NMC

Horizon Report > 2015 Library Edition

The *NMC Horizon Report > 2015 Library Edition* examines key trends, significant challenges, and important developments in technology for their impact on academic and research libraries across the globe.

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The *NMC Horizon Report: 2015 Library Edition*
is a collaboration between the NEW MEDIA CONSORTIUM, UNIVERSITY OF APPLIED SCIENCES (HTW) CHUR, TECHNISCHE INFORMATIONSBIBLIOTHEK (TIB) HANNOVER, and ETH-BIBLIOTHEK ZURICH.

The research behind the *NMC Horizon Report: 2015 Library Edition* is a collaboration between the New Media Consortium (NMC), University of Applied Sciences (HTW) Chur, Technische Informationsbibliothek (TIB) Hannover, and ETH-Bibliothek Zurich. Their critical participation in the production of this report and their strong support for the NMC Horizon Project is gratefully acknowledged.

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ISBN 978-0-9962832-4-3

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Citation
Johnson, L., Adams Becker, S., Estrada, V., and Freeman, A. (2015). *NMC Horizon Report: 2015 Library Edition*. Austin, Texas: The New Media Consortium.

Cover Photograph
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Inside Front and Back Cover Photograph
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Executive Summary

What is on the five-year horizon for academic and research libraries worldwide? Which trends and technologies will drive change? What are the challenges that we consider as solvable or difficult to overcome, and how can we strategize effective solutions? These questions and similar inquiries regarding technology adoption and transforming teaching and learning steered the collaborative research and discussions of a body of 53 experts to produce the *NMC Horizon Report: 2015 Library Edition*, in partnership with the University of Applied Sciences (HTW) Chur, Technische Informationsbibliothek (TIB) Hannover, and ETH-Bibliothek Zurich. The *NMC Horizon Report* series charts the five-year horizon for the impact of emerging technologies in learning sectors across the globe. With more than 13 years of research and publications, it can be regarded as the world's longest-running exploration of emerging technology trends and uptake in education.

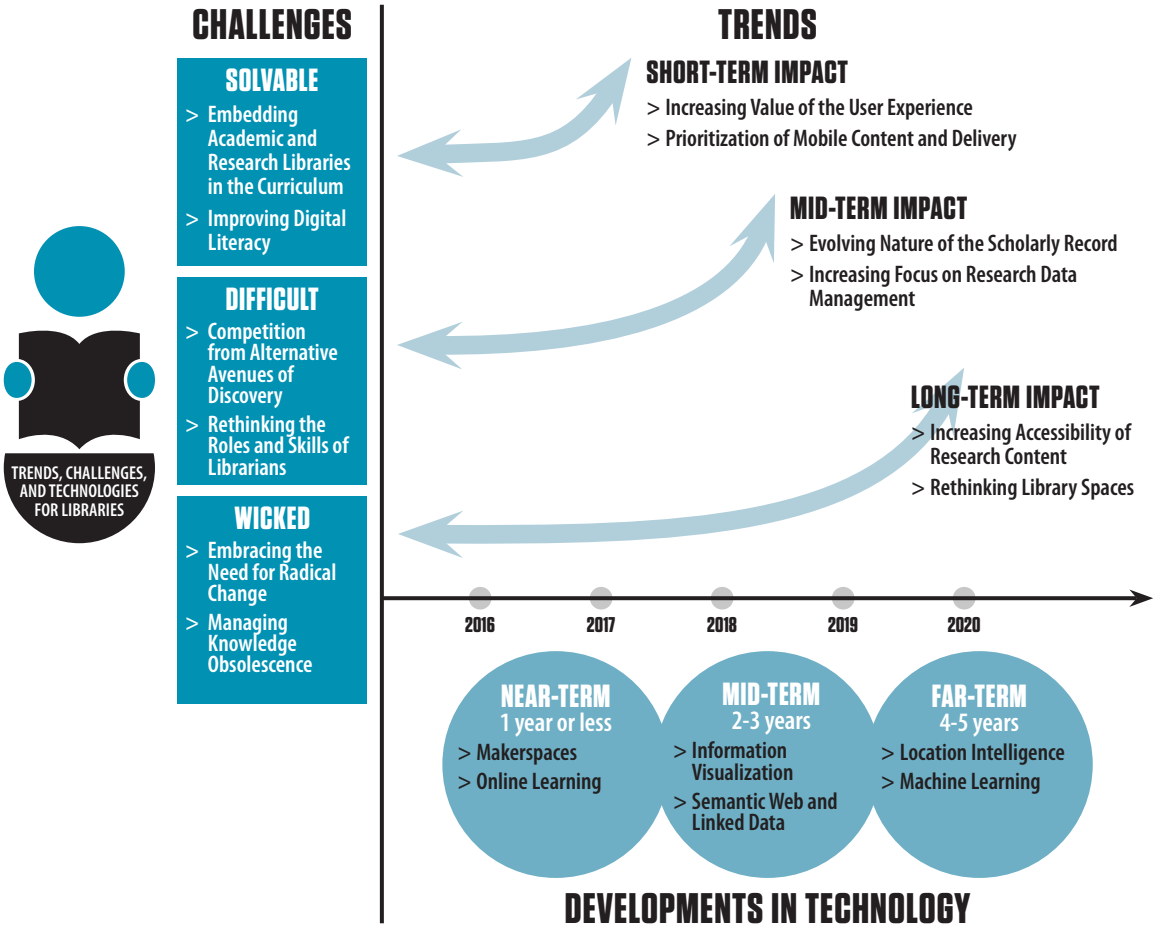
The experts agreed on two long-term trends: increasing the accessibility of research content, as well as rethinking library spaces to foster more hands-on activities and training opportunities. The former has been gradually growing, largely due to the open content movement as more libraries facilitate open access models for research outputs; the latter is the result of the ways in which the move away from print materials are freeing up physical areas of libraries that can be dedicated to facilitating workshops, media production, and training. These are just two of the 18 topics analyzed in the *NMC Horizon Report: 2015 Library Edition*, indicating the key trends, significant challenges, and important technological developments that are very likely to impact changes in libraries across the world over the next five years.

