. Libraries are ideal environments to serve as creation hubs on campus. This function is a natural extension of their traditional role as facilitators of knowledge creation and as spaces where scholars can connect. To catalyze creativity, many library makerspaces are adopting emerging technologies such as 3D printers, flexible displays, media production tools, and natural user interfaces to enable the act of making. As this trend accelerates, libraries are increasingly responsible for managing the volume and variety of the creations that materialize.

Rethinking Library Spaces. At a time when discovery can happen anywhere, students are relying less on libraries as the sole source for accessing information and more for finding a place to be productive. According to an EBSCO survey on how college students conduct research, 68% start their research process by using Google and Wikipedia. As a result, institutional leaders are starting to reflect on how the design of library spaces can better facilitate the face-to-face interactions that most commonly take place there. In this manner, staff are examining patron behavior to inform decisions for strategic plans and budgetary considerations. Many libraries are making room for active learning classrooms, media production studios, makerspaces, and other areas conducive to collaborative and hands-on work. These changes reflect a deeper pedagogical shift in higher education to foster learning experiences that lead to the development of real-world skills and concrete applications for students.

Short-Term Trends: Driving technology adoption in academic and research libraries over the next one to two years

Research Data Management. The growing availability of research reports through online library databases is making it easier than ever for students, faculty, and researchers to access and build upon existing ideas and work. Archiving the observations that lead to new ideas has become a critical part of disseminating reports. Enhanced formats and workflows within the realm of electronic publishing have enabled experiments, tests, and simulation data to be represented by audio, video, and other media and visualizations. Emergence of these formats has led libraries to rethink processes for managing data throughout the research lifecycle, from collection to analysis, visualization, and preservation. Advancements in digital data management are leading to more accurate subject search results and citations, while enabling libraries to more effectively curate and display relevant resources for patrons. As libraries continue to update repositories with new data formats, they must look to future developments within higher education to prepare for emerging methods of data curation to incorporate cutting-edge technologies.

Valuing the User Experience. User experience (UX) refers to the quality of a person's interactions with services and products. The term is commonly applied to assess exchanges with websites, mobile devices, and operating systems, but libraries are also applying the same usability principles to physical spaces. In the digital realm, easy navigation, digestible content, and practical features are encompassed in effective website and database designs. Further, companies such as Amazon and Google are identifying patterns in users' online behaviors to better tailor search results at the individual level. Direct feedback from users in the form of ratings on websites including NetFlix and TripAdvisor help companies customize content and adjust user interface design. The result is a more efficient and personal experience for users. Librarians are now favoring more user-centric approaches, leveraging data on patron touchpoints to identify needs and develop high-quality engaging experiences. Library publishing services can also benefit from understanding how user interface and design decisions impact both authors and readers.

Cross-Institution Collaboration

Long-Term Trend: Driving technology adoption in academic and research libraries for five or more years

Collective action among institutions is growing in importance for the future of academic and research libraries. Today's global environment is allowing them to unite across international borders and work toward common goals concerning technology, research, and shared values. Within the current climate of shrinking budgets and increased focus on digital collections, collaborations enable libraries to improve access to scholarly materials and engage in mission-driven cooperative projects.[1] More and more, libraries are joining consortia to combine resources or to align themselves strategically with innovation in higher education.[2] Support behind technology-enabled learning has reinforced the trend toward open communities and consortia as library leaders, educators, and technologists come together to develop platforms and software that help institutions aggregate and store data, ensuring sustainable access and preservation.

Overview

Collaboration in the form of reciprocal borrowing agreements has been commonplace for some time. IFLA's "Guidelines for Best Practice in Interlibrary Loan and Document Delivery" draws its recommendations from studies performed in the late 1990s and early 2000s.[3] One longstanding service is BorrowDirect, which has grown from its 1999 launch to include all Ivy League institutions as well as MIT, Duke University, Johns Hopkins University, and the University of Chicago.[4] Library organizations are also facilitating the sharing of e-resources. For example, members of the Lebanese Academic Library Consortium benefit from economies of scale through cooperative purchasing of subscriptions to major databases.[5] Collaborations of this nature have potential to impact participating libraries' acquisitions. Leaders may opt not to purchase resources held in other members' collections to allow additional flexibility around purchasing digital technologies, particularly as endowment funds are not always structured to accommodate innovation initiatives.[6]

As library professionals collaborate with other institutions, they may encounter challenges such as conflicting priorities or issues around funding responsibilities; however, joint initiatives are becoming more essential in the library field due to budgetary constraints. By working together, libraries can leverage subject matter expertise not present within their own staff, more efficiently bring promising programs to scale, and tackle issues too large for single institutions to address.[7] In its "Strategic Thinking and Design Initiative" report, the Association of Research Libraries interviewed leadership from large-scale library collaborations such as HathiTrust, Europeana, and DPLA. Key lessons learned included fostering a culture of non-competitiveness within the project space; developing a shared vision to drive the work; and focusing on existing problems within higher education that are present on participating campuses. Leaders also noted that as technology evolves and matures, a more collaborative model of scholarship is emerging; library projects serving multiple institutions are part of this environmental shift.[8]

Libraries are also working together to develop new technologies to build collaborative collections and improve delivery of library services. MIT Libraries, New York University Libraries, Princeton University Library, and Stanford University Library have developed GeoBlacklight, an open access geospatial search application.[9] This software is leveraged in initiatives including the Big Ten Academic Alliance Geospatial Data Project, in which librarians and geospatial specialists from ten institutions have aggregated a discoverable collection of GIS datasets and digitized historical maps.[10] Further, the Open Library Foundation aims to advance innovation by providing infrastructure to enable collaborations and communities of practice.[11] The organization supports the FOLIO initiative, a next-generation platform where librarians, technologists, and service providers can discuss and co-develop open source software to meet library needs.[12]

Implications for Policy, Leadership, or Practice

The Council of the European Union recently met to discuss the future directions of Europeana,[13] a digital search platform and virtual exhibition space for cultural heritage content institutions across the EU. Changes were recommended to the funding structure of this project, moving from primary reliance on member state contributions to a model in which EU funds cover the majority of operational costs.[14] At the institutional level, library directors must consider formulating policies around managing funding and sharing resources when working with other libraries. Decision-makers may opt to organize collaborative efforts within legal entities

separate from their institutions. For example, Emory University Library and Georgia Tech Library have joined forces to open the Library Service Center, a cold-storage facility located on Emory's campus that allows faculty, staff, and students from both institutions to access the shared collection.[15] The institutions contributed equal support for facility construction and operating costs through EmTech, a 501(c)(3) organization.[16]

Organizations and initiatives are supporting academic and research libraries in cross-institutional efforts. EIFL (Electronic Information for Libraries), a nonprofit network of libraries and consortia across Africa, Asia, and Europe, offers professional development opportunities and resources to increase knowledge sharing and collaboration. Librarians can access toolkits, webinars, and white papers on topics including consortium development and open educational resources.[17] As part of the Laura Bush 21st Century Librarian Program, the Biodiversity Heritage Library (BHL), a global consortium of over 30 research, natural history, and botanical libraries, has received IMLS funding to host National Digital Stewardship Residency positions at five of its partner institutions. The residents aim to improve digital tools and processes that BHL will use in creating the next-generation version of its online open access collection of biodiversity literature. Best practices for digital libraries developed by the resident cohort will inform other large-scale initiatives including the Digital Public Library of America and Europeana.[18]

Eight Hong Kong universities have partnered to improve students' information literacy with support from the Hong Kong University Grant Council. Each institution will create one module for an interactive courseware program on a shared platform. Librarians from participating institutions will co-develop strategies for working with faculty to integrate the modules into curricula.[19] Libraries are also collaborating to foster comprehensive digital preservation. The California Digital Library, Harvard Library, and UCLA Library have received an IMLS grant to develop Cobweb, an open-source platform for capturing and archiving web content metadata that provides participants a window into the work of other libraries and archives.[20] The platform will help curators avoid duplicative action and prevent gaps in coverage. Cobweb aims to promote collaboration and enable libraries to efficiently allocate their resources toward these efforts.[21]

For Further Reading

The following resources are recommended for those who wish to learn more about cross-institution collaboration:

Challenges Facing the Formation of Library Cooperation and Resource Sharing
go.nmc.org/tanzlib
(Jaffar Msafiri Ponera, *International Journal of Research*, January 2017.) The author examined collaborations between two Tanzanian university libraries. Recommendations include the development of formal cooperative policies at each institution and the signing of memoranda of agreement detailing the sharing of information resources.

Development of a Cross Institutional Digital Repository (PDF)
go.nmc.org/crossdep
(Maggie Farrell, IFLA World Library and Information Congress 2015, August 2015.) By engaging multiple institutions in the development of digital repositories, diverse skill sets can be leveraged to accomplish the work of building appropriate technology and contributing resources. Best practices for managing joint efforts are identified.

Digital Resources Management in Libraries: Step towards Digital Bangladesh
go.nmc.org/bangla
(A.I.M. Rahman et al., Proceedings of the National Seminar on Cross-talk of Digital Resources Management, 2015.) To meet future goals of developing a national federated interface for digital resources, this article recommends that academic and research libraries experiment with smaller-scale cross-institutional collaborations to create standards and guidelines based on lessons learned.

The Myanmar Academic Library Consortium is Born
go.nmc.org/myanlib
(Electronic Information for Libraries, 13 December 2016.) Leadership gatherings held by EIFL set the stage for nine institutions to form the Myanmar Academic Library Consortium. The organization aims to coordinate professional development for library staff and provide financial benefits to members through consortium-wide sharing of e-resources.

New UK-wide Service Will Transform Library Collaboration
go.nmc.org/jiscserv
(Jisc, 3 February 2017.) Jisc has partnered with global library cooperative OCLC to build a system supporting the creation of a national bibliographic knowledge base for the UK. The project will leverage technology used by OCLC's WorldCat database to aggregate digital resources and metadata to ensure sustainable access for scholars.

Open Pathways to Student Success
go.nmc.org/acadoer
(Joseph A. Salem Jr., *The Journal of Academic Librarianship*, January 2017.) Libraries can lead their institutions in developing open educational resource repositories to improve student academic performance. This article describes efforts in progress by multi-institution partnerships such as the Open Textbook Network.

Evolving Nature of the Scholarly Record

Long-Term Trend: Driving technology adoption in academic and research libraries for five or more years

Once limited to print-based journals and monographic series, scholarly communications now reside in networked environments and can be accessed through an expansive array of publishing platforms.[22] The internet is disrupting the traditional system of scholarship, which was founded on physical printing and distribution processes. Now scholarly records can be published as soon as peer review has taken place, allowing communication to happen more frequently and publicly. No longer limited to text-based products, scholarly work can include research datasets, interactive programs, complex visualizations, and other non-final outputs, as well as web-based exchanges via social media. There are profound implications for libraries, especially those that are seeking alternative routes to standard expensive publishing venues.[23] As different kinds of scholarly communication are becoming more prevalent on the web, librarians are expected to discern the legitimacy of these innovative approaches and their impact in the greater research community through emerging altmetrics tools.

Overview

This trend reflects a growing convergence of several vital priorities for the field: digital scholarship, altmetrics, and open access resources.[24] Libraries are increasingly the gatekeepers of their academic communities' research outputs and scholarly works. Historically, this role has been undertaken by subscription-based academic journals and university presses. Scholarship is still steeped in these traditional approaches because of the inherent prestige; quality and impact are often evaluated by how prominently and where a work is published. However, technology is gradually but significantly transforming the way information is collected, validated, and disseminated, prompting a host of alternative publication models. The digitization of scholarly records and the transition from text-based materials to more dynamic, rich formats are key steps of this evolution.[25] In this new realm, scholars need librarians' support in demonstrating the impact of their various outputs at tenure and promotion reviews.[26]

As a result of this long-term shift, libraries are growing more adept at managing repositories, curating research data, and promoting the sharing of open data.[27] The Canadian Association of Research Libraries (CARL) and the Canadian Research Knowledge Network (CRKN) have been seminal in initiating advocacy and support activities that inform institutional leaders on the evolution of scholarly communication with a focus on open access.[28] Last year, CRKN launched the Institutional Mobilization Toolkit to aid libraries in their discussions around the cost and availability of research resources.[29] Another major focus area for libraries is altmetrics — digital indicators that demonstrate the activity and engagement deriving from an output, both quantitatively and qualitatively. This evaluation process can, for example, include mentions on social media.[30] While traditional citation tools expose the frequency in which other researchers reference a work, altmetrics can reveal how scholarly records influence policies and real-world practices.[31]

The transformation of scholarly publishing has also sparked important discussions about the future of peer review. Open peer review — the act of exposing authors' and referees' identities to each other — is on the rise as a means of alleviating chronic issues like efficiency and reviewer accountability.[32] *PeerJ* is one journal that aims to accelerate the peer review process while minimizing cost; authors can sign up for a lifetime membership to enable unlimited free publishing, and all works are released under a Creative Commons license.[33] In F1000Research's open research platform, all articles receive transparent peer review and benefit from the inclusion of all source data. Articles, slides, and posters are published on a rapid timeline without editorial bias.[34] Certification can also be performed online through platforms such as PubPeer,[35] an open peer review site where scientists comment on articles published using a digital object identifier. While this model has not been consistently scaled across research fields, proponents suggest that open review accurately reflects that all research is a work in progress.[36]

Implications for Policy, Leadership, or Practice

As the variety of alternative scholarly records grows, more libraries are measuring the impact through altmetrics. To date, however, there has been no standardization for guidelines. The National Information Standards Organization (NISO) launched the Alternative Assessment Metrics Project with the goal of identifying best practices that inform policy. A report on the findings of the project pinpoint several recommendations, including stating that metrics

about the use of research data should be made widely accessible; altmetric citations must encompass persistent identifiers that are machine actionable across all systems; and formulations need to reflect the growing trend of non-human downloads.[37] Further, altmetrics have significant implications for tying research outputs to specific policies. London's Altmetric LLP published "Understanding the Impact of Research on Policy Using Altmetric Data" to showcase how their Altmetric Policy Miner tool is helping World Bank Group and Cochrane UK to better understand how the knowledge they have generated through reports, papers, and articles is being leveraged by policymakers worldwide.

The movement toward open access publishing at scale requires leadership from championing organizations and consortia. Fifty partners from European Union countries are collaborating on OpenAire2020, an effort to promote open scholarship by improving the discoverability and reusability of research data. Research libraries, national e-infrastructure and data experts, and legal researchers are leveraging the online OpenAire platform to create open scholarship workflows and guidelines for the broad adoption of an all-purpose repository.[38] Another trailblazer in this arena is National Science Communication Institute, who has forged a long-term partnership with UNESCO in establishing the Open Scholarship Initiative. Scholarly publishing decision-makers are routinely convened to share their perspectives and identify actionable solutions to challenges. They are working to address barriers to open access, the affordability of journals, and ways in which institutional repositories can work together to encompass the full breadth of the world's knowledge.[39]

Across the field, traditional processes are being revamped in favor of future-focused publishing models. The University of Cape Town Libraries is the first higher education institution in Africa to publish an open monograph using the Open Monograph Press platform, raising the national profile of the movement towards libraries as open-source publishers.[40] At the University of Illinois, the Publishing Without Walls project aims to develop a library-based service model for scholarly publishing to provide university libraries with the support and resources they need to integrate openly accessible, scalable, and sustainable publishing services that better cater to scholars' needs.[41] Additionally, more libraries are leveraging information visualization technologies to showcase scholarly work and pinpoint connections between research. At the Coalition for Networked Information's (CNI) Fall 2016 meeting, Cornell University Library presented a data and visualization service called Scholars@Cornell. The goal of this new initiative is to bolster the visibility of the institution's research while illuminating explicit and latent patterns of scholarly collaboration.[42]

For Further Reading

The following resources are recommended for those who wish to learn more about the evolving nature of the scholarly record:

ACRL Scholarly Communication Toolkit
go.nmc.org/acrlsct
(Association of College & Research Libraries, accessed 9 February 2017.) This seminal toolkit was created to help librarians integrate scholarly communication perspectives into library operations and programs as well as to prepare presentations on the surrounding issues.

Altmetrics in the Library (PDF)
go.nmc.org/altmet
(Anne E. Rauh, *Syracuse University SURFACE*, 21 August 2016.) A science and engineering librarian provides context and visuals championing the importance of academic libraries' role in integrating altmetrics.

The Cost of Open Access to Journals: Pay It Forward Project Findings
go.nmc.org/costof
(MacKenzie Smith, CNI, 30 November 2016.) The Pay It Forward project explored the viability of open access models by factoring in institutional costs, faculty and student opinions, and ways to financially support article processing charges.

Five Librarians Discuss the Future of the Academic Book (PDF)
go.nmc.org/fivelib
(Christina Kamposiori, *British Academy Review*, January 2017.) The program officer of Research Libraries UK conducted interviews with academic librarians of varying backgrounds to frame a vision for the future of scholarly works. Among the perspectives surfaced was libraries' active position in designing evolved resources and content.

Scholarly Communication/Publication: Scholarly Communication & OA
go.nmc.org/witsza
(University of the Witwatersrand Johannesburg, accessed 9 February 2017.) This library guide from a South African institution was created to help researchers and students navigate multiple modes of publishing and includes checklists, open access resources, and more.

What are the Challenges of Open Peer Review?
go.nmc.org/oprchall
(Stephanie Boughton, *BioMed Central*, 15 June 2016.) The author discusses skepticism towards open peer review. There is a lack of research both into this emergent model and into peer review in general. She believes the first step is to establish a clearer definition of open peer review.

Patrons as Creators

Mid-Term Trend: Driving technology adoption in academic and research libraries over the next three to five years

A shift is taking place in the focus of pedagogical practice on university campuses worldwide as students, faculty, and researchers across disciplines are learning by making and creating rather than by simply consuming content.[43] Creativity, as illustrated by the growth of user-generated videos, maker communities, and crowdfunded projects in the past few years, is increasingly the means for active, hands-on learning. People now look to libraries to assist them and provide tools for skill-building and making. Libraries are ideal environments to serve as creation hubs on campus. This function is a natural extension of their traditional role as facilitators of knowledge creation and as spaces where scholars can connect. To catalyze creativity, many library makerspaces are adopting emerging technologies such as 3D printers, flexible displays, media production tools, and natural user interfaces to enable the act of making. As this trend accelerates, libraries are increasingly responsible for managing the volume and variety of the creations that materialize.