Regarding the challenges for libraries, improving digital literacy among library professionals and the campus populations they serve is considered to be solvable. Library leaders are already addressing the root problem by developing new models for training and providing guiding resources. In Australia, for example, the Deakin University Library is collaborating with and advising faculty and instructional designers on how to train and assess digital literacy among students.[1] On the other hand, the experts identified the task of embracing the need for radical change as a wicked challenge — one that is difficult to define, let alone solve. Libraries are not often set up with the proper infrastructure and support to quickly adapt to new digital strategies and business models. The end goal of solving this challenge will be for libraries to be organized in ways that enable them to continuously innovate and cater to patrons' expectations.

In view of the trends and challenges observed, the panel also signalled important developments in technology that could support these drivers of innovation and change. Makerspaces and online learning are expected to be increasingly adopted by libraries in one year's time to transform peoples' experiences both within and outside of their walls. Designed to facilitate creative hands-on activities, makerspaces further position libraries as gateways to new skills, in addition to new knowledge. Online learning, on the other hand, illuminates the benefits of having library databases and virtual resources directly at peoples' fingertips. The time-to-adoption for information visualization and the semantic web and linked data are estimated within two to three years, though they already play an important role in libraries today, while location intelligence and machine learning are expected to be mainstream in libraries within four to five years.

The three key sections of this report constitute a reference and straightforward technology-planning guide for librarians, library leaders, administrators, policymakers, and technologists. It is our hope that this research will help to inform the choices that institutions are making about technology to improve, support, or extend learning and research at libraries across the globe. Education leaders worldwide look to the NMC Horizon Project and both its global and regional reports as key strategic technology planning references, and it is for that purpose that the *NMC Horizon Report: 2015 Library Edition* is presented.

Topics from the *NMC Horizon Report > 2015 Library Edition*



Introduction

The *NMC Horizon Report: 2015 Library Edition* was produced by the NMC in collaboration with the University of Applied Sciences (HTW) Chur, Technische Informationsbibliothek (TIB) Hannover, and ETH-Bibliothek Zurich. The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlooks* are part of the NMC Horizon Project, a comprehensive effort established in 2002 by the NMC that identifies and describes important developments in technology likely to have a large impact over the coming five years in education around the globe. Each of the four global editions of the *NMC Horizon Report* — higher education, K-12 education, museum, and library — highlights six emerging technologies or practices that are likely to enter mainstream use within their focus sectors over the next five years. Key trends and challenges that will affect current practice over the same period frame these discussions.

In the pages that follow, 18 topics carefully selected by the 2015 NMC Horizon Project Library Expert Panel related to the learning and research applications of technology are examined, all of them areas very likely to impact technology planning and decision-making over the next five years. Six key trends, six significant challenges, and six important developments in technology 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, policy, leadership, and practice.

The report's first two sections focus on an analysis of 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, along with examples and relevant readings.