Overview

The traditional view of libraries as places to quietly conduct research and engage in independent study has given way to environments that emphasize collaboration and experimentation. Larger societal trends towards participatory cultures are prompting libraries to adopt a new vision of their patrons as innovators, and to cultivate spaces and resources that support the act of creating.[44] Libraries have been well-positioned to house campus makerspaces that encompass 3D printers and scanners, computer assisted design (CAD) software, and more. The goal is to empower patrons to engage in hands-on, interdisciplinary learning that can lead to the discovery of new knowledge and interests, the initiation of new research, or entrepreneurial activities.[45] The library makerspace at Kent State University Tuscarawas, for example, helps patrons turn ideas into business ventures and marketable products. By also serving as the home for the Ohio Small Business Development Center, the site is bolstering digital and entrepreneurial literacy.[46]

A recent survey by the Association of Research Libraries (ARL) revealed that 64% of responding libraries in North America are engaged in providing, planning, or piloting makerspace services. Another 17% plan to investigate the services.[47] Many are including a combination of central services such as reference, training, hardware, scanning, and a repository for models — with an emphasis on 3D design, printing, and scanning. However, fostering effective opportunities for technology-enabled creation will require human support. Almost all of the surveyed libraries make available or plan to offer in-person technology training and skill-building sessions. Additionally, 75% provide digital resources to guide patrons with design, models, and software. In response to the survey, ARL developed the Rapid Fabrication/Makerspace Services SPEC Kit for libraries. As this trend gathers steam, libraries are also revising their budgets, shifting from traditional collection development to patron-driven acquisitions.[48]

A growing host of academic and research libraries exemplify this trend. New York University modeled its data services on the format of an art studio; the open lab space is supported by data librarians and technologists, and provides access to software, data sources, and training, empowering people to easily discover resources to create.[49] Meanwhile, the German National Library of Science and Technology in Hannover held a workshop to help campus scientists and engineers create brief video abstracts using mobiles and free web applications, as well as guiding them on choosing appropriate licenses and online publishing sites.[50] Canada's Ryerson University recently opened its first library makerspace, the Isaac Olowolafe Digital Media Experience (DME) Lab.[51] Designed with a peer-to-peer learning service model, the DME Lab provides students with access to Oculus virtual reality headsets and other technologies. A variety of workshops are available there, as well as individual instruction in the use of advanced media creation tools.

Implications for Policy, Leadership, or Practice

Many libraries have adopted policies regarding the use of 3D printing and other creative tools, generally restricting students to uses of the equipment that are not prohibited by law, dangerous, or impinging on others' intellectual property rights. In many instances, patrons submit their designs and obtain approval before library employees operate the 3D technology.[52] Some institutions have procedures regarding the

prioritization of printing projects, often based on academic priority, class due dates, or time of approval of the submission. At the University of Toronto's Gerstein Science Information Centre, students may operate the technology independently after completing a safety and training session, and reserving access time.[53]

Libraries are initiating programs and partnering with university faculty and other organizations to promote active learning and innovation. Through a grant from the Andrew W. Mellon Foundation, the University of Virginia Library's Scholars' Lab developed the Praxis Program, which awards graduate students with fellowships that allow them to apprentice with library employees to design and construct a digital project centered on the humanities or a specific software tool. Participating students developed Prism, a software tool that expands the capabilities of text by allowing for collaborative interpretation.[54] In an effort to give skilled, creative students a greater role in the library's innovation efforts, UCLA Library launched Simul8. Through this program, student employees at the UCLA Library are designing apps to increase the ease of sharing library collections.[55]

The most important practical implication of this trend in libraries is an increase in patron creation and innovation. Students at NUI Galway used the 3D design software and printers in the library makerspace to generate a variety of sculptures and to design and print models of molecules.[56] In Australia, patrons of the Curtin University's TL Robertson Library makerspace have experimented with using batteries, LEDs, and conductive thread to connect a circuit and attach it to a garment or soft item.[57] Integrating electronics, mechanics, and game design, a group of Carnegie Mellon University (CMU) students collaborated to build a virtual reality tank game in the IDeATe Experimental Fabrication Lab, one of several makerspaces hosted in CMU's Hunt Library. The invention featured a physical chair system that required players to engage with the game using their hands and feet, simulated turns, and allowed multi-player participation. In recognition of their achievement, the students received the Outstanding Project Award in Build18, an annual CMU freestyle tinkering festival that gives CMU student engineers free rein to showcase their creativity.[58]

For Further Reading

The following resources are recommended for those who wish to learn more about patrons as creators:

Ascending Bloom's Pyramid: Fostering Student Creativity and Innovation in Academic Library Spaces
go.nmc.org/ascend
(Mark Bierangel and Stern Neill, *College & Research Libraries*, February 2016.) The authors explore the way in which the design of spaces either fosters or impedes creative processes and behaviors.

The KnowledgeLab
go.nmc.org/knowlab
(Neilson Library Knowledge{Lab}, accessed 2 March 2017.) The KnowledgeLab at Smith College Libraries is a participatory space for undergraduate students to engage with emerging practices around the making and sharing of knowledge. The space serves as a platform for showcasing creative student scholarship and experiments generated and implemented by students through a mini-grants program.

MLab
go.nmc.org/mlabuv
(Maker Lab in the Humanities, University of Victoria, accessed 7 February 2017.) Some library makerspaces have narrowed their focus to provide deeper dives into particular disciplines and research areas. The MLab at University of Victoria Libraries concentrates on the intersection of culture criticism, experimental prototyping, and electronics.

NCSU Libraries Code + Art Student Visualization Contest
go.nmc.org/codeart
(North Carolina State University, accessed 7 February 2017.) During the NCSU Libraries Code + Art Student Visualization Contest, students create a wide range of data visualizations, procedurally generated environments like game environments, and virtual and augmented reality experiences.

SLUB Makerspace
go.nmc.org/slubde
(Dresden Technology Portal, accessed 7 February 2017.) Germany's Saxon State and University Library Dresden (SLUB), a three-branch library that serves Dresden University of Technology, provides patrons with a makerspace in which to experiment, realize their creative vision, and cultivate a community with a common interest in making.

The State of Library Makerspaces
go.nmc.org/thestate
(Fangmin Wang et al., *International Journal of Librarianship*, 2016). This article provides a comprehensive overview of the maker culture in academic libraries. The authors profile several makerspaces at North American universities, including North Carolina State University, Ryerson University, and the University of Nevada in Reno.

Rethinking Library Spaces

Mid-Term Trend: Driving technology adoption in academic and research libraries over the next three to five years

At a time when discovery can happen anywhere, students are relying less on libraries as the sole source for accessing information and more for finding a place to be productive. According to an EBSCO survey on how college students conduct research, 68% start their research process by using Google and Wikipedia.[59] As a result, institutional leaders are starting to reflect on how the design of library spaces can better facilitate the face-to-face interactions that most commonly take place there. In this manner, staff are examining patron behavior to inform decisions for strategic plans and budgetary considerations. Many libraries are making room for active learning classrooms, media production studios, makerspaces, and other areas conducive to collaborative and hands-on work.[60] These changes reflect a deeper pedagogical shift in higher education to foster learning experiences that lead to the development of real-world skills and concrete applications for students.[61]

Overview

The transformation of physical spaces is an ongoing trend within higher education. Listed as a long-term trend in the *NMC Horizon Report > 2015 Library Edition*, the 2017 expert panelists believe that the reconceptualization of library spaces is maturing. Recent studies are helping to highlight the ways in which these changes are occurring. The report *Planning and Designing Academic Library Spaces*, for example, identified the approaches, challenges, and best practices in designing new academic library learning spaces. Through a series of interviews, the authors found that 77% of architects and 50% of librarians prioritized flexibility, favoring spaces that are movable and customizable based. Supporting a spectrum of learning needs was another shared goal. Most interviewees noted that new library spaces were being designed to support academic learning activities, with collaboration at 83%, individual study at 73%, and point-of-need services at 63%.[62]

The advancement of information and communication technologies has had a profound impact on spatial considerations. To better understand the role of physical spaces in libraries, a study titled "The Library as a Multidimensional Space in the Digital Age" was conducted by a researcher at the University of Tampere, Finland. Through interviews and the consultation of planning and design documents, the study concluded that libraries are now perceived as hybrid environments — a fusion of physical, social, and digital spaces and services. In analyzing the Helsinki University Main Library building project, the research indicated that the input of several stakeholders, including users, informed spatial consideration in the design process. The physical space dimension allows for multiple functions; the social space dimension fosters face-to-face interactions; and the digital space dimension facilitates greater responsiveness to patrons' mobile devices.[63]

Over time, academic libraries have been reconsidering their spaces based on the evolving needs of their patrons. Faculty are increasingly accessing resources online, such as journal articles, from their homes or offices. As a result, higher education institutions are encouraging educators to be more involved in building a vibrant learning community. For example, the Montana State University Library created the Innovation Learning Studio (ILS) to attract faculty back to the library. The ILS is an additional educational space in the library that enables more active teaching and flipped-classroom opportunities, as well as the exploration of new educational technologies.[64] While libraries are expected to become more involved in facilitating innovative instructional and research methods, new types of active learning spaces are emerging. "Beta spaces" are defined as "environments within a larger library ecosystem created to prototype and deploy new ventures." While nascent, these efforts are furthering the concept of makerspaces, emphasizing ideas over technology.[65]

Implications for Policy, Leadership, or Practice

Policymakers at every level can apply emerging research about this trend to inform policies that anticipate the evolution of academic libraries. Since 2007, the New Zealand Ministry of Education has produced a series of documents titled "Digital Quality Learning Spaces" in partnership with the local Building Research Association. Version 2.0 of DQLS Acoustics is substantially updated from the first version; the document reflects the introduction of new pedagogies and greater interest in flexible learning spaces, and was rewritten to inform the work of architects, designers, and engineers. At the

institutional level, Stony Brook University is devising new strategic goals towards creating a 21st century library that meets diverse user demands. This includes aligning technology with physical spaces and furnishings to support the bring your own device (BYOD) movement by providing adequate power outlets and charging stations, as well as high-speed Wi-Fi.[66]

Several leading organizations have developed resources to help libraries worldwide to plan and evaluate their spaces. Since 2012, a core team consisting of the EDUCAUSE Learning Initiative, SUNY System, MERLOT, Society of College and University Planning, and others have helped create the FLEXspace Flexible Learning Environments eXchange Initiative — a robust, open-access repository showcasing detailed examples of innovative learning spaces.[67] Using contemporary pedagogy as the starting point, the resources describe the kinds of spaces most appropriate to accelerate active learning.[68] Similarly, the Universities and Colleges Information Systems Association offers the UK Higher Education Learning Space Toolkit as a practical guide that shares best practices when creating learning spaces. Topics include managing a learning space project, change management in transition, and evaluation.[69] Assessment is at the core of the Learning Space Ratings System (LSRS). The LSRS is a tool developed to rate formal learning spaces on their effectiveness in encouraging active learning and is used for renovations or new building projects.[70]

Academic and research libraries are actively updating their spaces and creating new ones to emulate the innovative vision established by leadership initiatives. The newly opened Auchmuty Library Learning Lounge at the University of Newcastle Australia is a 24-hour access facility with ergonomic group study spaces that supports BYOD and contains a "survival station" with hot water and a microwave.[71] The Claremont Colleges Library is the campus hub for digital humanities and digital scholarship, and to further those focus areas, the library is constructing a Digital Tool Shed — an incubator for innovative digital research, teaching, and learning.[72] Also in development is Virginia Commonwealth University's new Cabell Library where 90% of the space is intended for student use instead of book and material storage, and is designed with flexibility to support new technologies and student needs.[73]

For Further Reading

The following resources are recommended for those who wish to learn more about rethinking library spaces:

Coalition for Networked Information Introduction and Program Plan 2016-17
go.nmc.org/cnipro
(Consortium of Networked Information, accessed 20 February 2017.) CNI has produced a program plan that has three major features, including transforming organizations, professions, and individuals, under which spaces and services that support technology-enhanced research and learning reside.

Evaluating and Designing Learning Spaces Guide
go.nmc.org/jisceval
(Jisc, accessed 20 February 2017.) Jisc's website provides a quick guide to the evaluation and design of learning spaces, covering assessment methods, project management, and the design process.

Imagine Our Library
go.nmc.org/ucdlib
(UC Davis University Library, accessed 20 February 2017.) The UC Davis Library is soliciting suggestions from students, faculty, and researchers about how the library's space, technology, and services can best serve their needs. Phase one involves visioning, phase two focuses on detailed programming, and phase three is the actual design.

Learning Spaces Collaboratory
go.nmc.org/lsc
(Learning Spaces Collaboratory, accessed 20 February 2017.) The Learning Spaces Collaboratory is synthesizing findings from research and practice in learning space design to build resources to shape and assess undergraduate learning environments, such as an "Emerging Template for Assessing Learning Spaces."

Library Refurbishments
go.nmc.org/refurbish
(The University of Western Australia Library, accessed 20 February 2017.) The University of Western Australia libraries are transforming to provide more interactive, flexible, and collaborative spaces. Once home to print collections, the Medical and Dental Library will be renovated with e-learning suites, computer training facilities, and collaborative learning areas.

Measure the Future
go.nmc.org/measure
(Measure the Future, accessed 20 February 2017.) Using inexpensive sensors that collect data about a building's usage, the Measure the Future project will help libraries track the number of visits, items patrons browsed, and which parts of the library were busy during specific times. The data collected will inform the strategic decisions of librarians, creating more effective operations.

Research Data Management

Short-Term Trend: Driving technology adoption in academic and research libraries over the next one to two years

The growing availability of research reports through online library databases is making it easier than ever for students, faculty, and researchers to access and build upon existing ideas and work. Archiving the observations that lead to new ideas has become a critical part of disseminating reports. Enhanced formats and workflows within the realm of electronic publishing have enabled experiments, tests, and simulation data to be represented by audio, video, and other media and visualizations. Emergence of these formats has led libraries to rethink processes for managing data throughout the research lifecycle, from collection to analysis, visualization, and preservation.[74] Advancements in digital data management are leading to more accurate subject search results and citations, while enabling libraries to more effectively curate and display relevant resources for patrons. As libraries continue to update repositories with new data formats, they must look to future developments within higher education to prepare for emerging methods of data curation to incorporate cutting-edge technologies.

Overview

Methods of data generation and the capabilities for storing vast amounts are constantly expanding. Within academic and research libraries, the focus has evolved from exploring e-publishing, as described in the *NMC Horizon Report > 2014 Library Edition*, the impact of metadata standards in the 2015 edition, to the current role of librarians within the research lifecycle and ways to embrace new media data at present. While this trend is not new, it has gained momentum as openness in publishing and increases in data collection have further solidified libraries' role in research data management (RDM).[75] A study conducted by LIBER and DataOne showcases an uptick in European university libraries providing support and training for staff in research data management.[76] Leveraging research conducted three years prior as a baseline, this study highlights a majority of libraries' movement towards staff development and collaboration with other sectors to create RDM policies and guidelines.[77]

Working with other university sectors, the library has transitioned into a role that can be synthesized into three overlapping parts: access, support, and data management.[78] Access, the most traditional role within the library, includes identification of relevant data repositories for learners to apply existing research as well as providing the most up-to-date standards for citation and reference to be identifiable for future use.[79] In order to ensure long-term discoverability of research, library staff have also increased their scope of work to include support systems for data research. Arguably one of the most important forms of support is the ability for libraries to identify metadata standards, which record a combination of source, purpose, and methods behind data.[80] The third role, data management, encompasses both access and support, while also emphasizing storage planning and data curation to "preserve and add value to the data over time, extending from the lifecycle of the research project to its potential reuse."[81]

The expansion of technology is diversifying the types of data formats, including graphics, audio, and video.[82] This has led to creating infrastructure that can store, preserve, and manage new media data. Digital asset management (DAM) is a subset within research data management focused on developing processes to store digital formats, creating new metadata standards that encompass evolving formats.[83] The International Press Telecommunications Council recently published recommendations for video metadata that includes specifications for content properties and technical implementation standards.[84] Projects are already underway to incorporate digital data into library repositories. Smith College recently established the Collaboration for Technology Enhanced Learning, which convenes cross-disciplinary leaders to develop systems that incorporate multimedia data from research initiatives spanning the institution.[85] To prepare for new formats of data curation, libraries can also benefit from keeping apprised of emerging technology trends including virtual reality and artificial intelligence.

Implications for Policy, Leadership, or Practice

An international study conducted by the White Rose University Consortium that surveyed institutions throughout North America, Australia, and Europe revealed that most RDM policies stem from leadership within campus libraries; however, the process of developing policies involves multiple stakeholders, with a range of participants that also includes information technology departments, research officers, legal officers, and others.[86] With emerging formats and new

technologies, universities must develop guidelines to ensure data is generated in deliberate and thoughtful ways. Both Monash University and the Imperial College London have published resources under their libraries' homepages to guide researchers in using best practices, understanding the legalities of data curation, promoting storage and data repositories, and more.[87,88] Privacy concerns are also at the forefront as data sharing increases. Librarians can look to the work being done through Jisc's Safeshare Pilot project with universities within the Farr Institute to ensure sensitive data is being shared safely.[89]

Leaders in RDM are being acknowledged for their work through multiple foundations' grant programs. Three awards were announced through the Institute of Museum and Library Services (IMLS) for academic library RDM initiatives this year. Totaling investments over $200,000, these projects highlighted universities across the US and focused on ensuring librarians' role within RDM are sustainable over time, showcasing the continued growth of this trend within library spaces.[90] As students become more involved within research initiatives, universities have a vested interest in supporting greater faculty involvement in RDM. While budgetary constraints have not allowed for the hiring of dedicated research librarians, North Carolina State University Libraries has overcome this obstacle by deploying their Data Management Review Service to train current staff on competencies needed to support RDM across multiple disciplines.[91]

Academic and research libraries that have successfully applied RDM strategies are exploring the impacts of these implementations on research disciplines. In South Africa, libraries are beginning to produce frameworks that outline effective policies, infrastructures, and staff training. For example, Cape Peninsula University of Technology Library has published research that investigates how e-research is being used within biomedical studies and details ways in which the university library can develop tools for data management.[92] Another notable exemplar is the University of Michigan Library, which plans to launch a suite of data management services, including a repository that will assist researchers throughout all phases of the research lifecycle. The initiative, known as Deep Blue Data, is an extension of their current repository and will incorporate efforts of over 50 librarians and staff to develop data management plans, schematics, and preservation strategies.[93]

For Further Reading

The following resources are recommended for those who wish to learn more about research data management:

Academic Libraries and the EDUCAUSE 2017 Top 10 IT Issues
go.nmc.org/itlib
(Bohyun Kim, *EDUCAUSE Review*, 17 January 2017.) Academic libraries and institutional IT departments are facing similar challenges in data management. Staff from both sectors can work in tandem to develop operational guidelines to inform data-driven decisions to improve student success and operational efficiency.