The third section, in which six important developments in technology are described, is ultimately framed by these trends and challenges. The adoption or abandonment of these technologies by libraries will be very much determined by the responses taken across the world to these drivers of and obstacles to innovation and change.

Each topic closes with an annotated list of suggested readings and additional examples that expand on the discussion in the report. Throughout the report, supporting research for every topic is referenced in the form of endnotes. Readers are encouraged to further explore the articles, papers, and media that often elaborate on key points made in this report by visiting the websites listed in the endnotes section.

An expert panel identified 18 topics very likely to impact technology planning and decision-making: six key trends, six significant challenges, and six important developments in technology.

The process used to research and create the *NMC Horizon Report: 2015 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 important trends, challenges, and developments in technology, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and technologies is selected. This process takes place online, where it is captured in the NMC Horizon Project wiki. The wiki is intended to be a completely transparent window into the work of 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 wiki used for the *NMC Horizon Report: 2015 Library Edition* can be found at library.wiki.nmc.org.

The panel was composed of 53 education and technology experts from 15 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.

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The procedure for selecting the topics in the report is based on a modified Delphi process refined over the now 13 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 past 13 years of the NMC Horizon Project research, more than 1,500 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.

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 RSS feeds 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 trends do you expect to accelerate emerging technology uptake in academic and research libraries worldwide within the next five years?

2 What do you see as the significant challenges impeding emerging technology uptake that academic and research libraries worldwide will face over the next five years?

3 Which of the important developments in technology catalogued in the NMC Horizon Project Listing will be most important to 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 advancing 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, this time in reverse. The final topics selected by the expert panel are those detailed here in the *NMC Horizon Report: 2015 Library Edition*.

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 impact trends that typically have already been impacting decision-making, and will continue to be important for more than five years; mid-term impact trends that will likely continue to be a factor in decision-making for the next three to five years; and short-term impact 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 impact trends have already been the topic of many academic and research library leaders' discussions and extensive research, short-term impact 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 library.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.

Policy. All of the identified trends had policy implications, but two trends in particular are expected to have a strong impact on policy decisions over the next five years. It is widely agreed that libraries should continue to support increased availability of research outputs to make it easier for the research community to access key findings and build upon published bodies of work. While this long-term impact trend has been materializing at libraries for some time, national governments recognize that there is still room for progress. The Danish Ministry of Higher Education recently announced plans to make 80% of peer-reviewed articles openly accessible over the next two years, and 100% by 2022.[2]

Furthermore, the types of content available are rapidly expanding, as evidenced by the mid-term impact trend — the evolving nature of the scholarly record. The rise of digital content has popularized formats such as video, podcasts, and data visualizations that may have been previously represented by all-text documents and articles. As a result, there is a need for policies that guide libraries in the storage, publication, and dissemination of emerging formats. The Online Computer Library Center (OCLC) has been instrumental in this process, publishing two reports in 2014[3] and 2015[4] that provide conceptual frameworks and pose recommendations for developing effective stewardship models for libraries.

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.

Leadership. Although there are leadership implications highlighted for all the identified trends as well, the two short-term impact trends stand out as opportunities for innovative vision —especially in order to solidify them as vital aspects of library missions. First, the growing focus on developing a positive user experience is informing the enhancement of libraries' web presence and digital resources. As custodians of vast amounts of data and assets, libraries have a responsibility to their communities to ensure that it is all easy to navigate and understand. Keeping a pulse on patron expectations and needs can help leaders accelerate this trend. For example, leadership at the

North Carolina State University Library System conducts user experience studies across their institution to pinpoint insights that help them more effectively tailor their virtual offerings to students, faculty, and researchers.[5]

Increasingly, these online services and resources are being accessed via mobile devices as people expect to study and conduct research any time, anywhere. Thus, academic and research libraries must not only have a rich mobile presence through apps and responsive design approaches, but also understand the evolving landscape of smartphone and tablet delivery. In the UK, JISC has stepped up to support continuous growth in this area; through the JISC Mobile Infrastructure for Libraries Program, the Mobilizing Academic Content Online project was launched to establish a best practices toolkit.[6]

Practice. Each of the six trends identified by the expert panel has numerous implications for academic and research libraries, and in many cases, current examples are easy to find. A long-term and widespread emphasis on rethinking physical spaces is expanding the benefits of on-campus libraries. In the past several years, libraries have been moving a large amount of print collections to offsite storage centers as they have transitioned to more digital offerings in the form of e-books and online journals. As such, libraries are reimagining how they can best use the extra room. The University of Colorado at Colorado Springs Kraemer Family Library recently traded in the shelving that once encompassed print materials to create a flexible learning space for patrons to facilitate more peer discussions and active learning.[7]

Finally, the move to a more expansive online presence is calling for state-of-the-art data management processes that both make content more discoverable and ensure long-term preservation. Libraries have long played key roles in this area and are continuing to refine their workflows as well as the digital infrastructures that support them. Furthermore, they have a responsibility to educate researchers in their communities on the proper protocol for uploading research assets and related metadata. Stanford University Libraries' data management services,[8] for example, guide researchers and provide them with data management planning tools and repositories.[9]

The following pages provide a discussion of each of the trends highlighted by this year's expert panel that includes an overview of the trend, its implications, and curated recommendations for further reading on the topic.

Increasing Accessibility of Research Content

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

Academic and research libraries are gradually embracing the movement toward openness, a concept that has garnered a meaningful following in the library community among those who wish to eliminate the financial and intellectual barriers that impede the dissemination of scholarly works.[10] There are an increasing number of major funding entities such as the UK's Research Excellence Framework,[11] the National Science Foundation, and National Institutes of Health that have implemented guidelines requiring researchers to include more comprehensive dissemination plans for their data along with their outputs, expanding access to encompass all scientific outputs.[12] Open access is gaining traction on a global scale, and scholars in some regions of the world, such as Latin America, have been operating under this philosophy for decades.[13] As this trend continues to impact the scholarly community at large, there will be more opportunities for libraries to drive and engage in discussions about efficient ways to make access a priority for the long-term.

Overview

Concerns about the long-term escalation of scholarly journal subscription fees have accelerated international discussions about the role of academic and research libraries in publishing.[14] According to the American Library Association (ALA), the cost of serial subscription rates has grown significantly over the past two decades. They note that their average cost increased 315% from 1989 to 2003, and about 9% year over year since then.[15] In an environment that some call fiscally unsustainable and academically restrictive,[16] University of Montreal researchers analyzed documents indexed on the Web of Science and found that in both natural and medical sciences, as well as the social sciences and humanities, the top five most prolific publishers accounted for more than 50% of all papers published in 2013.[17] As a result, librarians have been focused on finding or creating more cost effective avenues to increase access to scholarly materials, and this trend reflects those positive efforts.

Open access publishing has brought more attention to the ideal of a global, barrier-free research environment. There are two different categories of open access publishing — the first is referred to as green, which is self-archiving through the submission of content to a free repository; and the other is gold access, which requires an Article Processing Fee (APC) that is either funded by subsidy, support from a university or governing body, or an author.[18] A recent survey of more than 3,000 librarians in 30 countries by the Publishers Communication Group found that 47% of librarians reported that researchers covered the costs of APCs, and 23% said they were funding the cost of APCs out of their library's operating budget.[19] While the majority of respondents believe that the library should advocate for open access, there is still a major need for economical, mainstream solutions that can get buy-in from all stakeholders involved.

While the open access movement is gradually gaining traction in libraries, there has also been progress on a global level, with strong support in some regions. In Latin America, researchers have been publishing publicly funded research on open access platforms such as SciELO since 1998. Established with the goal of helping researchers increase their visibility and democratize access to scientific research, SciELO garners an average of 1.5 million journal article downloads a day. While Peru and Argentina are the only countries in Latin America that have federal mandates in place for public research, the philosophy of open access is understood and practiced widely in this part of the world.[20] There are a number of other countries that have formalized their commitments to disseminating research produced with public funding, including Australia, Austria, Canada, the European Union, India, and South Africa.[21]

Implications for Policy, Leadership, or Practice

Some governments have established formal policies on the accessibility of research outputs. In the US, the "Increasing Access to the Results of Federally Funded Research Policy" memorandum directed heads of executive departments and agencies with over $100 million in annual extramural research and development budgets to make publications resulting from federally funded research freely available to the public within one year of publication.[22] Similarly, the Danish Ministry of Higher Education recently launched the Danish Open Access Strategy, which has the lofty goal to make 100% of publically funded peer-reviewed articles openly accessible by 2022.[23] Universities have also established

institutional policies in this arena. The University of Sydney adopted the Open Access to University Research Policy last year to articulate their commitment to accessibility of scholarly works and data by providing and maintaining open publishing platforms and repositories.[24]