Diving into Data: Planning a Research Data Management Event
go.nmc.org/datares
(Robyn B. Reed, *Journal of eScience Librarianship*, 16 July 2015.) Librarians can leverage their data management work to support research and scholarship across disciplines at their institutions. In developing a data management symposium, library staff at Penn State Hershey engaged the researcher community to identify unmet needs and topics of interest.

A Practical Approach to Digital Preservation Planning at a Mid-Sized Academic Library (PDF)
go.nmc.org/preserve
(Christine S. Wiseman, IFLA World Library and Information Congress, 24 June 2016.) The Atlanta University Center Robert Woodruff Library recognizes the shift to an increase in the amount of digital data. Collaborative efforts have proved essential to the curation and preservation of these vast amounts of data.

Researcher-library collaborations: Data Repositories as a Service for Researchers
go.nmc.org/datarep
(Andrew S. Gordon et al., *Journal of Librarianship and Scholarly Communication*, 22 September 2015.) The digital repository Databrary has collaborated with NYU Libraries to harness library staff skills in developing technical infrastructure for data management and sharing. Libraries can also benefit from adopting Databrary's practices of working with scholars to better understand how to support their research processes.

UO Libraries Invites Researchers to 'Love Your Data' This Week
go.nmc.org/lovedata
(University of Oregon, 13 February 2017.) The second annual Love Your Data week served as an awareness-building event for best practices in the rapidly evolving field of data management.

Using Scenarios in Introductory Research Data Management Workshops for Library Staff
go.nmc.org/pdscen
(Sam Searle, *D-Lib Magazine*, November 2015.) As academic and research libraries progressively focus on RDM, there is a need for staff to develop the requisite competencies. An exemplar professional development model used scenario-based learning to identify challenges and find solutions in data management.

Valuing the User Experience

Short-Term Trend: Driving technology adoption in academic and research libraries over the next one to two years

User experience (UX) refers to the quality of a person's interactions with services and products.[94] The term is commonly applied to assess exchanges with websites, mobile devices, and operating systems, but libraries are also applying the same usability principles to physical spaces.[95] In the digital realm, easy navigation, digestible content, and practical features are encompassed in effective website and database designs. Further, companies such as Amazon and Google are identifying patterns in users' online behaviors to better tailor search results at the individual level.[96] Direct feedback from users in the form of ratings on websites including NetFlix and TripAdvisor help companies customize content and adjust user interface design. The result is a more efficient and personal experience for users. Librarians are now favoring more user-centric approaches, leveraging data on patron touchpoints to identify needs and develop high-quality engaging experiences. Library publishing services can also benefit from understanding how user interface and design decisions impact both authors and readers.[97]

Overview

UX embraces ethnography and design to understand and improve patrons' experiences with library services. Ethnography studies of student research behavior, such as the ERIAL Project at Illinois Academic Libraries,[98] have been central to how libraries address student needs in service design.[99] While ethnography encompasses observational and participatory research to recognize how users work and the unique challenges they encounter, there is still a need for library staff to adopt a more unified approach. For example, an important facet of UX is desirability, which incorporates elements like aesthetics, emotional appeal, and personal connections. In addition to ensuring web text is clear, concise, and friendly, proactive customer service impacts visitors' decisions about using library services.[100] Conversational user interfaces that leverage virtual chatbots can respond to patrons' questions, guiding them to the appropriate services, databases, and articles.[101]

A holistic approach to library UX considers the library experience from many different touchpoints, including signage, the search and retrieval of a text, and the entire web experience across a range of devices. Library UX designers are better understanding patrons by analyzing multiple resources, combining surveys and ethnographic studies with digitally-captured metrics that track the searching and access of digital resources.[102] Data on how and where people are using library spaces, for example, has helped Grand Valley State University Libraries identify its busiest rooms so they can avoid using them for events and activities. Further, they found that displaying space use data on digital displays throughout the library conveniently informs students of open seating.[103]

To implement better UX, some libraries are employing design thinking, which uses design principles to accommodate people's needs with technologically feasible strategies.[104] This model helps define and resolves issues based on the needs and aspirations of patrons and prospective users.[105] The University of Technology Sydney, Australia recently leveraged a design thinking process, documenting user behaviors and engaging them in informal conversations over a several month period to conduct a signage audit. They found that library staff mistakenly believed that many inquiries from students visiting the information desk had already been addressed in various signs. A number of issues were surfaced, including too many signs and confusing language. Additionally, some information previously made visible in the physical library space was more pertinent to the website or mobile experience, such as how to print from a laptop, tablet, or phone. Revising the library's website became an essential part of their overall approach to advancing UX.[106]

Implications for Policy, Leadership, or Practice

While there are no known government policies specifically addressing the quality of UX within institutions' services, academic libraries looking to develop or implement standards can start with IDEO's Design Thinking for Libraries toolkit. IDEO partnered with the Chicago Public Library and Denmark's Aarhus Public Libraries to observe librarians in ten countries and subsequently develop a toolkit that guides libraries through inspiration, ideation, and iteration. Library stakeholders can improve planning and design by viewing challenges as opportunities to generate and test new ideas — and then implement those that prove to be beneficial to their users.[107] Further, many libraries have developed positions or departments devoted to ensuring that UX plays a role in any library decision-

making and planning. North Carolina State University's department of user experience works across all its libraries, focusing on how patrons can better navigate library spaces, services, and collections.[108]

Prioritizing user experience in libraries requires a leadership-driven commitment to regularly incorporate practices that better illuminate patron needs. The User Experience Working Group is leveraging digital collaboration tools along with monthly meetings to develop guidelines and best practices for digital library user and usability studies; they share resources and expertise to help library leaders understand user behavior, learnability, and accessibility of library services.[109] For face-to-face training and professional development, UXLibs Conferences convene globally diverse groups of librarians to explore ethnography, usability, and human-centered design, and share their own research results.[110] Some library leaders are developing tools to enable more efficient and personalized interactions with resources. For example, the EEXCESS project aims to bring library content directly to patrons by analyzing their research and automatically providing recommendations from connected databases such as Europeana, EconBiz, and Mendeley. This tool can inject additional background information sources and infographics into a Wikipedia or WordPress page.[111]

Libraries are recognizing that an ongoing focus on UX is vital to making digital library services relevant as user needs change with the advent of new interfaces and technologies. Duke University Libraries has published "Vision and Values" for maintaining a high-quality web presence with user-centric design priorities and strategies for evolving services by anticipating future needs.[112] Based on user feedback, the University of the Arts London Library recently updated its library search tool, which searches across both printed and electronic resources, making it more visual and dyslexia-friendly. They also aim to assess accessibility of the tool from the staff's perspective in the same manner they have focused on the customer side.[113] Linköping University Library has implemented continuous systematic in-house usability testing applied to all digital services as a grassroots initiative in which they organized their own usability team that routinely gathers to conduct testing. This initiative has informed updates to their library website, search box, and discovery tool, as well as holdings information and the link resolver interface.[114]

For Further Reading

The following resources are recommended for those who wish to learn more about valuing the user experience:

Designing the Future: A Design Thinking Workshop
go.nmc.org/libjourn
(*Library Journal*, 5 October 2016.) *Library Journal* provides UX-focused professional development opportunities, offering a design thinking workshop for library staff to practice strategies for learning about library users through observation and empathy exercises.

Explora
go.nmc.org/explora
(ETH Library, accessed 20 March 2017.) The Explora platform recontextualizes and presents information to library users in novel ways by creating stories from the multimedia contents, holdings, and services of ETH Library that are further enhanced with data visualizations and infographics.

Improving Library Websites
go.nmc.org/implib
(Carrie Smith, *American Libraries Magazine*, 3 January 2017.) Libraries looking to optimize the user experience on their websites can explore these tips and product recommendations to help them give patrons more efficient access to a wider online catalog.

Library Collections in the Life of the User: Two Directions
go.nmc.org/inthelife
(Lorcan Dempsey, *Liber Quarterly*, 11 October 2016.) In the current digital, networked environment, libraries are evolving toward an increased focus on user activities. In response, libraries are increasingly playing a larger role in managing outputs of the university as well as facilitating access to a broader range of resources.

Mobile Website Ease of Use: An Analysis of Orbis Cascade Alliance Member Websites
go.nmc.org/easof
(Zebulin Evelhoch, Digital Commons, 2016.) This paper identifies ways to improve academic library mobile websites based on an analysis of library websites made by members of the Orbis Cascade Alliance.

Speed Matters: Performance Enhancements for Library Websites
go.nmc.org/speed
(Scott W.H. Young, *Weave Journal of Library User Experience*, 2016.) A Montana State University researcher developed and implemented the seven-step "Library Web Performance Enhancement Plan" to improve PageSpeed Insights score, YSlow score, page weight, and HTTP requests — ultimately saving time for patrons.

User Experience in Libraries: Can Ethnography Help?
go.nmc.org/canethn
(Helen Edwards, *referisg*, 2 July 2016.) Ethnography can be a valuable avenue to a broader understanding of UX in libraries because it focuses on how users behave — not just their direct feedback; in some cases, users cannot articulate their own needs or incorrectly predict how they may use a service.

Challenges Impeding Technology Adoption in Academic and Research Libraries

The six challenges described on the following pages were selected by the project's expert panel in a series of Delphi-based cycles of discussion, refinement, and voting; the expert panel was in consensus that each is very likely to impede the adoption of one or more new technologies if unresolved. A complete record of the discussions and related materials was captured in the online work site used by the expert panel and archived at horizon.wiki.nmc.org/Challenges.

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge. The NMC Horizon Project defines solvable challenges as those that we both understand and know how to solve; difficult challenges are ones that are more or less well-understood but for which solutions remain elusive; and wicked challenges, the most difficult, are categorized as complex to even define, and thus require additional data and insights before solutions will be possible. Once the list of challenges was identified they were examined through three meta-expressions: their implications for policy, leadership, and practice. Below are summaries of the six significant challenges that will be explored more in-depth in this section, with citations and resources included.

Solvable Challenges: Those that we understand and know how to solve

Accessibility of Library Services and Resources. Although libraries have served as leaders in welcoming disabled patrons, new obstacles are surfacing as technology changes the way users access information. A growing focus on enhancing the accessibility of digital resources will impact the types of skills library professionals must possess. To meet the charge of anti-discrimination legislation and institutional policies, librarians are challenged to implement technologies and learning resources that may not be created with diverse needs in mind. The incorporation of universal design principles in library programming can improve the user experience for all patrons. Additional strategies being deployed include usability testing, digital accessibility audits, and the development of accessibility standards for learning technologies. Integrating the student voice will be paramount in meeting this challenge. Libraries can pave the way for their campuses by working with other institutional stakeholders to implement policies that ensure equality of opportunity for disabled students, faculty, and scholars.

Improving Digital Literacy. The productive and innovative use of technology encompasses 21st century practices that are vital for success in the workplace and beyond. Digital literacy transcends gaining isolated technological skills to generate a deeper understanding of the digital environment, enabling intuitive adaptation to new contexts, co-creation of content with others, and an awareness of both the freedom and risks that digital interactions entail. Libraries are positioned to lead efforts to develop students' digital citizenship, ensuring mastery of responsible and appropriate technology use, including online identity, communication etiquette, and rights and responsibilities. This category of competence is affecting curriculum design, professional development, and student-facing services and resources. Due to the multitude of elements comprising digital literacy, library leaders are challenged with continuously championing institution-wide efforts that connect students and staff with growth opportunities. Libraries are playing a major role in developing overall strategies to implement digital literacy practices.

Difficult Challenges: Those that we understand but for which solutions are elusive

Adapting Organizational Designs to the Future of Work. There is increasing attention to the organizational structure of academic and research libraries to better align them with the agile and 21st century practices of the future workplace. Technology, shifting information demands, and the evolving roles of librarians are forcing them to rethink the traditional functional hierarchy. Libraries must adopt more flexible, team-based matrix-like structures to remain innovative and responsive to campus and patron needs. At Ithaka S+R, researchers are beginning a new study to examine the effect of academic libraries' organizational structure on decision-making. The findings from this project have implications for institutions' structures and policies. In order to adapt, libraries are examining motivating factors for flexible designs, but often face steep learning curves and resistance among staff.

Maintaining Ongoing Integration, Interoperability, and Collaborative Projects. To earn funding from agencies, research institutions have become more reliant on creating partnerships with other institutions to enhance their visibility and reinforce their standings. In this climate, libraries are under intense pressure to produce high-quality research and quantify outputs. Despite improvements in recent years, existing infrastructure for publication and dissemination often requires researchers to undergo many steps to share their work. For a growing number of academic and research libraries seeking to improve the research ecosystem, satisfy requirements of funding agencies, and alleviate administrative burdens on researchers, interoperability has become a key priority. Interoperability, in this context, is the ability to make research systems operate together harmoniously so that scientific knowledge and data can be exchanged seamlessly across institutions, sectors, and disciplines. Ultimately, the aim is to bolster the ease with which institutions can share their findings with funders and other stakeholders.

Wicked Challenges: Those that are complex to even define, much less address

Economic and Political Pressures. Flat or declining college enrollments, increasing subscription fees and publishing output, and decreasing government support contribute to a web of complexities for academic and research libraries. As a result, they are increasingly prioritizing technologies and digital resources that reduce the expenses associated with delivering services. Complicating this challenge is the notion that technology adoption can trigger a variety of costs. The adoption and creation of open educational resources (OER) are viewed as a potential solution for reducing costs. Open access is a strategy to not only combat the rising costs of paid journal subscriptions, but also to expand the accessibility of research, changing the way libraries work with scholarly outputs. Expanding responsibilities, such as provision of researcher profile systems and open data repositories for their institutions, without expanding resources also brings economic and political pressures. Further, new administrations and government policy action are raising concerns, particularly as academic libraries are organized around core intellectual freedom principles that are being challenged.

Embracing the Need for Radical Change. Academic and research libraries are facing ongoing leadership issues that impact every aspect of their facilities and offerings, including updating staffing models and addressing a lack of financial resources. The advent of mobile technologies is impacting the accessibility of information: would-be patrons can now begin their searches from their personal devices without setting foot in a library. As information is now increasingly stored in the cloud rather than in a tangible format, libraries are rethinking acquisition strategies and how physical library space can best be utilized. Further, libraries must position themselves as allies in helping institutions meet student success benchmarks by designing new services that align with campus priorities. Staff are challenged to help faculty and students understand and maximize the value proposition of libraries, encouraging the integration of library offerings into academic study and instruction.

Accessibility of Library Services and Resources

Solvable Challenge: Those that we understand and know how to solve

Although libraries have served as leaders in welcoming disabled patrons, new obstacles are surfacing as technology changes the way users access information. A growing focus on enhancing the accessibility of digital resources will impact the types of skills library professionals must possess.[115] To meet the charge of anti-discrimination legislation and institutional policies, librarians are challenged to implement technologies and learning resources that may not be created with diverse needs in mind.[116] The incorporation of universal design principles in library programming can improve the user experience for all patrons. Additional strategies being deployed include usability testing, digital accessibility audits, and the development of accessibility standards for learning technologies. Integrating the student voice will be paramount in meeting this challenge. Libraries can pave the way for their campuses by working with other institutional stakeholders to implement policies that ensure equality of opportunity for disabled students, faculty, and scholars.[117]

Overview

The library profession has long been committed to providing services to disabled persons and promoting inclusivity. This leadership was formalized over 100 years ago when the ALA formed its first committee for services to people with disabilities.[118] As technology evolves, the skills and digital competencies to meet disabled patrons' needs are also changing. The Ontario Library Association has noted that job listings for Canadian library positions are increasingly seeking candidates with experience in creating accessible web destinations and conducting usability testing.[119] Libraries can look to the principles of universal design for learning — guidelines for curriculum development grounded in flexibility and acknowledgment of learner differences[120] — as they select technologies and create programming. By eliminating barriers and promoting access for a wide range of abilities, these principles help libraries better serve all users.[121]

While legislation in many countries prohibits institutions from discriminating against persons with disabilities and requires equal access to educational and employment opportunities,[122,123] institutions continue to grapple with compliance. With the advent of leasing digital items in lieu of physical acquisitions, libraries must find ways to improve accessibility across extensive collections of database subscriptions.[124] Additionally, commercial publishers and education technology companies are not obligated to create accessible products,[125] placing the burden on decision-makers to sift through the array of learning resources, reviewing accessibility policies on an individual basis; alternatively, they must ensure that supplemental assistive technologies such as text-to-voice are compatible with selected products. Library professionals are challenged to integrate these duties into their workflows alongside additional priorities such as improving digital literacy and supporting curriculum design.

In a survey of learners registered with Student Accessibility Services at the University of Guelph, 60% of respondents revealed that they regularly encounter inaccessible documents and websites.[126] There is an opportunity for library staff to help faculty understand legal obligations and manage accessibility of resources for assignments and classroom learning technologies. Libraries can also support their institutions in becoming more attuned to how disabilities have potential to impact academic achievement. Following a study of disabled students' experiences with library services at the University of Limpopo in South Africa, recommendations included conducting individual assessments and creating user profiles to ensure students receive the help they need; forming partnerships with publishers to increase availability of materials in accessible formats; and providing extended library service hours for students with disabilities.[127] To improve inclusivity for instructors with disabilities, libraries can also partner with on-campus groups such as Temple University's Committee on Faculty Disabilities Concerns to better understand their challenges and integrate best practices for serving these communities.[128]

Implications for Policy, Leadership, or Practice

Recent policy developments stand to greatly enhance access to printed materials for disabled populations. The Marrakesh Treaty to Facilitate Access to Published Works for Persons Who Are Blind, Visually Impaired, or Otherwise Print Disabled recently went into effect following ratification by 22 countries. This treaty mandates participating countries to enact laws that allow the creation of accessible-format copies of copyrighted works that can be shared domestically.