A number of leading initiatives have been established to support academic and research libraries in their missions to increase access to scholarly work. UNESCO recently launched "OA Curricula for Researchers and Library Schools" to enhance higher education institutions' capacity to understand global open access issues. These materials can be converted to self-paced e-learning tools, and they have been translated into several languages.[25] A major initiative by the University of California, Davis and the California Digital Library is poised to help define the future of open access to scholarship. "Pay It Forward: Investigating a Sustainable Model of Open Access Article Processing Charges for Large North American Research Institutions" is a year-long effort to study the implications of new funding models for scholarly works, with the aim of creating a flexible financial model that will ensure open access APCs will continue to be more affordable than the current journal subscription model.[26]

Academic and research libraries are adapting to this trend by developing new resources and funding opportunities for researchers. DART Europe is a partnership of research libraries and library consortia throughout the EU that provides researchers with a single portal for the discovery of theses and dissertations.[27] Cornell University Library emphasizes open access scholarly publishing through their website, which contains links to open access journals such as BioMed Central[28] and open access repositories such as arXiv.org.[29] Additional information includes how to vet open access journals, policies and perspectives, and copyright issues.[30] The Colorado State University (CSU) Libraries has allocated $45,000 to support the Open Access Research and Scholarship Fund which supports CSU authors in choosing appropriate open access venues for their work, reduces total cost of publishing in open access journals, and collects data to measure effectiveness and fiscal impacts of new models of support.[31]

For Further Reading

The following resources are recommended for those who wish to learn more about the increasing accessibility of research content:

Open Data Policy of ETH-Bibliothek's Image Archive
go.nmc.org/digim
(ETH-Bibliothek e-pics, accessed 19 July 2015.) Digital images in ETH-Bibliothek's Image Archive, including around two million photographs that date back as far as the mid-19th century, can be downloaded for free as they are categorized as public domain or are licensed under Creative Commons BY-SA 4.0. > *Policy*

Penn State Librarians Approve Open Access Policy for Scholarly Work
go.nmc.org/pennst
(Penn State News, 17 March 2015.) Penn State University Libraries faculty voted to pass an Open Access Policy into legislation at the Library Faculty Organization meeting that encourages authors to leverage open access opportunities whenever feasible. > *Policy*

Archnet
go.nmc.org/archn
(ArchNet, accessed 19 July 2015.) A partnership between the Aga Khan Trust for Culture and the Aga Khan Documentation Center at MIT Libraries launched Archnet to present Muslim visual and material culture to facilitate teaching and scholarship. > *Leadership*

B.C. Librarians Collaborate to Address Growth and Navigation of Open Education Resources
go.nmc.org/bcoer
(BCcampus, 2 July 2015.) The BCOER Librarians group developed objectives, guides, and tools including a well-tested rubric for librarians reviewing OER repositories and a collaborative working space to share best practices with OER. > *Leadership*

OpenAIRE2020
go.nmc.org/opai
(OpenAIRE, accessed 19 July 2015.) OpenAIRE2020 is improving the discoverability and reusability of research publications and data by creating a sustainable scholarly communication infrastructure. > *Leadership*

Göttingen University Press
go.nmc.org/gott
(SUB Göttingen, accessed 18 July 2015.) Göttingen University Press supports the use of online content for users free of costs and limitations and aims to facilitate high-quality publications that are not easily accepted by commercial publishing houses. > *Practice*

The Ohio State University Libraries Journal Publishing
go.nmc.org/jopub
(OSU.edu, accessed 18 June 2015.) The Ohio State University Libraries offers free journal publishing services including publishing workflow support and journal archiving and distribution to allow the OSU community to publish their work in its digital open access journals. > *Practice*

Rethinking Library Spaces

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

At a time when discovery can happen anywhere, students are relying less on libraries for accessing information, and more for finding a place to be productive. According to the 2015 Student Engagement Insights survey, 77% of college students said they visit the library to study on their own, while only 51% indicated they go to use the online databases.[32] 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. Library staff are increasingly studying patron behavior to inform decisions for strategic plans and budgetary considerations. A number of libraries are expanding to make room for active learning classrooms, media production studios, makerspaces, and other areas conducive to hands-on work. These changes reflect a trend that is being driven by 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.

Overview

The image of a library as an impervious vault wherein librarians serve as the gatekeepers, guiding patrons through myriad stacks, has become outdated. The Internet and mobile technologies have revolutionized the way that people find, consume, and interact with content. A preliminary indicator of this trend has manifested itself in the removal of books and serial journals from libraries to offsite storage units, which has proven to be controversial for some academic communities. Yet, these decisions about the fundamental use of space are giving way to more flexible arrangements that better suit community needs.[33] Many academic and research libraries already house media production centers and learning commons that provide access to technologies and workshops as part of their services.[34] While this trend is not new, the recognition of these changes as part of a larger pedagogical trend is helping library leadership see the bigger picture, which is informing their long-term strategies.

Over time, academic libraries have been redefining their relationship to their patrons based on their fulfillment of emerging roles as part of a larger scholarly institution. As detailed in the challenge "Rethinking the Roles and Skills of Librarians" later in this report, librarians are expected to become more involved in facilitating innovative instructional and research methods, and the integration of active learning spaces is one way of addressing this goal. Active learning spaces are student-centered workspaces where learners engage in discussion and problem solving while the educator acts as the facilitator of the activity. The University of Minnesota has pioneered one of the most well known active learning classroom (ALC) research initiatives, serving as a model for many other higher education institutions.[35] A number of universities have renovated their campus libraries to offer access to ALCs to every department and to encourage informal learning among students beyond scheduled class times.[36]

Changing expectations about visitor needs are also leading new visions of the future of libraries. A recent publication by the Association of College & Research Libraries, "The Living Library: An Intellectual Ecosystem," explores the concept of libraries as laboratories for cross-disciplinary investigation through anthropological and architectural perspectives. Authored in collaboration with college library leaders, the text expands on the participatory dimension of library design.[37] University libraries are also integrating makerspaces that invite creative tinkering and experimental learning. Often added as an extension to the digital media labs, the library makerspace is believed by many leaders in the field to support a new form of learning that is key to the future of higher education.[38]

Implications for Policy, Leadership, or Practice

Policymakers at every level can use emerging research about this trend to inform policies that anticipate the evolution of academic libraries. The Council on Library and Information Resources has published "Participatory Design in Academic Libraries," a compilation of studies on the planning, implementation, and evaluation of user-centered design schemes. This novel approach to design acknowledges that new ways of working and collaborative practice are not limited by geographic proximity or by what technologies the institution offers.[39] Many library professionals have seen the participatory design research methodology as a systematic way of providing qualitative data in support

of innovative policy decisions.[40] Furthermore, many institutions explicitly acknowledge the importance of patron needs to inform library design, such as Boston University Libraries' Strategic Plan for 2010-2015.[41]

A number of organizations are bringing together leaders in the field to share how they have redesigned their library spaces to fulfill patron expectations. The Association of Research Libraries Architecture Group was established to lead the conversation about planning libraries for the users of the future. At their 2014 seminar, presenters from all over Europe shared the latest architectural concepts that are guiding designs of academic and research libraries. For example, an architect from TIB Hannover and University of Regensburg in Germany conveyed emerging concept designs for staff workspaces based on a communication spectrum that ranges from open interactive spaces to private closed spaces where users can concentrate.[42] Similarly, the Re-think It: Libraries for a New Age conference features librarians from institutions such as the University of Illinois at Urbana-Champaign and San Jose State University that have had success with their progressive plans.[43]

Guided by leadership and the breadth of recent projects, academic and research libraries are actively updating their spaces to emulate these new visions. MacPhaidrin Stonehill College in Massachusetts recently transformed an outdated classroom into the Flynn Discovery and Collaboration Space, also known as the DisCo, an active learning environment equipped with movable furniture, computers and whiteboards, private spaces, and comfortable chairs. Use of the space is encouraged campus-wide through a regularly scheduled informal reading group open to all faculty.[44] The Kraemer Family Library at University of Colorado at Colorado Springs renovated their space to reclaim underutilized areas and eliminate shelving, creating much-needed flex space for students. The library dean underlined the need for promoting awareness about the recycling process for physical texts to avoid the backlash that these types of major changes may provoke.[45]

For Further Reading

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

Academic Library Building Design: Resources for Planning
go.nmc.org/forplan
(Association of College & Research Libraries, accessed 4 August 2015.) ACRL and the Library Leadership and Management Association created a guide to provide a basic framework for architects, planners, and librarians who are designing libraries for higher education. Included are resources for addressing safety and security issues, as well as policy-related standards. > *Policy*

JISC Infokits: Learning Spaces
go.nmc.org/learnspa
(JISC InfoNet, accessed 4 August 2015.) JISC's learning space infokit provides illustrated case studies and guides academic leaders through the design, implementation, and evaluation of new build projects. Governance and financial issues, sustainability, procurement, and risk management are all examined. > *Policy*

Blended Library
go.nmc.org/blenlib
(University of Konstanz, accessed 18 July 2015.) The Blended Library project at the University of Konstanz and University Library Tuebingen is facilitating exploration of the information space in a more natural manner by blending the digital databases, metadata, and other virtual library features with the physical space, texts, and objects. > *Leadership*