Additionally, libraries are permitted to distribute these copies across borders, allowing cooperating countries to grow their collections.[129] While the US and the EU have not yet ratified the Marrakesh Treaty,[130, 131] proposed US legislation aims to address the challenges faced by libraries and other higher education stakeholders in identifying accessible technologies for campus deployment. The Accessible Instructional Materials in Higher Education Act, introduced in the US House of Representatives in 2016, would convene a commission to develop a set of voluntary accessibility standards for electronic learning resources and technologies. These guidelines have potential to shape the vendor marketplace, ultimately improving educational access for disabled students.[132]

Establishing best practices and professional development will help libraries address this challenge. The University of Wisconsin-Milwaukee has received a National Leadership Grant from the IMLS for a project intended to help digital libraries serve the blind and visually impaired (BVI) in compliance with the Americans with Disabilities Act. A research team will review current efforts of digital libraries to assist BVI users with accessibility and usability queries. The findings will steer the development of design guidelines to better satisfy BVI users' needs.[133] Librarians can also look to Ontario Council of University Libraries' Accessibility Information Toolkit for guidance on meeting diverse needs.[134] The Lithuanian Library for the Blind recently held its Libraries for an Inclusive Society conference focused on library outreach to disabled populations, organizational strategies to enhance accessibility of library services, and implications of the Marrakesh Treaty.[135]

To understand barriers within its library's online resources, Western Washington University ran an automated accessibility checker on its most frequently used systems and used its results to prioritize solution development. The library is planning a future partnership with the campus's student-run Disability Outreach Center to conduct usability testing and improve responsiveness.[136] The University of Central Florida provides several services to enhance accessibility. The library's streaming video collection is equipped with audio transcripts; instructors can easily pull video clips tailored to their assignments. Patrons can also request one-on-one research assistance with library staff to accommodate cognitive and physical disabilities. Additionally, an "Ease of Access" folder appears on every public use computer in its libraries, containing tools for magnifying text and text narration.[137]

For Further Reading

The following resources are recommended for those who wish to learn more about accessibility of library services and resources:

Access Is Not Problem Solving: Disability Justice and Libraries (PDF)
go.nmc.org/accessjust
(Alana Kumbier and Julia Starkey, *Library Trends*, Winter 2016.) The authors champion a transformative value of equal access to information for all users as a way for libraries to enhance diversity at their institutions and advance social justice.

Dispelling the Top 5 Myths of Library Web Accessibility (Video)
go.nmc.org/libmyths
(Marc Zablatsky, ALA Midwinter Conference 2016, 3 March 2016.) This presentation identifies the limits of compliance rules in meeting disabled patrons' needs and offers actionable solutions to help libraries improve the accessibility of their online resources.

Feds Single Out Library as International Model for Disabled Patrons
go.nmc.org/libmodel
(Mike Nichols, *Grand Rapids Business Journal*, 11 April 2016.) The US State Department has collaborated with Colleagues International to foster knowledge-sharing between American and international disability rights advocates. Representatives from the Middle East and Africa recently visited a Michigan library to learn about their accessible programming.

Obtaining Alternative Formats
go.nmc.org/altforms
(Jisc, 27 February 2016.) This resource provides a workflow to meet user requests for written materials in accessible formats with the goal of promoting learner independence. Strategies will vary depending upon the amount of text involved.

Web Accessibility Toolkit
go.nmc.org/arltools
(Association of Research Libraries, accessed 17 February 2017.) This seminal guide aims to help research libraries meet the charge of inclusivity in digital space. Guidance on universal design and technical standards is offered to improve accessibility of web content; users can also view a directory of other institutional policies addressing these challenges.

World Book Day: ABC Award Winners on the Importance of Accessible Books
go.nmc.org/nepalaccess
(Accessible Books Consortium, 22 April 2016.) The Accessible Books Consortium (ABC) recognized the work of Action on Disability Rights and Development, a Nepalese NGO, with its ABC International Award for Accessible Publishing. The organization was selected for its commitment to making Braille books and audiobooks available to students with disabilities following Nepal's massive earthquake in 2015.

Improving Digital Literacy

Solvable Challenge: Those that we understand and know how to solve

The productive and innovative use of technology encompasses 21st century practices that are vital for success in the workplace and beyond.[138] Digital literacy transcends gaining isolated technological skills to generate a deeper understanding of the digital environment, enabling intuitive adaptation to new contexts, co-creation of content with others, and an awareness of both the freedom and risks that digital interactions entail.[139] Libraries are positioned to lead efforts to develop students' digital citizenship, ensuring mastery of responsible and appropriate technology use, including online identity, communication etiquette, and rights and responsibilities.[140] This category of competence is affecting curriculum design, professional development, and student-facing services and resources. Due to the multitude of elements comprising digital literacy, library leaders are challenged with continuously championing institution-wide efforts that connect students and staff with growth opportunities. Libraries are playing a major role in developing overall strategies to implement digital literacy practices.

Overview

In today's digital information environment, library staff, faculty, and students are expected to evaluate information through a lens of credibility that is dependent on the context in which information is used.[141] While they are often familiar with a variety of digital tools and platforms, they may not be in the habit of thinking critically about how they use these resources, interpret information, and prepare content to share online. As social networking platforms proliferate and more interactions take place digitally, there are more opportunities for propagation of misinformation,[142] copyright infringement, and privacy breaches. Libraries cannot solve this challenge alone; cross-disciplinary teams can help to expand research capabilities. For example, Project Information Literacy has convened a group of faculty, library professionals, and others to engage in a national study on how young people find, evaluate, and select information in educational settings and beyond.[143]

Mindful media consumption is one facet of digital literacy that has proven to be critical in combatting "fake news." The Stanford History Education Group released a report revealing that many students have trouble distinguishing credible sources from unreliable ones.[144] Recent instances of widely-circulated fake news and resources have fueled socially divisive and dangerous activities, from anti-abortion groups intentionally masquerading as government health resources in France, to lies about crimes committed by refugees in Germany being circulated by anti-Islam groups.[145] Libraries are challenged to leverage the current public attention on the severity of these widespread issues to advance the embedding of digital literacy across university curricula. These competencies must be authentically integrated into all courses to help students manage knowledge creation dissemination across disciplines, while practicing empathy. Alfred University has elevated its information literacy offerings from a single session into a First Year Experience Introduction to Sociology course that includes five hands-on information literacy sessions along with the development of personal e-portfolios and one-on-one meetings with a librarian.[146]

While the expert panel has identified this challenge as solvable, digital literacy efforts will remain ongoing as advancements in technology, as well as the real-world skills valued in the workforce, continue to evolve. Jisc has defined digital literacies broadly as "capabilities which fit an individual for living, learning and working in a digital society."[147] Tools, such as Jisc's Student Digital Experience Tracker, can assist libraries in gathering evidence from learners about their digital experience and shifting needs while tracking changes over time.[148] Further, the University of Michigan School of Information pinpoints data and statistical literacies as key cross-disciplinary skills. They are training future librarians in instructional strategies for teaching understanding of data practices with the belief that these competencies will aid learners in developing new ways of thinking and communicating within digital environments.[149]

Implications for Policy, Leadership, or Practice

Governments are prioritizing digital literacy initiatives to encourage economic development and enable citizens' full participation in digital society. Ireland has set an example with its All Aboard project, funded by the National Forum for the Enhancement of Teaching & Learning. By identifying the skills that higher education faculty and graduates need to feel confident and creative when learning and working in the digital world, the project has produced a framework, digital badging

initiative, and events aimed at building the country's digital capacity. These outputs will be useful to librarians in developing and updating their own policies and initiatives.[150] Libraries can also inform policy design by learning from initiatives that target specific aspects of digital literacy, such as the Library Freedom Project, a partnership among librarians, technologists, attorneys, and privacy advocates aimed at helping libraries become more attuned to protecting patrons' privacy.[151]

Leading organizations are developing resources to guide libraries in integrating digital literacy efforts into day-to-day operations. The Association of College & Research Libraries' (ACRL) "Framework for Information Literacy for Higher Education" provides groundwork in defining universal information literacy outcomes for today's graduates that can help shape digital literacy initiatives.[152] The Public Library Association's site, DigitalLearn.org, offers a collection of self-directed tutorials for users to increase their digital competencies, as well as a community of practice for educators to share relevant materials and best practices. Libraries can also create their own digital literacy training sites that allow learners to customize their courses, track progress, and receive certifications.[153] Professional development can be built into digital literacy services and initiatives. Library leaders are contributing resources that aid this process, such as Library Intelligence, a free diagnostic tool to assess the digital literacy capabilities of library staff along with self-paced online courses.[154]

Uniquely situated as information literacy authorities, libraries can help take the reins on campus digital literacy initiatives. The Open University's (OU) Library Services has launched a university-wide project to establish resources and approaches to grow the digital capabilities of OU staff, tutors, researchers, and students. They are developing a set of minimum competencies for digital literacy and providing programs and training so staff and students can achieve them.[155] Penn State University Library has implemented an information literacy digital badging initiative that offers students personalized and flexible activities to build competencies underlying ACRL's Information Literacy Competency Standards for Higher Education. The badges can be exported to students' LinkedIn profiles to reveal progress towards goals.[156]

For Further Reading

The following resources are recommended for those who wish to learn more about improving digital literacy:

Beyond Library Walls: Supporting Academic Capacity Building with Digital Technologies
go.nmc.org/beyondlib
(Sharon Chua, VALA 2016.) The author explains how librarians can support faculty by identifying ways to promote capacity building in digital literacy, and describes the digital tools that have helped Deakin University Libraries address skill gaps.

DigiComp 2.0: The Digital Competence Framework for Citizens
go.nmc.org/digicomp
(European Commission, 2016.) To support curriculum modernization and planning for the digital future, the DigComp framework can serve as a good starting point for libraries; it describes digital competencies to aid the assessment of digital knowledge and support the design of targeted educational initiatives.

DIY Digital Privacy and Security for Students
go.nmc.org/privsec
(Adam Rogers, Knight Foundation, 21 March 2016.) North Carolina State University Libraries is prototyping a toolkit and workshop materials that combine a realistic assessment of privacy and security threats with recommendations on how students can be more proactive in protecting their own digital lives.

From Written to Digital: The New Literacy
go.nmc.org/newlit
(Phillip Ventimiglia and George Pullman, *EDUCAUSE Review*, 7 March 2016.) Digital literacy enables more variety in the ways students think and communicate and has become a prerequisite for employment and intellectual independence. For example, Georgia State University has added coding to their Honors English Composition curriculum as a digital literacy that allows graduates to better understand e-publication options.

Opportunities for Academic and Research Libraries and Wikipedia
go.nmc.org/wikiped
(The International Federation of Library Associations and Institutions, 2016.) This paper describes the potential for collaborations between Wikipedia editors and academic and research libraries to promote open knowledge resources, improve students' critical assessment skills, and help develop and disseminate toolkits for reusing Wikipedia's content and metadata.

Rethinking Digital Literacy to Serve Library Staff and Users eCourse
go.nmc.org/ecour
(American Library Association, 8 September 2016.) ALA is facilitating a four-week online course to help participants incorporate evolving definitions of digital literacy into learning opportunities and promote digital literacy in their institutions through developing frameworks and designing learning opportunities.

Adapting Organizational Designs to the Future of Work

Difficult Challenge: Those that we understand but for which solutions are elusive

There is increasing attention to the organizational structure of academic and research libraries to better align them with the agile and 21st century practices of the future workplace. Technology, shifting information demands, and the evolving roles of librarians are forcing them to rethink the traditional functional hierarchy. Libraries must adopt more flexible, team-based matrix-like structures to remain innovative and responsive to campus and patron needs. At Ithaka S+R, researchers are beginning a new study to examine the effect of academic libraries' organizational structure on decision-making.[157] The findings from this project have implications for institutions' structures and policies. In order to adapt, libraries are examining motivating factors for flexible designs, but often face steep learning curves and resistance among staff.

Overview

As the contemporary workforce is evolving to favor higher social and analytical skills,[158, 159] the nature of work is also changing in libraries. Historically, most organizational structures, including those found in libraries, have been hierarchical. In this scenario, one director oversees a number of employees that are responsible for traditional services. They operate according to a rigid ladder of authority and regulations, with strong emphasis on technical over interpersonal skills. Decision-making power rests predominately at the top with less power cascading down organizational levels.[160, 161] This type of structure is straightforward but does not accommodate the sheer quantity of information needed for libraries to adjust in a continuously changing environment. Libraries are challenged to cater to shifts in visitor demographics and expectations when they are not structured in an agile manner.[162]

To meet the need of today's patrons, libraries must draw from different functional areas and adopt a flexible, matrix-like organizational structure.[163, 164] Matrix designs are advantageous because they formulate experts from different functional areas into teams that can undertake projects temporarily or permanently. Originally developed at NASA, organizations including IBM, Kaiser Permanente, and Citibank all leverage the matrix management model and are seeing higher margins on knowledge-related work.[165] In 2016, approximately one-third of Institute of Museum and Library Services (IMLS) grants supported digital library projects.[166] These initiatives require expertise on a broad range of areas including digitization, metadata, preservation, and technology solutions. The advent of makerspaces (as exemplified in the Patrons as Creators trend in this report) is enabling the creation of conceptual and physical products.[167, 168] However, developing successful environments necessitates the knowledge and skills of a diverse library staff including instructional designers, technologists, social media experts, and more.

While there are advantages in deploying this kind of flexible structure, such as seamless exchanges of information, increased technical competence, and more efficient use of resources, obstacles are preventing seamless adoption. For example, there are steep learning curves associated with changing roles, resistance to change,[169] and added confusion as people report to multiple bosses.[170] A technologist assigned to work on a library makerspace may feel torn between responsibilities to the makerspace project manager and functional team manager, struggling to manage schedules and demands across multiple reporting relationships. Libraries can consider implementing matrices so that relationships, information management, and priorities between multiple managers are clear and explicit.[171] The University of Adelaide Library aims to foster greater agility by simplifying its organizational structure. Leadership plans to eliminate redundancies and non-essential positions to create four or five functional units to enhance coordination between units and improve the library's ability to respond to a changing context.[172] Productivity technologies such as Slack also have the potential to bolster and streamline project communications.[173]

Implications for Policy, Leadership, or Practice

Recently, leading organizations have implemented policies that elevate the importance of matrix-like structural flexibility. In March 2015, employees across various divisions of academic libraries attended the Academic Library Planning and Revitalization Institute conference and converged on four areas that need attention to inform better policies that focus on

serving students' needs. One point of consensus was that libraries should resemble a learning community. To promote this goal, participants suggested that libraries encourage collaboration inside the facility, provide integrated service, foster flexibility, and take interdisciplinary approaches to solving problems.[174] A matrix-like design is one important way to support this goal as it not only allows libraries to pull from many different expertise areas, but also increases interactions and openness — two factors that promote innovative processes and learning.

Any system-wide change requires explicit support and commitment from senior leadership.[175] In solving this challenge, individuals at all levels of library leadership are advocating for integrating greater agility across structures. For example, the University of Virginia's new university librarian and dean of libraries is pressing for more cross-collaboration in research activities. The dean envisions librarians partnering with faculty on externally-funded research projects. Major funding agencies are also recognizing the cross-disciplinary nature of effective initiatives. The National Institute of Health provides funding to programs that bring library information specialists into biomedical research teams. Librarians' function in these teams is to ensure effective record-keeping, storage, and circulation of data. This strategy to embed librarians into external research programs is one that requires a flexible structure, along with vital support from the top.[176]

To solve this challenge, more libraries are trending toward models with greater flexibility. University of Manchester Library, for example, abandoned the traditional subject-based team model comprised of five areas and moved to three function-based teams — research services, teaching and learning, and academic engagement. This shift allowed them to cull different expertise to work on projects directly linked to the university's strategies. While change agents foresee challenges, they are convinced this restructuring will eliminate redundancy and help the library adapt to changing needs. Already, they have seen strides in their ability to build and enhance services. For example, the new function-based teams have developed services such as Manchester e-scholar, the institutional repository. These teams are also engaging in a project aimed at monitoring, disseminating, and creating a publishing strategy to increase Manchester researchers' citation levels.[177]

For Further Reading

The following resources are recommended for those who wish to learn more about adapting organizational designs to the future of work:

2016 Top Trends in Academic Libraries
go.nmc.org/top2016
(Association for College & Research Libraries, 2016.) This article discusses the top trends in academic libraries including research data services, digital scholarship, and agile collection assessment approaches. Many of the trends outlined point to an increasing need for flexible organizational designs.

Changing Roles and Changing Needs for the Academic Librarians
go.nmc.org/changin
(Danny Kingsley, University of Cambridge Office of Scholarly Communication, 29 November 2016.) Librarians' roles are changing to require greater research, data management, and curation skills. Before leaders can talk about changes in libraries' organizational structure, there is a need to understand the changing roles and needs for librarians.

Follow the (Grant) Money
go.nmc.org/follow
(Brian Kenney, *Publishers Weekly*, 14 October 2016.) Grant announcements indicate what the future of libraries holds. Digital library projects, maker activities, and community outreach activities are receiving funding and will require agile organizational designs.

Making Matrix Organizations Actually Work
go.nmc.org/matrix
(Herman Vantrappen and Frederic Wirtz, *Harvard Business Review*, 1 March 2016.) This article outlines principles for making organizational matrices work. While written for a general audience, library leadership can apply these guidelines to their organizations.

Organizing the Work of the Research Library
go.nmc.org/organi
(Roger C. Schonfeld, Ithaka S+R, 18 August 2016.) In this research project, Ithaka S+R interviewed selected library directors to gain insight into the leadership and change management issues associated with the organizational structure of research libraries.

Subject Matrices: An Innovative, Collaborative Approach to Serving the Agricultural Sciences
go.nmc.org/submat
(Jenny K. Oleen et. al., *Western Libraries Faculty & Staff Publications*, 8 January 2015.) Kansas State Libraries moved from subject-based departments to user-based departments. During this transition, an agricultural and biological sciences matrix emerged, drawing librarians and professional staff from across departments, including content development librarians, data service librarians, and scholarly communications librarians.

Maintaining Ongoing Integration, Interoperability, and Collaborative Projects

Difficult Challenge: Those that we understand but for which solutions are elusive

To earn funding from agencies, research institutions have become more reliant on creating partnerships with other institutions to enhance their visibility and reinforce their standings.[178] In this climate, libraries are under intense pressure to produce high-quality research and quantify outputs. Despite improvements in recent years, existing infrastructure for publication and dissemination often requires researchers to undergo many steps to share their work. For a growing number of academic and research libraries seeking to improve the research ecosystem, satisfy requirements of funding agencies, and alleviate administrative burdens on researchers, interoperability has become a key priority. Interoperability, in this context, is the ability to make research systems operate together harmoniously so that scientific knowledge and data can be exchanged seamlessly across institutions, sectors, and disciplines. Ultimately, the aim is to bolster the ease with which institutions can share their findings with funders and other stakeholders.[179]

Overview

Libraries balance universities' interests in institutional success with the support of information flows and the individual researchers' needs. As a result, they manage boundaries between the institution's separate but sometimes-overlapping research information management system (RIMS) and digital repository, along with the metadata they encompass. RIMS aggregate information about institutional research activities for reporting at the institutional, national, or funder level, while digital repositories store and grant access to data and objects. As open access initiatives and open-source repository platforms grow, libraries are challenged to keep pace with the evolution of repositories. The Open Archive Protocol for Metadata Harvesting (OAI-PMH) was established as a seminal interoperability protocol for standardizing information exchange between repositories. Data providers are repositories that expose structured metadata via OAI-PMH, while service providers make OAI-PMH service requests to harvest that metadata.[180]

Despite progress, significant obstacles persist with integrating open-access repositories and making them interoperable with RIMS, journal publishing platforms, indexing and abstracting services, and search engines. Challenges to interoperability between repositories and repository networks derive from many sources, such as the resources available for network development; speed of network development; and directives for the repositories and networks that undermine common goals. Additionally, language barriers and cultural, organizational, and legal variances present impediments. In this diverse landscape, the creation of a unified body of research materials hinges on whether repositories and other systems follow consistent standards for interoperability that allow for transfer of metadata and digital objects between systems. The University of Florida (UF) is piloting a solution by linking their repository with *ScienceDirect*, Elsevier's online journal and e-book catalog.[181] Using application programming interfaces (APIs), the university routinely searches *ScienceDirect* for UF researchers' articles and stores the metadata, allowing researchers to find links to over 30,000 articles.

Researchers' fragmented online identities across a variety of platforms, along with a lack of persistent unique identifiers, are compounding this challenge. It is especially difficult for would-be collaborators to view the full scope of another scholar's work and determine whether partnerships would be beneficial. Fortunately, the ORCID ID has emerged as the standard research identification structure across all disciplines. ORCID helps researchers distinguish themselves from those with similar or identical names; maintain connection to their research, funders, and publishers despite job or affiliation changes; and automate linkages to publications, grants, and patents. Due to its interoperability with other systems, researchers can synchronize publication records by linking their ORCID to their Scopus Author ID or ResearchersID, as well as to Researchfish, a UK research impact assessment system. These capabilities save time on research management tasks, making it easier for institutions and funding agencies to link research funding with research outputs or commercial interests.[182]

Implications for Policy, Leadership, or Practice

Libraries globally are challenged in selecting standards and strategies to inform technology policies. In the US, there is an opportunity for libraries to influence the adoption of institutional guidelines addressing data access issues, as less than half of the 206 American universities surveyed in the *Journal of Librarianship and Scholarly Communication* have standalone comprehensive policies.[183] Presently, there is a disconnect between funder policies

emphasizing sharing, dissemination, and openness with institutional policies focused on legal issues and ownership. As institutions respond to evolving funding parameters and government policies, libraries will have a unique opportunity to shape institutional data policies that align with overarching trends toward increased openness and accessibility. Librarians from the University of Wisconsin-Milwaukee, University of Illinois at Chicago, and Carnegie Mellon University are currently conducting research to inform development of best practices for institutional data policies.[184]

Successfully increasing integration, interoperability, and collaboration between research institutions across numerous interfaces worldwide necessitates strong partnerships. In the US, the Big Ten Academic Alliance (BTAA)[185] Library Deans and Directors investigated challenges related to providing a more seamless user experience from information discovery to fulfillment. Library leadership recognized a need for greater interplay, planning, and vetting of collective decisions between public services, resource sharing services, and technology services units to optimize BTAA libraries' ability to develop and integrate systems and service layers. The resulting report series provides a framework and recommendations for a discovery to delivery model.[186] To better address interoperability in the open access movement, national and regional repository networks have also emerged. The Digital Repository Federation, for example, is a network of Japanese institutional repositories; the Chinese Academy of Sciences network harvests records from 96 affiliated institutional repositories; and OpenAIRE, a European network, provides a central portal for aggregated EC-funded research.[187]

Several academic libraries worldwide, including Vienna University Library and Archives Services, Peking University Library, Helsinki University Library, and Lund University Libraries, have joined the Confederation of Open Access Repositories (COAR). COAR has created a forum to better align the technical interoperability policies and services with repositories to aggregate their content. The initiative aims to build services that track research outputs, monitor publication use, mine text and data, and facilitate peer review. COAR's members have identified highest priorities for interoperability work that will impact individual libraries, including exposing citation formats and bibliographic information, supporting data export functions, and supporting search engine optimization.[188] In Australia, 13 public institutions have launched HuNI, a research and discovery platform developed by and for humanities and creative arts scholars. HuNI focuses on integration and interoperability of 30 of the nation's most significant cultural datasets, comprising more than two million authoritative records.[189]

For Further Reading

The following resources are recommended for those who wish to learn more about maintaining ongoing integration, interoperability and collaborative projects:

European Cloud Initiative - Building a Competitive Data and Knowledge Economy in Europe
go.nmc.org/eci
(Eur-Lex, 19 April 2016.) The European Commission has proposed the European Science Cloud and European Data Infrastructure as solutions to interoperability challenges. This document provides a comprehensive outline of the development steps.

Green OA and the Interoperability of Institutional Repositories
go.nmc.org/interop
(John Parsons, *Library Journal*, 31 May 2016.) Global initiatives are underway to share common strategies and technologies for improving metadata standardization to promote interoperability.

Harvard Medical School Launches Digital Repository of Medical Evidence
go.nmc.org/libofevid
(HIT Consultant, 16 September 2016.) A team of librarians, clinicians, and engineers have developed the Harvard Library of Evidence, which aids practicing physicians in selecting imaging tests for patients based on recommendations generated by literature review.

Overview of Systems Interoperability Project (PDF)
go.nmc.org/osipreport
(Ian Lyne et al., Research Councils UK, 17 June 2015.) Findings are shared from the Overview of Systems Interoperability Project (OSIP), which reviewed the complex landscape of research interoperability. The authors make recommendations for maximizing the interoperability of the research data systems used by the Research Councils UK.

The Research Data Alliance
go.nmc.org/rd-a
(Research Data Alliance, accessed 21 February 2017.) The Research Data Alliance provides a forum for members to come together in working groups to develop and adopt infrastructure that promotes data-sharing and data-driven research.

Status of Open Access Institutional Digital Repositories in Agricultural Sciences
go.nmc.org/openasia
(Bijan Kumar Roy et al., Library Philosophy and Practice, February 2016.) In a review of 43 open access repositories for agricultural sciences in Asia, 79% lacked standard guidelines for researchers to self-archive open access scholarship. The authors recommend mandatory archiving policies to improve accessibility and usability of resources.

Economic and Political Pressures

Wicked Challenge: Those that are complex to even define, much less address

Flat or declining college enrollments, increasing subscription fees and publishing output, and decreasing government support contribute to a web of complexities for academic and research libraries.[190] As a result, they are increasingly prioritizing technologies and digital resources that reduce the expenses associated with delivering services. Complicating this challenge is the notion that technology adoption can trigger a variety of costs.[191] The adoption and creation of open educational resources (OER) are viewed as a potential solution for reducing costs. Open access is a strategy to not only combat the rising costs of paid journal subscriptions, but also to expand the accessibility of research, changing the way libraries work with scholarly outputs.[192] Expanding responsibilities, such as provision of researcher profile systems and open data repositories for their institutions, without expanding resources also brings economic and political pressures. Further, new administrations and government policy action are raising concerns, particularly as academic libraries are organized around core intellectual freedom principles that are being challenged.[193]

Overview

Since the economic downturn of 2008, academic and research libraries have been challenged with increasing competition for funding, prompting them to rethink how to effectively allocate resources and decipher the impact of globalization on budgets. ALA's *State of the Library Report 2016* underscores this challenge with a sobering statistic regarding economic pressures in the US; they report that last year, nearly 50% of chief academic officers believed their institutions had not yet recovered from the recession.[194] State cuts to public higher education are putting extra pressures on campus libraries.[195] According to a poll conducted by Wiley, budget concerns were cited as the top challenge for academic librarians around the world.[196] The global impact of currency fluctuations is also creating financial burdens for academic libraries.[197] In South Africa, a sluggish commodities market has depreciated their currency. This impacts local libraries because university subscriptions to international journals are typically priced in dollars and euros.[198, 199]

Academic libraries are increasingly working with new forms of scholarly publications to provide greater accessibility and lower costs. Many scholars and funders view the open access movement as the future of scholarly publications, with potential implications for face-to-face services; the expansion of open access resources for conducting research is prompting libraries to shift their roles from housing collections to fostering deeper connections around the information via spaces that are scholar-centered rather than collection focused.[200, 201] Unfortunately, Jisc reports that for many years, the academic journal market has been largely dominated by large publishing companies that are driving up costs; though they see open access as a solution, the current path to widespread implementation is glacial and expensive.[202]

Political action, whether through changes in policy or government administrations, is also a source of stress for libraries.[203] The EU referendum known as the Brexit has had unintended consequences for libraries in the UK. For example, in addition to the devaluation of the British pound, a decrease in scholarly collaboration will impact academic libraries because fewer European partnerships means a reduction in the number of co-authored articles available in British Open Access collections.[204] Overall measures of austerity in the UK have threatened libraries for years, stirring up political activism in defending their critical role in society.[205] In the US, the recent presidential election is causing concern across the library community as speculation mounts about President Trump's potential slashing of government agencies. Stakeholders fear cuts may impact innovation funding in research and cultural organizations.[206] The new administration could also affect trade between nations, raising the cost of the mobile devices that have fostered the growth of digital publishing over the past decade. Further, there is concern that US libraries must defend their core values of information privacy and intellectual freedom, while advocating against policies that support corporate over public interests through net neutrality laws.[207, 208]

Implications for Policy, Leadership, or Practice

As more academic libraries look to open access to lower costs and broaden the availability of research, policies are needed to ensure quality control. Hundreds of academic institutions have open access policies that govern faculty and staff-authored publications, and international funding agencies often require supported research projects to provide open access to journal articles.[209] In the US under the Obama administration, a memorandum directed federal departments with annual

research and development expenses of over $100 million, including the Department of Homeland Security and Environmental Protection Agency (EPA), to prioritize the accessibility of federally-funded scholarly publications and digital data. Consequently, more than 20 federal departments representing 99% of federal research and development expenditures have instated plans in 2017.[210] The future impact of this policy is uncertain given the current speculation on the Trump administration plans to drastically cut or potentially eliminate federal agencies and departments, such as the EPA,[211] impacting scholarly research and academic libraries.

Libraries around the world are collaborating with each other and external organizations to address rising financial pressures. The Canadian Association of Research Libraries (CARL) brings together more than 30 institutions to improve access to knowledge, promote effective and sustainable scholarly communication, and the sharing of best practices and policies for Canada's research community.[212] Their white paper, "Canadian Universities and Sustainable Publishing (CUSP)," explores how libraries can move forward under a growing oligopoly of international publisher and university budget constraints.[213] Similarly, the international Open Access 2020 initiative of more than 560 signatory institutions is helping to accelerate the movement of scholarly journals from subscription to open access publishing.[214] They have created a transformation roadmap for five core areas of activity; topics include framework, analysis, reorganization, negotiation, and sharing.[215]

In response to escalating publications costs, efforts are underway to help academic libraries take charge of their futures. While major publishers such as Elsevier and Wiley-Blackwell bundle their services, requiring libraries' purchases to include journals they may not need, institutions like the University of Missouri Libraries have attempted to pass on library fees to students with mixed success.[216] Other academic libraries are sidestepping large publishers altogether by creating their own scholarly presses. Concordia University Press is an open access academic press publishing in both English and French. They intend to create a sustainable operation for disseminating research on the arts, humanities, and social science through free ebooks.[217] Similarly, Lever Press is a collaborative project involving more than 40 US liberal arts college libraries to publish open access, digitally native, scholarly monographs. Each library contributes to the cost of identifying, editing, and producing scholarly material.[218]

For Further Reading

The following resources are recommended for those who wish to learn more about economic and political pressures:

The Forbidden Forecast: Thinking About Open Access and Library Subscriptions
go.nmc.org/forbid
(Rick Anderson, *The Scholarly Kitchen*, 21 February 2017.) At the Researcher to Reader Conference in London, a library thought leader ponders whether Green Open Access (GOA) is likely to reduce paid journal subscriptions in academic libraries. He concludes that if GOA gains traction, the cost of identifying expendable titles will be considerably reduced.

Funding Open Access Monographs
go.nmc.org/fund
(Rupert Gatti and Marc Mierowksy, *College & Research Libraries News*, October 2016.) Recent studies from Ithaka S&R and OAPEN-NL have provided academic libraries with reliable data on the costs and revenue associated with publishing open access monographs in relation to traditional publishing models.

Gale Gets Ready to Toast to the New Year
go.nmc.org/toast
(*Gale Blog*, 20 December 2016.) Library leaders share their thoughts on academic library trends in 2017, which include libraries undertaking more visible roles in shifting budget priorities through the coordination of OER as well as providing more support for improving student skill acquisition.

Has the Library Outlived its Usefulness?
go.nmc.org/outli
(Donald A. Barclay, *University World News*, 6 May 2016.) In the US, academic libraries are under increasing pressure to eliminate non-critical expenses. Recent trends such as the rise of the e-book, drops in annual circulations, and reallocation of space are shifting budgets to maximize their relevance.

Research Libraries, University Presses Oppose Trump's Immigration Order
go.nmc.org/oppose
(Richard Senese, *EdSurge*, 30 January 2017.) When President Trump issued an executive order temporarily barring entry of immigrants from seven countries, the Association of Research Libraries and Association of American University Presses publically opposed it. They asserted that the order not only immediately blocks students and academics from entering or returning to the US, but will also undermine international academic collaboration.

The Wrench in the Gears: How Independent Academic Presses Can Disrupt the Publishing Model
go.nmc.org/wrench
(Brian Gaines and David Blakesley, *Digital Rhetoric Collaborative*, 28 November 2016.) In this interview, a Clemson University professor describes the rise of independent academic presses and their implications for academic libraries.

Embracing the Need for Radical Change

Wicked Challenge: Those that are complex to even define, much less address

Academic and research libraries are facing ongoing leadership issues that impact every aspect of their facilities and offerings, including updating staffing models and addressing a lack of financial resources. The advent of mobile technologies is impacting the accessibility of information: would-be patrons can now begin their searches from their personal devices without setting foot in a library. As information is now increasingly stored in the cloud rather than in a tangible format, libraries are rethinking acquisition strategies and how physical library space can best be utilized.[219] Further, libraries must position themselves as allies in helping institutions meet student success benchmarks by designing new services that align with campus priorities.[220] Staff are challenged to help faculty and students understand and maximize the value proposition of libraries, encouraging the integration of library offerings into academic study and instruction.

Overview

Technology is increasingly shifting the focus of the library from management of acquisitions to the provision of services and support for faculty and students.[221] As this transition unfolds, library professionals are witnessing a sea change in the types of skills valued by their institutions, facing uncertainty on how to maintain their own relevance. These struggles closely relate to another difficult challenge in this report, Adapting Organizational Designs to the Future of Work. In hiring new staff and redistributing duties, leadership must identify not only which skills are critical to serve today's patrons, but also anticipate the future of library services.[222] Innovative libraries are identifying unmet user needs, implementing technologies to enhance the user experience, and engaging in campus outreach.[223] Helping existing staff garner new skills and adjust to reimagined roles requires support and training,[224] which can prove difficult as budgets contract.

Libraries are also challenged to rethink the marketing of their offerings within their campus communities. Ithaka S+R's survey of over 9,000 US faculty found that the vast majority are not utilizing library staff or services for their own scholarly pursuits; just 2% of respondents begin explorations of disciplinary literature by asking librarians. Further, when faculty encounter articles not accessible through their institutions' collections, they are more likely to search for freely available versions online than to seek interlibrary loan services. However, the findings indicate that faculty value librarians' role in improving undergraduates' information literacy competencies, with half of respondents strongly agreeing that librarians assist students in developing research skills and contribute significantly to student learning by helping them locate and integrate sources into their coursework. While undergraduate support was identified as the library's second-most important function (behind acquisitions), 40% of faculty report that their students "rarely" interact with campus librarians.[225] Instead of waiting for patrons to come in for assistance, libraries must adopt an outward-facing orientation to raise awareness of their services.[226]

As budgetary tensions mount, institutions are facing greater pressures to adopt programming and technologies to increase student success and retention. Libraries are aligning their work with larger institutional goals that support teaching and learning.[227] Thought leaders have suggested strategies for libraries to unbundle library services, build relationships, and bring the library perspective into larger institutional conversations — including appointing library professionals to university committees and collaborating with student services and faculty.[228, 229] To increase responsiveness to future needs, libraries must foster greater agility. Maintaining a positive atmosphere through uncertainty and transition is no small feat; many organizations are incorporating change management principles elucidated by John Kotter, including communicating urgency, developing a shared vision, obtaining stakeholder buy-in, and celebrating progress.[230]

Implications for Policy, Leadership, or Practice

Libraries are creating policies to clarify their vision and drive change. In its strategic declaration, "The University Library: Entering Its Third Century," the University of Virginia Library notes the persistence of its central mission in promoting the creation of new knowledge, but acknowledges the limits of 20th century models built around physical collections and reference desks. The document details a framework of services centered on innovation. For example, staff provide face-to-face and online training on new learning technologies and develop programs on issues such as digital copyright

law.[231] At the University of Adelaide, the Library of the Future committee's "Recommendations for a Bold and Agile University Library" outlines plans to adopt a client-facing service model, forging close working relationships with faculty on pedagogical design to further institutional commitments emphasizing students as creators. They will also shift to a "closed-stack" access model, aggressively reducing the onsite collections' footprint to allow space for studying and learner collaboration, while promoting use of digital resources.[232]

Addressing these challenges will require visionary leadership, and professional development is helping library staff envision new solutions and thrive in evolving environments. The Harvard Graduate School of Education's "Library Leadership in a Digital Age" event series convenes annually to help participants think critically about the future of learning and technology's impacts, as well as to identify opportunities for libraries to contribute to the intellectual progress of their institutions.[233] Similarly, the theme of the University of Hong Kong Libraries' annual Library Leadership Institute for 2017 is "Libraries at the Crossroads: Challenges for Leadership." Library directors from Asia will gather in Bangkok to develop management and leadership skills through hands-on, interactive simulations and discussions on topics including strategic planning, branding and awareness-building, and fostering innovation.[234]

Library staff at the University of Western Australia have teamed up with student services to promote learner success. At WRITE*Smart* Drop-in sessions, students meet with Learning Skills Advisors to strengthen their writing, while librarians improve students' research techniques and provide guidance on citation formats. The collaboration provides a one-stop destination for learners and increases visibility of library services.[235] The UK's University of Huddersfield is using findings from its Library Impact Data Project to identify evidence-based approaches to marketing and increasing student engagement. The Roving Librarian program positions library staff at booths in high-traffic areas on campus to advertise their services and assist students via iPads. Pop-up banners at the booths use branding consistent across email and social media campaigns, so students associate the logos with library offerings. Librarians are also offering personalized visits to academic staff offices to promote discipline-specific resources; this outreach builds personal relationships and increases the likelihood that staff will refer students to the library.[236]

For Further Reading

The following resources are recommended for those who wish to learn more about embracing the need for radical change:

Effective Techniques for the Promotion of Library Services and Resources (PDF)
go.nmc.org/libpromo
(Zhixian Yi, *Information Research*, March 2016.) A study of academic libraries at Australian universities examined the prevalence and efficacy of a variety of techniques for marketing library services to their campus communities. Digital promotions were considered effective, especially social media campaigns that foster interactivity and support user-generated content.