The Peggy V. Helmerick Collaborative Learning Center
go.nmc.org/helm
(The University of Oklahoma, accessed 19 July 2015.) As part of the University of Oklahoma University Libraries, The Peggy V. Helmerick Collaborative Learning Center features a 117-inch prysm wall and a digital scholarship lab featuring a 3D television and a state-of-the-art video conferencing room. > *Practice*

Spacefinder at Cambridge
go.nmc.org/spacefind
(Kirsten Lamb, *Futurelib*, 15 May 2015.) The University of Cambridge is prototyping a spacefinder app to connect library patrons to the right spaces for their study, research, and working needs. > *Practice*

UB Mannheim Learning Center
go.nmc.org/ubmann
(Mannheim University Library, accessed 20 July 2015.) Mannheim University Libraries in Germany transformed its traditional reading room to create a multifaceted, modifiable learning space. Students can browse a virtual textbook collection using three large wall-mounted touch screens to select and upload any e-books of interest to their own mobile devices. > *Practice*

Evolving Nature of the Scholarly Record

Mid-Term Impact Trend: Driving technology adoption in academic and research libraries over the next three to five 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.[46] 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 such as blogging. There are profound implications for academic and research libraries, especially those that are seeking alternative routes to standard publishing venues, which are often expensive for disseminating scientific knowledge.[47] As different types and methods of scholarly communication are becoming more prevalent on the web, librarians will be expected to stay up-to-date on the legitimacy of these innovative approaches and their impact in the greater research community.

Overview

The evolution of the scholarly record is being driven by two related developments: the move from the printed record to digital, and the shift from text-based materials to research datasets, computer models, laboratory notebooks, and more.[48] Traditionally, researchers published their outputs as articles in scholarly journals by registering a finding through the submission of a manuscript, certifying the validity of a claim through peer review, archiving the record through the printed output, and creating awareness through discovery systems. Increasingly, these functions are being accomplished through digital means. Certification can be performed online through platforms like PubPeer,[49] an open peer review where scientists comment on articles published using a digital object identifier, or papers can be archived and distributed through arXiv.[50] This new ecosystem is what researchers Van de Sompel and Treloar call a "Web of Objects" that include software and operating systems, as well as increasingly new forms of digital data.[51]

Beyond discussions about emerging formats, there is also more focus on how new kinds of publishing opportunities can improve the reputations of researchers. The shift from the importance of the journal to the individual is prompting university faculty to search for new ways to measure the impact of their research in order to gain and retain tenure positions. Academic libraries are in a unique position to help authors understand how to gather necessary analytics and present them in accessible ways.[52] The recent report "Emerging Reputation Mechanisms for Scholars" by the European Commission's Joint Research Centre provides an analysis of new tools and platforms that are driving scholarly reputations, such as GitHub[53] where users can publish and share codes produced during their research.[54] Experts believe that the librarian of the future should be well versed in this networked environment and more directly embedded in the information aspects of the research lifecycle.[55]

Some leaders in the field envision major changes in the scholarly record as new workflows develop. One idea put forward recently is the notion of the evolving manuscript, which can provide a more dynamic approach to capturing scholarly works. Researchers would start with a pre-publication, move to a pre-peer review version of an article, and then publish the approved article. This process would enable researchers to update a paper as studies unfold; subsequent versions could enhance the original findings while bolstering researchers' reputations. Evolving manuscripts would create more organic publications that enable researchers to theoretically write multiple versions of a paper that continuously progress over the time of their study, instead of having to start from scratch with every new manuscript.[56]

Implications for Policy, Leadership, or Practice

The Online Computer Library Center (OCLC) is sparking serious discussions among institutional leaders and librarians about the impact of this trend on the future of scholarship. Published in 2014, "The Evolving Scholarly Record" is an effort to address the changes inherent in digital scholarship as it evolves with technology. Their conceptual framework guides policy discussions about transforming scholarly records and defining the categories of materials it encompasses as well as the

roles of key stakeholders involved.[57] A 2015 follow-up OCLC report, "Stewardship of the Evolving Scholarly Record," offers recommendations on developing new stewardship models that take into account the increasingly digital, networked nature of the scholarly record. OCLC emphasizes conscious coordination as an important organizing principle for the transition away from autonomous local collections to networks of cooperative activity across many organizations.[58]