Empathy as the Leader's Path to Change
go.nmc.org/empathy
(Steven Bell, *Library Journal*, 27 October 2016.) As library directors implement novel processes and guide their organizations in the direction of new priorities, they may encounter resistance from staff. The author advocates for empathy as a key trait allowing leaders to unite their teams.

How Libraries Are Boldly Innovating to Meet the Needs of Changing Communities
go.nmc.org/boldlib
(Anna Pratt, Truthout, 26 November 2016.) With persistent budget challenges, academic and public libraries are making efforts to increase user engagement to foster a sense of ownership among patrons. Librarians are working to change public perceptions by creating pop-up events and programming designed to meet unique community needs.

Institute-wide Task Force on the Future of Libraries
go.nmc.org/mitfuture
(MIT Ad Hoc Task Force on the Future of Libraries, 24 October 2016.) A task force consisting of faculty, staff, and students reviewed procedures at MIT Libraries and issued a series of recommendations to best position the libraries in supporting content creation and knowledge sharing with the global community.

Leadership in Disruptive Times
go.nmc.org/iflalead
(James M. Matarazzo and Toby Pearlstein, *IFLA Journal*, 27 September 2016.) This article draws distinctions between managers, focused on operational objectives and day-to-day services, and leaders, who contribute vision towards achieving organizational sustainability. Both roles must work in harmony to guide library staff in meeting current challenges.

Yale Libraries Adapt in Digital Age
go.nmc.org/yaleadapt
(Ishaan Srivastava and Ryan Gittler, *Yale Daily News*, 13 October 2016.) At Yale University, the Personal Librarian Program provides students with a single point of contact throughout their time at the institution.

Important Developments in Technology for Academic and Research Libraries

Each of the six developments in technology detailed in this section were selected by the project's expert panel using the Horizon Project's Delphi-based process of iterative rounds of study, discussion, and voting. In the NMC Horizon Project, technology is defined in a broad sense as tools and resources that are used to improve teaching, learning, creative inquiry, research, and information management. While many of the technologies considered were not developed solely for academic and research libraries, they have clear applications in the field.

The developments, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three time-related categories — near-term developments in technology that are expected to achieve widespread adoption in one year or less; mid-term developments in technology that will take two to three years; and far-term developments in technology, which are forecasted to enter mainstream use in libraries within four to five years.

The initial list of topics considered by the expert panel was arranged into categories that were based on the primary origin and use of the technology. The potential applications of the technologies featured, specifically in the context of global academic and research libraries, were considered in a series of online discussions that can be viewed at horizon.wiki.nmc.org/Horizon+Topics.

The expert panel was provided with an extensive set of background materials when the project began that identified and documented a range of existing technologies used in both education and beyond. The panel was also encouraged to consider emerging technologies whose applications for academic and research libraries may still be distant. A key criterion for the inclusion of a new technology in this edition was its potential relevance to academic and research libraries worldwide.

In the first round of voting, the expert group reduced the master set, shown on the next page, to 12 technology developments that were then researched in much greater depth by the NMC staff before the list was cut in half during the final round of voting. Technologies that do not make the interim results or the final report are often thoroughly discussed on the project wiki at horizon.wiki.nmc.org. Sometimes a candidate technology does not get voted in because the expert panel believes it is already in widespread use, or, in other cases, they believe the technology is more than five years away from widespread adoption. Some technologies, while intriguing, do not have enough credible project examples to substantiate them.

A key criterion for the inclusion of a new technology in this edition was its potential relevance to academic and research libraries worldwide.

There are currently seven categories of technologies, tools, and strategies for their use that the NMC monitors continuously. These are not a closed set, but rather are intended to provide a way to illustrate and organize emerging technologies into pathways of development that are or may be relevant to academic and research libraries. The list of seven categories has proven fairly consistent, but new technologies are added within these categories in almost every research cycle; others are merged or updated. Collectively, the categories serve as lenses for thinking about innovation; each is defined below.

> **Consumer technologies** are tools created for recreational and professional purposes and were not designed, at least initially, for educational use — though they may serve well as learning and research aids and be quite adaptable for use in libraries. These technologies find their ways into institutions because people are using them at home or in other settings.

> **Digital strategies** are not so much technologies as they are ways of using devices and software to enrich teaching, learning, research, and information management, whether inside or outside the library. Effective digital strategies can be used in both formal and informal learning; what makes them interesting is that they transcend conventional ideas to create something that feels new, meaningful, and 21st century.

- **Enabling technologies** are those technologies that have the potential to transform what we expect of our devices and tools. The link to learning in this category is less easy to make, but this group of technologies is where substantive technological innovation begins to be visible. Enabling technologies expand the reach of our tools, making them more capable and useful.
- **Internet technologies** include techniques and essential infrastructure that help to make the technologies underlying how we interact with the network more transparent, less obtrusive, and easier to use.
- **Learning technologies** include both tools and resources developed expressly for the education sector, as well as pathways of development that may include tools adapted from other purposes that are matched with strategies to make them useful for learning. These include technologies that are changing the landscape of learning, whether formal or informal, by making it more accessible and personalized.
- **Social media technologies** could have been subsumed under the consumer technology category, but they have become so ever-present and so widely used in every part of society that they have been elevated to their own category. As well-established as social media is, it continues to evolve at a rapid pace, with new ideas, tools, and developments coming online constantly.
- **Visualization technologies** run the gamut from simple infographics to complex forms of visual data analysis. What they have in common is that they tap the brain's inherent ability to rapidly process visual information, identify patterns, and sense order in complex situations. These technologies are a growing cluster of tools and processes for mining large data sets, exploring dynamic processes, and generally making the complex simple.

The following pages provide a discussion of the six developments in technology highlighted by the 2017 NMC Horizon Project Library Expert Panel, who agree that they have the potential to foster real changes in academic and research libraries. As such, each section includes an overview of the technology; a discussion of its relevance to academic and research libraries; and curated project examples and recommendations for further reading.

Consumer Technologies
- Drones
- Real-Time Communication Tools
- Robotics
- Wearable Technology

Digital Strategies
- Location Intelligence
- Makerspaces
- Preservation & Conservation Technologies

Internet Technologies
- Blockchain
- Digital Scholarship Technologies
- The Internet of Things
- Library Services Platforms
- Syndication Tools

Learning Technologies
- Adaptive Learning Technologies
- Microlearning Technologies
- Mobile Learning
- Next-Generation LMS
- Virtual & Remote Labs

Social Media Technologies
- Crowdsourcing
- Online Identity
- Social Networks
- Virtual Worlds

Visualization Technologies
- 3D Printing
- Information Visualization
- Mixed Reality
- Virtual Reality

Enabling Technologies
- Affective Computing
- Artificial Intelligence
- Big Data
- Electrovibration
- Flexible Displays
- Mesh Networks
- Mobile Broadband
- Natural User Interfaces
- Near Field Communication
- Next-Generation Batteries
- Open Hardware
- Speech-to-Speech Translation
- Virtual Assistants
- Wireless Power

Big Data

Time-to-Adoption Horizon: One Year or Less

Today, almost any interaction made over the internet or through the consumption of goods and services is being tracked, stored, and used in targeted ways. This has led to the notion of big data — massive amounts of data that reflect the behavior and actions of various populations.[237] Data scientists and data collection platforms are now able to computationally organize petabytes and exabytes of data, making it easy to analyze and identify patterns that may have otherwise gone undetected. With the complexity surrounding such large, diverse sets of data, displaying the information in a digestible format is crucial to its success. Visual data analysis blends highly advanced computational methods with sophisticated graphics engines to illuminate patterns, and structure even the most complex visual presentations. Information visualization uses infographics, the graphical representation of technical data designed to be quickly and easily understood. Libraries are thus ideally situated to serve academia, government, and business as information collectors, curators, and analysts. In particular, libraries can serve an integral function as collaborators and enable education institutions to make informed decisions that reflect and serve real learner needs.

Overview

Big data has become a major focus of academic and research libraries due to the rapid evolution of data mining technologies and the proliferation of data sources like mobile devices and social media. Although definitions vary, big data is typically understood through the 3Vs framework: volume, variety, and velocity.[238] Volume refers to data set size (typically terabytes and petabytes); variety indicates that big data is unstructured and varied (e.g., text, audio, video, and images); and velocity denotes the high frequency at which this data is generated — 90% of world data was created in the last two years alone.[239] SAS embraces two other dimensions in its consideration of big data: variability, or the peaks and valleys of data generation, and complexity, which refers to heterogeneous data from diverse sources.[240] IBM includes veracity (data uncertainty) as yet another characteristic.[241]

The exponential growth and availability of big data has led to data-driven science, a new research paradigm founded on three core activities: capture, curation, and analysis.[242] Essentially, data-driven inquiry requires research data management (RDM), which affords libraries the opportunity to be active and integrated participants in the overall research process at their institutions.[243] In response, a number of academic libraries have established research data services departments which offer a range of consulting services including data curation, developing data management workflows, identifying and selecting appropriate data storage and repository tools, and archiving and publishing project results.[244] Texas A&M University, for example, supports data-driven research by focusing on the development of structured, curated data sets that use ontologies and metadata schemas to organize the highly heterogeneous data streams that make up big data or help aggregate small data.[245]

However, the promise of big data is also accompanied by the ethical challenges of patron privacy and confidentiality during collection, analysis, and usage. For instance, born-digital firms such as Netflix and Amazon routinely collect and share personal information for monetizing and content recommendations. For libraries, on the other hand, the American Library Association asserts, "protecting user privacy and confidentiality is necessary for intellectual freedom and fundamental to the ethics and practice of librarianship."[246] It behooves libraries, especially as they actively use social networks, to connect with their user base and develop comprehensive data confidentiality and security policies that uphold the ethical values that matter to academic librarianship, in addition to remaining compliant with the legal parameters within which they operate.[247]

Relevance for Academic and Research Libraries

Big data has significant implications for academic libraries in their roles as facilitators and supporters of the research process. Although the emphasis of data-centric research is in the hard and social sciences, researchers and librarians are beginning to note the possibilities of big data use in the form of digital humanities research. This area comprises large-scale digital objects that contain text or visual data such as Google Earth, photos and micro-messages shared on social media, and the ever-growing corpus of academic scholarship citations.[248] These data repositories can create new knowledge and expand human understanding in unprecedented ways through text mining and topic modeling techniques. Consider the Robots Reading *Vogue* project at Yale University comprising 2,700 covers, 400,000 pages, and 6 terabytes

of data. The initiative has leveraged the analytical and quantitative methods of the digital humanities librarian and the outreach skills of the public service librarian to create research studies across a range of disciplines from gender studies to art history to computer science.[249]

Additionally, libraries themselves generate data through their online resources and services, and the social media services they use to promote their programs and amenities.[250] Digital collections purchased by libraries, as well as campus scholarship in the form of documents and data, could also be construed as big data sets.[251] This in-house data can be analyzed to identify strategic services that are personalized to the needs of the library patrons.[252] As a result of this growing emphasis on data and analytics, academic data librarianship has emerged as a vital aspect of library services in recent years. Typically, data librarians provide analytical research assistance as well as instructional programming.[253] As such, they are expected to be data literate, possessing the understanding and the ability to analyze, transform, and present data for knowledge creation. They are often very knowledgeable about multiple data formats and familiar with data analysis and visualization software such as SPSS and Tableaux. Strong communication and presentation skills are also critical in their role as information consultants and research collaborators.

Libraries are increasingly seeking to recruit for positions such as research data librarians, data curation specialists, or data visualization specialists, while library and information science programs are developing curricula to address this need, particularly for future library professionals. For example, the School of Information Sciences at the University of Illinois offers a specialization in data curation as part of its MS/LIS program.[254] The Council on Library Information Resources' Data Curation Fellowships provide recent PhDs with professional development, education, and training opportunities in data curation.[255] In the UK, the Digital Curation Centre (DCC) offers a range of services, products, and training on RDM. As part of its institutional engagement program, the DCC partnered with the Open University, UK in developing an institutional RDM framework through support of requirements gathering, training, and developing guidance materials.[256]

Big Data in Practice

The following links provide examples of big data in use that have direct implications for academic and research libraries:

Big Data, Small Library (PDF)
go.nmc.org/bigsmall
Shell Australia's Technical Librarians worked with colleagues in geosciences, information technology, and data management to ensure efficient management of Shell's growing volume of geoscientific data. Their support services included identifying metadata fields, developing controlled vocabularies and naming conventions, defining required search parameters, and developing workflow procedures.

HathiTrust Digitized Library Big Data Project
go.nmc.org/hathitrust
The HathiTrust project uses data mining tools to interpret vast volumes of digitized text without violating copyright laws. Computational analysis and metadata is leveraged to collect, connect, and visualize data acquired from large-scale digitized texts.

Library Data Labs Project
go.nmc.org/libdat
In this project, five cross-institutional teams from 23 universities supported by Jisc analyzed library data to gain specific insights on library-related services and present them using appropriate data visualizations. Issues addressed included electronic resources usage, using dashboards to support excellence frameworks, and use and impact of library facilities and spaces.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about big data:

Directions for Research Data Management in UK Universities (PDF)
go.nmc.org/direc
(Sheridan Brown et al. Jisc, March 2015.) This report outlines a vision for the direction of research data management over the next five years in the UK. Five key topics are identified in this domain: policy development and implementation; skills and capability; infrastructure and interoperability; incentives for researchers and support; and business case and sustainability.

The Paradox of Privacy: Revisiting a Core Library Value in an Age of Big Data and Linked Data
go.nmc.org/paradox
(D. Grant Campbell and Scott R. Cowan, *Library Trends, Vol. 64, No. 3*, 2016.) The authors address concerns around protecting the privacy of patrons within the context of big data and social media use by libraries. The authors suggest linked data as a better alternative to big data to maintain the balance between confidentiality and intellectual freedom.

Research Data Services in Academic Libraries: Data Intensive Roles for the Future?
go.nmc.org/intensive
(Carol Tenopir et al., *Journal of eScience Librarianship*, 2015.) This article reports the findings of a research study conducted to identify levels of research data service (RDS) academic libraries have provided since 2011. The study was conducted across academic institutions in North America with the intent to assess RDS growth and identify avenues and challenges to future growth.

Digital Scholarship Technologies

Time-to-Adoption Horizon: One Year or Less

Digital scholarship technologies refer to the suite of digital and computational tools currently being used to advance scholarship in higher education. The Chartered Institute of Library and Information Professionals (CILIP) defines digital scholarship as the implementation of technology to support the access, retrieval, and application of knowledge.[257] Products of digital scholarship can include digital media, websites, archives of scholarly information, and digital exhibits.[258] Although encompassing the digital humanities, digital scholarship is a cross-disciplinary field where participants from various backgrounds, including programmers and researchers, engage in collaborative scholarly inquiries.[259] Academic libraries are as focused on helping scholars understand new processes for research as they are in supporting the production of scholarly inquiry, requiring them to work with diverse workflows, tools, and content.

Overview

The concept of digital scholarship has origins in the late 1990s in the UK. Originally referred to as e-science, the idea of applying new technology and data analysis tools to scholarship cycled through other names like cyberinfrastructure and e-scholarship before landing on the current umbrella term. Comprising a series of information technologies including high performance computing, visualization technologies, database technologies, and high performance networking, digital scholarship has ushered in a new paradigm of data-intensive science.[260] Academic libraries were quick to position themselves as incubators for this transformation of research. Through a collaborative approach, libraries developed shared virtual and physical places for fostering scholarly inquiry. Early exemplars include the University of Richmond's Atlas of the Historical Geography of the United States portal and College of William and Mary and Virginia Commonwealth University's Center for Conservation Biology Project Portal.[261]

As new technologies for scholarly inquiry are implemented, many libraries are developing digital scholarship centers on their campuses. The Consortium of Networked Information (CNI) characterizes these spaces as being placed in academic libraries rather than faculty-run institutes, focused on digital humanities, and cross-disciplinary in nature.[262] One example of this new type of environment is the University of Leiden's Centre for Digital Scholarship that recently opened in the Dutch university's library. Its focus is to support and facilitate research projects at the institution in conjunction with other research institutes and national and international support organizations. The Centre fields inquiries regarding the creation and management of digital collections, long-term preservation, and metadata, among other topics.[263]

College and Research Libraries News listed digital scholarship as a top trend in 2016, citing that academic libraries are extending traditional research methods to include the application of new technologies such as GIS data, information visualization, and big data. In addition to training scholars to use new technologies, libraries offer services such as digital asset management, digital preservation, as well as consultation and resources.[264] The increasing interest in leveraging data-focused technologies for scholarly inquiry has prompted new job roles within the library; now-common titles such as science data librarian and data visualization coordinator were unheard of 20 years ago.[265] It is no simple task for librarians to gain the skills necessary to work with a variety of disciplines and methods. Therefore, academic libraries are working to build capacity internally to better serve their communities. At the Library Data Carpentry workshop, for example, data-minded librarians in Australia investigated the practice of digital scholarship and the data science lifecycle. The program built on materials from several existing library training initiatives to help familiarize attendees with techniques for data extraction, analysis, and visualization.[266]

Relevance for Academic and Research Libraries

Emerging digital scholarship technologies are helping libraries more effectively preserve and mine their collections as well as surface collaborative opportunities. The California College of the Arts Libraries' digital scholarship services department features cooperative projects such as "African Art: A Pedagogical Hypertexted Journey." Created in Twine, an open-source, non-linear digital storytelling platform, the art history curriculum represented the collective work of a professor, an instructional designer, and a digital scholarship librarian.[267] Similarly, the Project for the Study of Dissidence and Samizdat at the University of Toronto Libraries is a large-scale partnership

between multiple research institutions and scholars. It highlights the library's collection of Soviet dissidence and nonconformist culture in an electronic archive featuring periodicals, electronic editions of journals, and illustrated timelines of dissident movements.[268]

Increasingly, digital humanities scholars are leveraging new tools to aid in their work. In Australia, researchers can use library APIs to build their own customizable interfaces to catalogs and collections. For example, QueryPic enables the seeing, searching, and understanding of digitized newspapers from Australia and New Zealand. Scholars can follow changes over time, map trends, and explore patterns.[269] Similarly, Archives Viewer of the National Archives of Australia is an experimental portal for viewing digitized files in the national archives of Australia's RecordSearch database.[270] With the ubiquity of new forms of communication including social media, text analysis software such as Umigon is helping researchers gauge public sentiment. The tool aggregates and classifies tweets as negative, positive, or neutral.[271] The online text mining tool Voyant allows scholars to generate graphs of frequently used words across a body of work, compare multiple documents, and sort categories by geographical location.[272] One Rice University researcher used the tool to study the entire corpus of runaway slave advertisements from their library's collection and shared the results on GitHub.[273]

Digital scholarship technologies have had the dual effect of increasing the relevance of scholarly research and opening new realms of scholarship through data visualization. At the Digital Scholarship Lab at the Chinese University of Hong Kong Library, the visualization room contains a digital display wall as well as an 80-inch interactive touch screen consisting of twelve 55-inch high resolution LED monitors with a resolution of over 24 million pixels, allowing greater interactivity with data and digital objects.[274] Carnegie Mellon University (CMU) is developing a new digital scholarship center and two-year postdoctoral fellow position for data visualization and curation. Partnering with CMU Libraries and the Department of Statistics, the fellow will play a key role in creating a sustainable program for data visualization at the university.[275]

Digital Scholarship Technologies in Practice

The following links provide examples of digital scholarship technologies in use that have direct implications for academic and research libraries:

The Digital Humanities as an Emerging Field in China
go.nmc.org/dhchina
The first digital humanities center was established in 2011 at Wuhan University, and since then, several Chinese universities have been developing digital scholarship projects. Peking University, for example, is working with Harvard and Academia Sinica on the China Biographical Database Project; the initiative contains 370,000 historical figures spanning from the 7th to the 19th centuries.

The DiRT Directory
go.nmc.org/dirt
Evolving from the directory developed by Project Bamboo, the Digital Research Tools (DiRT) Directory aggregates information about digital scholarship technologies, making it easier for scholars to find and compare resources.

Oxford University Bodleian Libraries' Centre for Digital Scholarship
go.nmc.org/oxds
Oxford University's Centre for Digital Scholarship works with diverse partners across campus including the Bodleian Libraries, medical sciences, social sciences, and the humanities. They conduct multi-disciplinary research, host trainings for researchers, and highlight other departments' work that combine physical and digital library resources.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about digital scholarship technologies:

Digital Scholarship Week Explores Ways of Adapting New Technologies to Research
go.nmc.org/digschol
(Bert Gambini, University of Buffalo News, 25 February 2016.) The University of Buffalo's Humanities Institute and the Committee on Digital Scholarship and Cultures held a series of programs on the impact of digital technologies on scholarship. Topics included the digital reconstruction of St. George's Bermuda, the oldest town in English America.

Laying the Foundation: Digital Humanities in Academic Libraries
go.nmc.org/layfo
(John White and Heather Gilbert, Purdue University Press, 15 March 2016.) This series of essays addresses core themes from a College of Charleston convening on digital scholarship, including the case for digital humanities in libraries and building infrastructure and partnerships.

Libraries as Content Producers
go.nmc.org/libasco
(Daniel Tracy, College and Research Library, accessed 10 February 2017.) As libraries increasingly contribute to multimedia and digital humanities projects, the user experience must be considered. This study provides a foundation on the ways library publishing services implement user studies and their barriers.

Library Services Platforms

Time-to-Adoption Horizon: Two to Three Years

Libraries are at a critical point with regard to automation and resource management. The library systems landscape is growing increasingly complex. Patrons expect ubiquitous access across a multitude of devices, and library resource management needs to account for materials in multiple formats; as a result, librarians are assuming new roles as data custodians and analysts. On the other hand, legacy library management systems developed on 20th century technology for print resources are no longer adequate to confront the challenges of the knowledge era. Library services platforms (LSP) represent a new conceptual approach to library automation, meeting current needs for a cohesive system that is web-centric, provides comprehensive print and electronic resources management, and keeps pace with the operational needs of changing library environments. In essence, LSP offer libraries the opportunities to consciously address the intricacies of content, workflows, and discovery to better integrate with their patron community.[276]

Overview

Library services platforms comprise a genre of library automation systems that have emerged in recent years. Marshall Breeding, founder and editor of *Library Technology Guides*, coined the term in 2011 to describe products being developed to address growing library engagement with digital content.[277] LSP emerged as a direct response to the operational challenge of managing increasingly diverse resources and formats.[278] Concurrently, libraries were beginning to develop institutional repositories to store and manage all materials owned, licensed, and produced by their institutions.[279] Thus, the notion of a library collection expanded to encompass a broad spectrum of materials including journal articles, dissertations, theses, e-books, reports, and digital assets — all of which need to be stored, cataloged, and made accessible to patrons. Diversity of format and materials, in turn, required new approaches to content collection and curation that were unavailable in the incumbent integrated library systems (ILS), which are primarily designed for print materials.[280]

LSP is different from ILS in numerous ways. Conceptually, LSPs are modeled on the idea of software as a service (SaaS), which entails delivering software applications over the internet. The software provider hosts the application and is responsible for management, access, updates, security, and performance.[281] In contrast, ILS is managed in-house and installed at individual workstations. Thus, maintenance is handled internally and has to be conducted on each computer running that software. ILS takes a modular approach with discrete software for core functions such as cataloging, acquisitions, circulation, and public interface. Additionally, libraries previously invested in ancillary products such as link resolvers, electronic resource management systems, and digital asset management systems if absent in the core ILS.[282] However, LSP takes an inclusive approach by integrating resource management and operational tasks into a unified system that is "deployed through web-based platforms, with workflows streamlined through built-in knowledge bases."[283] LSP applications, therefore, eliminate the need for multiple software installations and maintenance on staff computers.

The transition from ILS to LSP is primarily occurring in large academic universities in the US, Australia and New Zealand, and Western Europe.[284] However, international vendors such as Ex Libris are also catalyzing LSP adoption in specific regions where they have presence. One such example is Beijing National University's (BNU) transition from Ex Libris' Aleph ILS to Alma in order to provide "a unified workflow for BNU's print, electronic, and digital resources."[285] Collections in developing nations, on the other hand, continue to have a larger proportion of print resources compared to electronic subscriptions. These countries are also constrained by access to and price of commercial proprietary products, along with unique needs such as product availability in local languages. As a result, they opt for ILS rather than LSP products, and particularly open-source options such as Koha.[286]

Relevance for Academic and Research Libraries

Library services platforms provide multiple benefits unavailable in legacy systems including time and cost efficiencies, new functionality, and transformative opportunities. For the University of Wales Trinity Saint David, the immediate value of moving to Ex Libris Alma and Primo platforms proved to be increased efficiency through a unified library management system and discovery service accessible to students and staff across all its campuses and on diverse devices.[287] HELIN Library Consortium needed a cloud-based library management system that would facilitate ease of material sharing

across consortium members and provide monetary savings. The consortium selected OCLC WorldShare Management Services (WMS) as it offered both features in one comprehensive platform.[288] An added benefit was the opportunity to communicate with other WMS users through the OCLC Community Center, which enabled them to discover best practices and stay updated on new product releases.

The time and fiscal savings that libraries recoup by investing in LSP enables them to develop new initiatives that improve operational efficacy. The library at Saddleback College, for example, recently conducted a full systematic inventory of its collection for the first time in over 40 years because the WMS LSP enabled streamlined workflows for routine tasks.[289] Saddleback librarians have also improved the quality of their physical collection as they now have time to visit the stacks and seek out and repair damaged items. In other instances, libraries are using LSP applications to enhance visibility and outreach. The Army's Engineer Research and Development Center, an early adopter of BLUEcloud Visibility, is sharing the scholarship available in its digital repository to a larger audience via search engines like Google and Yahoo.[290] Garland County Library, another Visibility user, is reaching users who have never previously visited the library. Although LSP is still a budding technology, it holds potential for significant gains for libraries, as evidenced by the Houston Area Library Automated Network (HALAN). A Texas consortium serving Houston and the East Central region, HALAN has seen exponential growth in web visits since its adoption of BLUEcloud Visibility in early 2016.[291]

Data analytics and metrics are other opportune areas as LSP products feature advanced functionality for data collection and analysis.[292] For example, the University of Leeds, which uses Innovative Interfaces' Sierra LSP, creates custom queries of user and other data to offer reading recommendations, expedite the ordering of in-demand titles, and identify suspicious activity such as hack threats.[293] For Radboud University, a research university in the Netherlands that has implemented OCLC WMS, library services platforms offer the opportunity to share library data with other libraries globally to develop best practices, identify innovations, and improve the overall library services experience.[294] Additionally, library data can be integrated with institutional big data, allowing libraries to play a stronger role in helping their institutions serve their academic community.[295]

Library Services Platforms in Practice

The following links provide examples of library services platforms in use that have direct implications for academic and research libraries:

Stellenbosch University — First South African Customer to Choose Ex Libris Alma for Optimizing Library Services
go.nmc.org/stellen
Investing in Ex Libris Alma was a strategic decision for Stellenbosch University. The university plans to leverage the advantages of a unified library management system to better manage its print and electronic resources, improve user experience, and maintain its ranking as a top-tier academic institution.

Swiss Library Service Platform (SLSP)
go.nmc.org/slsp
The collaborative project SLSP aims to help academic libraries in Switzerland use resources in a more cost-effective and efficient manner by establishing a centralized service platform incorporating technical solutions, standards, and library networking services.

Three Universities Choose SirsiDynix Solution for Unique Collaboration
go.nmc.org/sirsi
Canterbury Christ Church University, the University of Greenwich, and the University of Kent will share a Unified Library Management System on the BLUEcloud platform to improve student services and enhance collaboration.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about library services platforms:

Approaching Discovery as Part of a Library Service Platform
go.nmc.org/approa
(Nathan Hosburgh, *Rollins College Rollins Scholarship Online*, 2016). The author details how Olin Library at Rollins College transitioned to the Ex Libris Alma platform. The chapter describes the underlying motivation, the assessment and selection processes, and also provides an evaluation framework.

How to Conduct a Library Platform Services Review and Selection
go.nmc.org/lspreview
(Matt Gallagher, *Information Today*, October 2016.) This article offers a practical guide to critically assessing and selecting an LSP. The author recommends that libraries situate LSP considerations within the broader context of institutional technology infrastructure.

Implementing Kuali OLE at SOAS Library
go.nmc.org/kuali
(Simon Barron, ARIADNE, 29 June 2015.) SOAS Library at the University of London is the first library in Europe to implement an open source library services platform. This report describes the functional and technical details of implementing the Kuali OLE system.

Online Identity

Time-to-Adoption Horizon: Two to Three Years

Online identity, also referred to as digital identity, is the idea that everything interacting in the digital realm has or acquires a set of data or attributes, both inherent and changeable, that uniquely identify them as a person or entity online.[296] Relevant to issues of privacy and authentication,[297] online identity encompasses a wide array of contextual and technical identifiers that exist in an ontological taxonomy. Traits can be understood in mutually agreed upon contexts, such as providing one's name and address for a transaction, and in the more technical view that describes the relationships of entities and objects to each other in cyberspace. Another dimension of this topic is the persona one forges through online profiles and avatars. This development is escalating in importance for libraries for two reasons: 1) online identity is part of the broader view of digital literacy, and 2) research outputs can be attributed to an author across the web to reveal their growing body of work, also crystalizing the content's relationships to other scholarly research.

Overview

The proliferation of the internet and its tapestry of social networks has led to the concept of digital footprints. From the websites people visit to the discussions they participate in to the purchases they make, virtually every action is traceable and contributes to individuals' identities.[298] People's behaviors, viewpoints, relationships, and hobbies can all be illuminated by examining patterns and interactions over time. In the age of personal branding, the messages one shares online help define who they are. This notion bears substantial weight in academia as the work that faculty, students, and researchers disseminate across the web is attributed to their professional personas. As a result, online identity is an important facet of the ever-expanding subject of digital literacy. The University of Edinburgh and the School of Information Sciences at University of Illinois are among a growing host of institutions that have incorporated the management of digital footprints into their programming and resources.[299, 300]

Researchers from Savitribai Phule Pune University in India simplify the idea of digital footprint as "data about the data" that people are searching or using online. This data can take the form of a passive footprint, where users are not largely conscious that data is being collected (e.g., browsing websites) or an active footprint, where users have intentionally released personal data (e.g., creating a LinkedIn profile).[301] Entities that encompass vast canyons of user information and interactions have developed systems for crystalizing every relationship; Facebook's Open Graph enables any web page to become a rich object in a social graph based on the inclusion of metadata.[302] In turn, companies are able to tailor the content and advertisements they deliver to each user.[303] Privacy concerns have emerged with many feeling uncomfortable with their every move being monitored; Pew Research reports that 86% of internet users in America have taken steps to mask their digital footprints, such as clearing cookies or avoiding their real names when using social networks.

As resident champions for advancing digital literacy,[304] academic and research libraries are well-positioned to guide the process of understanding and crafting online identities. The UK's Open University Library Services developed a digital information and literacy framework that includes collaborating and sharing content as an essential element; they assert that digital literacy entails providing evidence of engagement in online communities and professional groups.[305] Online identity is also tied to the research outputs that patrons create, and the relationship of their content to other content on the web. For example, one student or researcher's study on climate change can be connected to a published paper on the same subject, creating a more visible pathway to an entire body of research, illuminating and substantiating key findings. Libraries play a significant role in creating standards for organizing outputs and making them discoverable through the semantic web and linked data.[306]

Relevance for Academic and Research Libraries

Libraries are becoming integral players in helping students understand how to create and manage their online identities. The Association for College and Research Library's (ACRL) "Framework for Information Literacy for Higher Education" includes the ability to "make informed choices regarding their online actions in full awareness of issues related to privacy and the commodification of personal information" among their list of skills literacies.[307] In Australia, the Queensland University of Technology Library specifically focuses on the productive use of social media and the role it

plays in identity. Their website includes a social media skills portal that enables students to view their digital presence through the lens in which others see them, and then learn how they compare to their peers.[308] Their goal is to aid students in becoming more favorable candidates for employment and in understanding their social media rights and responsibilities.

Faculty also need assistance from campus libraries to create and maintain their academic digital presence. Texas A&M Libraries has published a guide, "Managing Your Brand," to help faculty and researchers establish credible online identities and build citations profiles on Google Scholar to make their scholarly products more linkable and trackable across the web.[309] Online self-publishing and research-sharing platforms are on the rise, including ResearchGate,[310] Academia.edu,[311] Mendeley,[312] and SSRN.[313] Often linked to in-library repositories, these tools allow faculty and researchers to disseminate their findings and connect with peers. The Thomas G. Carpenter Library at University of North Florida guides faculty in making smart decisions about which online platforms to choose for publishing and peer review, providing a comparison of different systems.[314] At Washington University in St. Louis, the Bernard Becker Medical Library website helps academics to establish author profiles across multiple platforms and integrate social networking sites specific to the medical field.[315]

Further, it is essential for libraries to help faculty and researchers connect their names to their growing bodies of research and scholarly work across multiple sites. ORCID (Open Researcher and Contributor ID), a nonprofit organization, provides a persistent digital identifier that distinguishes one researcher or author from another;[316] previously, a specific person's contributions to publications were difficult to track as many names are not unique or are listed inconsistently. Now, researchers' work is tied to them, allowing them to continuously build their public portfolios and connect their ORCID records with their LinkedIn pages and other professional accounts. This system is gaining traction worldwide. In the Netherlands, ORCID has replaced the Dutch Digital Author Identifier system SURF.[317] Leiden University Libraries recently hosted a conference to educate the academic community on persistent identifiers and providers.[318] Last year, University of Pretoria signed an agreement with ORCID to become one of eleven South African institutional members.[319]

Online Identity in Practice

The following links provide examples of online identity in use that have direct implications for academic and research libraries:

Digital Identity: Making Your Mark
go.nmc.org/latrobeu
A team of academics, instructional designers, and librarians leveraged Smart Sparrow's Learning Design Studio to develop an adaptive, personalized online module that helps students understand the power of social media in crafting their digital identities. Lessons include evolving privacy policies and career influence.

Employability Skills and Resources
go.nmc.org/manchester
The UK's Manchester Metropolitan University Library provides resources for students to leverage social media for job hunting and networking as well as tips to help them manage an effective and engaging digital presence.

Managing Your Online Reputation
go.nmc.org/reput
Claremont Colleges Library provides open access resources for faculty, librarians and students to bolster their credibility in the digital realm. They provide pertinent videos on the subject as well as examples of altmetrics in use for scholarly research and publications tracking.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about online identity:

Digital Identity Development
go.nmc.org/gful
(Robin Ashford, Digital Commons @ George Fox University Libraries, June 2015.) This publication guides readers through important definitions of digital identity and describes the high stakes of building a credible online presence for securing employment.

Digital Literacy, Identity and a Domain of One's Own
go.nmc.org/domainof
(Doug Belshaw, DML Central, 15 September 2016.) As more people develop their personal and professional websites and profiles on borrowed domains, the author posits that identity is at stake; he suggests that owning one's domain is the equivalent of building a customized house versus renting an apartment with a short-term lease.

Exploring Researchers' Participation in Online Research Identity Management Systems (PDF)
go.nmc.org/explorerim
(Shuheng Wu et al., ASIST, October 2016.) In this study, nine motivations were identified for leveraging research identity management (RIM) systems, including connecting with peers and staying up to date on scholarly work. The authors also found that there are three general levels of RIM system participation — readers, personal record managers, and community members — with most falling under the personal record manager category.

Artificial Intelligence

Time-to-Adoption Horizon: Four to Five Years

In the field of artificial intelligence (AI), computer science is being leveraged to create intelligent machines that more closely resemble humans in their functions. Having access to abundant knowledge, including categories, properties, and relationships between various information sets, is the basis of the knowledge engineering that allows computers to simulate human perception, learning, and decision-making. Machine learning is a subset of AI that refers to computers programmed with algorithms that respond to new inputs after being trained on a different learning data set, resulting in their ability to act and react without being explicitly programmed to do so. As academic and research libraries begin to uncover ways in which AI can improve patron services, research processes, and learner outcomes, there is a need to develop guidelines informed by research to ensure ethical use of student data.[320]

Overview

In recent years, advancements in artificial intelligence (AI) have further blurred the line between synthetic and human intelligence. Like people, AI-enabled machines and applications can learn over time. While completing a task, these entities simultaneously collect data, store the information, and use it to improve responses in the future.[321] Although the concept of AI is not new, recent years have seen major implementations within the consumer sector. From Google's heavy financial and research investments in self-driving cars[322] to the voice recognition capabilities of Amazon's Echo,[323] AI is penetrating day-to-day life. A recent milestone for AI took place when computers beat the world's best Texas Hold 'Em players in a 20-day "Brains vs. Artificial Intelligence" poker tournament, triumphing over human rivals by a margin of over $1 million in poker chips.[324] Futurists in academic and research libraries are beginning to better conceptualize how these use cases of AI can translate into increased learner success.

Intelligent capabilities of machines have led to more sophisticated databases within libraries.[325] Machines can tailor content to meet the needs of learners in an instant, replacing the need for individuals to sift through hundreds of readings to locate relevant research. Scholarly processes are evolving as AI increases the capacity to learn from and draw on multiple users' experiences.[326] In fact, strategic implementations of AI could lead to more cross-disciplinary alignment within academic research by aiding scholars in locating connections within large sets of data, exposing them to a variety of viewpoints that might have otherwise been overlooked. The ability for technology to learn as the user progresses can also lead to an increase in personalization, as seen in the retail sector. Online stores have harnessed machine learning to gain insight into customer habits and recommend items for purchase based on these observed behaviors.[327] These developments hold potential for libraries to surface new ways to support learners.

As technology continues to facilitate a high percentage of learning interactions, community leaders have raised concern around a lack of governing guidelines to highlight the ethical use of personal data and analytics. The novelty of AI and its upward trajectory across multiple sectors has led industry leaders to develop consortia dedicated to outlining proper uses of AI. Google, Facebook, Amazon, IBM, and Microsoft recently joined forces to create the Partnership on Artificial Intelligence to Benefit People and Society, an organization devoted to developing best practices through research and open publishing.[328] Similarly, the Ethics and Governance of Artificial Intelligence fund is set to allocate $27 million to technology leaders and institutions including Harvard and MIT to "advance the development of ethical AI in the public interest."[329] As AI gains traction in academic and research libraries, resources must be devoted to protect student data and provide ethical guidance.

Relevance for Academic and Research Libraries

While academic and research libraries are still working to understand the different aspects of AI to effectively incorporate it into their systems, current uses could lead to potential breakthroughs. Semantic Scholar, an academic search engine launched in 2016, provides insight into research applications. In contrast to similar programs, which simply highlight key information at the top of search fields, Semantic Scholar leverages data mining and natural language processors to compare thousands of articles with the capacity to make judgments about which studies better align with a researcher's needs. Equipped with sophisticated abilities to draw conclusions about the methods, citations, and relevant data within each article, this artificially intelligent search engine contains over ten

million studies that have been vetted to include only those meeting highest quality standards.[330]

The range of capabilities afforded through AI has led some academic and research libraries to investigate how this technology can be applied to their mission. Exemplars in the field have already begun leveraging machine learning to improve learner outcomes. Research in law library settings is considering how AI agents, such as chatbots and location-based services, are shifting the focus of librarians, while also optimizing search engine results to increase student success. Initial conclusions indicate that artificially intelligent agents can alleviate the burden on librarians answering technical questions and free up time to increase focus on other duties, such as teaching and improving research. AI agents can also assist students using large databases by locating relevant resources based on personalized data. For example, an agent can take into consideration students' past course experiences to locate articles that align with their knowledge levels.[331]

As more data is being generated online, futurists and technology companies are beginning to look for ways in which this information can be leveraged to advance AI. For example, Yahoo is set to release what is being dubbed the largest online database — 13.5 terabytes of data — in hopes of spurring innovation within academic research. The company is already enlisting academic partners such as the University of California, San Diego in an effort to improve current research initiatives for emerging technologies including machine learning and AI.[332] Google Translate has also made waves within academic research following the release of its Google Neural Machine Translation, which is able to translate research papers into any language. This development could prove invaluable, as researchers now have access to international papers that were once unusable due to a language barrier or a lack of additional resources to translate, like time and money.[333]

Artificial Intelligence in Practice

The following links provide examples of artificial intelligence in use that have direct implications for academic and research libraries:

Artificial Intelligence Laboratory at the University of Michigan
go.nmc.org/umail
A key focus of the University of Michigan's AI lab is researching and developing assistive technology for those with physical and cognitive impairments. One such project is the design of a computer interface that automatically adjusts to cater to the needs of the visually-impaired — a compelling development for libraries as they strengthen resource accessibility.

IBM, Eight Universities to Train Watson for Cybersecurity Sleuthing
go.nmc.org/watson
IBM is partnering with universities across North America in a year-long research project that aims to move the needle in cybersecurity. The AI-based technology known as Watson will be deployed across eight campuses in an effort to improve security for student data, an issue currently confronting libraries as they move to more open online publishing.

Robot Librarian Designed by Aberystwyth University Students
go.nmc.org/hugh
Students at Aberystwyth University in Wales have prototyped "Hugh," an artificially intelligent robot that accesses electronic card catalog information to lead library patrons to materials' physical locations following a verbal query. Library staff are working with the students as they test the robot's location awareness and navigation capabilities.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about artificial intelligence:

Artificial Intelligence: Computer Says YES (But is it Right?)
go.nmc.org/policy
(Louise Walsh, University of Cambridge, 20 October 2016.) Driverless cars and healthcare applications allow AI systems to make choices that impact human lives. To build user trust, researchers stress the need for increased transparency into AI's data-driven decisions.

Libraries in an Artificially Intelligent World
go.nmc.org/focus
(Kristin Whitehair, Public Library Association, 11 February 2016.) As AI continues to close the gap between users and their access to vast amounts of information, libraries are in the unique position to streamline some processes, shifting focus and resources towards deeper engagements with learners.

Reinforcement Learning as a Framework for Ethical Decision Making (PDF)
go.nmc.org/reinforce
(David Abel et al., Association for the Advancement of Artificial Intelligence, 2016.) The authors explore current capabilities of reinforcement learning to improve AI systems' use of ethical considerations in decision making; challenges and areas for further inquiry are also identified.

The Internet of Things

Time-to-Adoption Horizon: Four to Five Years

The Internet of Things (IoT) consists of objects endowed with computing power through processors or imbedded sensors that are capable of transmitting information across networks. These connections allow remote management, status monitoring, tracking, and alerts.[334] Municipal governments are applying the capabilities of IoT, leveraging data to streamline processes and promote sustainability such as to conserve public resources by using energy-efficient smart LED lights,[335] and addressing transportation management through smart traffic sensors and mobile traffic apps.[336] Library leaders are discussing how libraries can benefit from similar environmental monitoring capabilities of networked devices to optimize energy use and track objects like A/V resources and books. IoT providers may also begin to look to libraries to contribute to the reference layer of the IoT, connecting objects to resources that contextualize their use. Further, linked data will likely be embedded into many IoT sensors to amplify the reach of library services by connecting their resources to web services and cloud-based applications, applying metadata in new ways.[337]

Overview

Gartner predicts that by 2020, nearly 21 billion connected objects will be in use.[338] Many libraries are already familiar with the concept of connecting objects to the web because they have been leveraging Radio Frequency Identification (RFID) technology, which provides books and other objects unique identifiers for more efficient check-out, inventory, and theft deterrence.[339] More recently, beacons are another iteration of the IoT that libraries have adopted; these small wireless devices transmit a small package of data continuously so that when devices come into proximity of the beacon's transmission, functions are triggered based on a related application.[340] The University of Oklahoma's Bizzell Library has installed Aruba Bluetooth low-energy beacons to link digital resources to physical locations, guiding patrons to these resources through their custom navigation app and augmenting the user experience with location-based information, tutorials, and videos.[341]

However, privacy and security concerns are rising in tandem with the growth of connected objects. A study by HP Enterprise Security Research revealed a high average number of vulnerabilities per IoT device: 70% use unencrypted network service, 60% provide user interfaces susceptible to basic attacks, and 80% use weak passwords.[342] In 2016, hundreds of thousands of poorly secured internet-connected devices such as DVRs and routers were hacked and infected with malware that led to a distributed denial-of-service attack on Dyn, a major provider of internet infrastructure. Major web services were disrupted including Netflix, Twitter, Spotify, and Reddit. The incident drew public attention to the impacts of future large-scale security breaches.[343] Academic libraries are well-positioned to advocate for transparency in data collection and privacy, keeping their visitors educated about risks and steps to maintain privacy. The ALA's Privacy Toolkit can help library leaders develop or revise privacy policies that protect themselves and their patrons from security breaches.[344]

Further, libraries have a stake in making information openly available while still protecting the interests of their users, positioning them as optimal resources for advancing IoT best practices. Decentralized systems in particular can help foster the free flow of information.[345] Because the IoT is decentralized by nature, libraries will need to consider protections throughout the generation and analysis of data produced by connected objects and devices. One possible solution is blockchain technology, which can record digital interactions in a way that is designed to be secure, transparent, resistant to outages, and auditable.[346] Blockchain enables an open distributed ledger shielded from manipulation by malicious entities because it does not exist in any single location. This concept can scale IoT networks so that billions of devices share the same network without the need for additional cloud or centralized network authorities.[347]

Relevance for Academic and Research Libraries

The IoT can bolster awareness among students and faculty of available library resources by allowing them to push personalized recommendations, information, and services directly to patrons' devices.[348] Technical University of Munich students and their computer science professor have partnered with Bavaria's State Library to develop a library app that triggers supplementary information about its art collection or other points of interest as users explore the space.[349] Meanwhile, a campus-wide network of collaborators at Western Michigan University is also working with

location-based services, enabled by beacons and LED sensor systems, that will interact with users' smartphones; this activity is part of their multi-year initiative for prototyping and deploying IoT solutions to develop a smart library infrastructure with Waldo Library currently serving as the testbed.[350]

Access to more data enabled by smart devices will allow libraries to better understand their patrons, informing strategies to meet evolving visitor needs. By tracking visitor traffic patterns to see the amount of time visitors spend in various sections, smart devices and beacons are becoming more adept at collecting information on library usage. Additionally, smart devices may alert staff and providers on equipment that needs servicing before a problem presents itself.[351] The smartLAB project in Germany is a model of a future lab based on the IoT that allows all laboratory components to be connected and self-sustainable, from self-cleaning lab benches to smart safety goggles that use VR to project safety information.[352] Libraries could take advantage of similar setups to manage tasks like preserving the stability of the temperature and humidity in areas housing books, or to maintain makerspaces and other library equipment.

Academic libraries are partnering with industry to educate patrons on the potential of IoT technologies and equip them with experience to apply to solving real-world problems. Pennsylvania State University has teamed up with New York-based startup littlebits to open an Invention Studio housed within the Penn State Knowledge Commons in Pattee Library, where students can prototype inventions that leverage the power of the IoT to collect and exchange data.[353] The D.H. Hill Makerspace recently held an interactive workshop on IoT as part of North Carolina State University Libraries' Making Space initiative geared toward women in STEM fields. Students in the workshop designed an IoT product that could aid processes related to cultivating vegetables, including local distribution and transportation.[354]

The Internet of Things in Practice

The following links provide examples of the Internet of Things in use that have direct implications for academic and research libraries:

Carnegie Mellon to Lead Internet of Things Expedition
go.nmc.org/carmell
A joint project between Carnegie Mellon University, Cornell, Stanford, Illinois at Urbana-Champaign, and Google is developing an open infrastructure called GIoTTO that enables an easier entry point for their campus communities to experiment with diverse IoT use cases.

Internet of Things Lab Fosters Student Innovation, Adds Industrial Partners
go.nmc.org/iotwisc
The University of Wisconsin–Madison provides an example of the potential in university-industry collaboration to enable innovative research that advances businesses and economic development by identifying areas where IoT makes processes more efficient.

UT Start Living Smart Campus
go.nmc.org/utsmart
In the Netherlands, the University of Twente's Living Smart Campus program is offering resources and funding to a collection of pilot projects in which students use IoT concepts and tools to experiment with solutions related to efficiency and sustainability, using their own campus community as a testbed.

For Further Reading

The following articles and resources are recommended for those who wish to learn more about the Internet of Things:

Internet of Things Applications in Academic Libraries
go.nmc.org/iotapp
(Ashwini Nag, *Research India Publications*, 2016.) This paper explores how IoT concepts such as magic mirror technology, pressure sensor pads, and wireless sensor networks can enhance academic library services and resource utilization and management.

The Internet of Things: Seizing the Benefit and Addressing the Challenges
go.nmc.org/seiz
(OECD, 2016.) The OECD encourages governments worldwide to implement policies that promote research and funding for IoT initiatives and the development of open data frameworks. They expect the IoT and resulting aggregated data to drive innovation and optimize services, leading to more targeted solutions to a number of global issues.

Understanding the Opportunities and Risks of the Internet of Things Environment on Campus
go.nmc.org/opprisk
(Chuck Benson, *The evolllution*, 27 January 2017.) IoT systems can change institutional facility management models, improve the capabilities of safety systems on campus, and facilitate a better research environment for faculty and students. However, institutions must prepare for substantial complexity in managing IoT before making investments.

Methodology

The process used to research and create the *NMC Horizon Report: 2017 Library Edition* is rooted in the methods used across all the research conducted within the NMC Horizon Project. All editions of the *NMC Horizon Report* are informed by both primary and secondary research. Dozens of meaningful trends, challenges, and important developments in technology are examined for possible inclusion in the report for each edition.

Every report draws on the considerable expertise of an international expert panel that first considers a broad set of topics and then examines each of them in progressively more detail, reducing the set until the final listing of 18 topics is selected. This process takes place online, where it is captured in the NMC Horizon Project workspace. The workspace is intended to be a completely transparent window into the project, one that not only provides a real-time view of the work as it happens, but also contains the entire record of the process for each of the various editions published since 2006. The workspace used for the *NMC Horizon Report: 2017 Library Edition* can be found at horizon.wiki.nmc.org.

The panel was composed of 75 education and technology experts from 14 countries on five continents this year; their names and affiliations are listed at the end of this report. Despite their diversity of backgrounds and experience, they share a consensus view that each of the profiled topics will have a significant impact on the practice of academic and research libraries around the globe over the next five years.

The procedure for selecting the topics in the report is based on a modified Delphi process refined over the now 15 years of producing the NMC Horizon Report series, and began with the assembly of the panel. The panel represents a wide range of backgrounds, nationalities, and interests, yet each member brings a relevant expertise. Over the decade of the NMC Horizon Project research, more than 2,000 internationally recognized practitioners and experts have participated on the panels; in any given year, a third of panel members are new, ensuring a flow of fresh perspectives each year. Nominations to serve on the expert panel are encouraged; see go.nmc.org/panel.

The panel was composed of 75 education and technology experts from 14 countries on five continents.

Once the panel for a particular edition is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertains to emerging technology. Members are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic in this edition is its potential relevance to the services and practices of academic and research libraries. A carefully selected set of articles from hundreds of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants.

Following the review of the literature, the expert panel engages in the central focus of the research — the research questions that are at the core of the NMC Horizon Project. These questions were designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the panel:

1 What key trends do you expect to accelerate technology adoption and progress in academic and research libraries worldwide over the next five years?

2 What do you see as the significant challenges that will impede technology adoption and progress in academic and research libraries worldwide will face over the next five years?

3 Which of the important developments in technology will be most impactful for academic and research libraries worldwide within the next five years?

4 What important developments in technology are missing from our list? Consider these related questions:

- **What would you list among the established developments in technology that some academic and research libraries are using today that arguably all academic and research libraries should be using broadly?**
- **What developments in technology that have a solid user base in consumer, entertainment, or other industries should academic and research libraries be actively looking for ways to apply?**
- **What are the important developments in technology you see developing to the point that academic and research libraries should begin to take notice during the next five years?**

In the first step of this approach, the responses to the research questions are systematically ranked and placed into adoption horizons by each expert panel member using a multi-vote system that allows members to weight and categorize their selections. These are compiled into a collective ranking, and inevitably, the ones around which there is the most agreement are quickly apparent.

From the comprehensive list of trends, challenges, and developments in technology originally considered for any report, the dozen that emerge at the top of the initial ranking process in each area are further researched and expanded. Once these interim results are identified, the group explores the ways in which these topics impact learning and research in academic and research libraries. A significant amount of time is spent researching real and potential applications for each of the topics that would be of interest to library professionals. The semi-finalist topics of the interim results are then ranked yet again. The final topics selected by the expert panel are those detailed here in the *NMC Horizon Report: 2017 Library Edition*.

The 2017 NMC Horizon Project Library Expert Panel

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Endnotes and Links

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