For academic and research libraries to understand the growing breadth of research activities and outputs, library leaders are developing new resources. SHARE is a higher education initiative led by the Association of Research Libraries in partnership with the Center for Open Science to make a comprehensive inventory of research more widely discoverable, accessible, and reusable. To do so, they are creating an open dataset across the life cycle of research activities, from proposal to execution to results.[59] Addressing the need for greater conscious coordination, SHARE's infrastructure activities increase the interoperability of repositories, metadata protocols, and analytic tools. The project's first effort is SHARE Notify, which aggregates research release events through a normalized feed from diverse sources and schema.[60]

University researchers are also leveraging social media to expand the reach of their work, establishing new partnerships and research methods. A study of social media use in higher education featured in the journal *Nature* found that a substantial percentage of scholars surveyed used sites such as ResearchGate,[61] Academia.edu,[62] and Twitter[63] to post content related to their work and to discover recommended papers. The study cites how ResearchGate enabled a scientist from Plateau State University in Nigeria find and establish an international collaboration with an Italian researcher from University of Messina when he needed expertise and equipment for a project. Additionally, the study explains how an ecologist at the University of Hawaii at Hilo uses Academia.edu to gather metrics on how often, where, and when a particular paper was downloaded.[64] Experts argue that librarians must recognize how social media is changing the nature of scholarly record elements and develop plans to properly capture and preserve these activities.[65]

For Further Reading

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

Emerging from the STM Meeting: 2015 Top Tech Trends
go.nmc.org/stm
(Jill O'Neill, *The Scholarly Kitchen*, 27 April 2015.) This article describes three technological trends impacting scholarly publishing activities over the next three to five years. The trends illuminate policy issues of funding, preservation, and fair use. > *Policy*

NISO Altmetrics Initiative
go.nmc.org/niso
(National Information Standards Organization (NISO), accessed 26 July 2015.) NISO is developing new assessment metrics for scholarly records, which include usage-based metrics, social media references, and network behavioral analysis. > *Policy*

Digital Sustainability Lab
go.nmc.org/digsust
(MIT Libraries, accessed 20 July 2015.) MIT's Digital Sustainability Lab is a space for investigations and experiments that address topics including optimal file formats. Experiments conducted focus on improvements to the acquisition, processing, preservation, accessibility, and audit of digital content in support of instruction, scholarship, research, and administration at MIT. > *Leadership*

Online Ancient Genome Repository
go.nmc.org/genom
(OAGR, accessed 20 July 2015.) The University of Adelaide Libraries are collaborating with the Australian Centre for Ancient DNA to produce the Online Ancient Genome Repository (OAGR), which captures a significant collection of DNA data from ancient human skeletons and microbes found in their dental plaque. > *Practice*

PolyU Institutional Repository
go.nmc.org/polyu
(The Hong Kong Polytechnic University, accessed 26 July 2015.) The PolyU Institutional Repository collects, preserves, and enhances the discovery of the research and scholarly output created by the PolyU community, including journal articles, conference papers, and presentations. > *Practice*

The Web Will Either Kill Science Journals or Save Them
go.nmc.org/willeither
(Julia Greenberg, *Wired*, 15 June 2015.) An interview with researcher Vincent Larivière sheds light on the Internet's effect on academic publishing and why researchers still rely on journals for symbolic rather than functional reasons. > *Practice*

Increasing Focus on Research Data Management

Mid-Term Impact Trend: Driving technology adoption in academic and research libraries over the next three to five 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.[66] The emergence of these formats has led to libraries rethinking their processes for managing data and linking them between various publications. As a result, connections between research publications are becoming more concrete; today's researchers can discern how findings from one study have impacted another, revealing a better picture of how an idea has evolved over time, while exploring it from different angles. Advancements in digital data management are ultimately leading to more accurate subject search results and citations, and enabling libraries to more effectively curate and display relevant resources for patrons.

Overview

JISC's DISC-UK "DataShare" report defines the act of data management as "that which is collected, observed, or created, for purposes of analyzing to produce original research results. Research data may be created in tabular, statistical, numeric, geospatial, image, multimedia or other formats."[67] As universities generate more data over time, libraries are well poised to be the managers and curators of this information. By digitally archiving the datasets from every publication they contain, tagging them with keywords, and making them searchable, library databases can uncover links and patterns between studies, revealing the full trajectory of an idea as it grows. Bibliometric tools such as Web of Science[68] aid this process by quantifying the number of times a publication has been cited so that libraries can see the entire body of work that builds upon it.[69]

While more tangible outputs such as journal articles and videos often comprise the ephemera of any scientific research project, the concept of metadata is essential to the storage process. The combination of the source, purpose, and methods behind the data collection, for example, become unique identifiers for each dataset when uploading them to any database or content repository. The metadata preserves the meaning of data, ensuring the research materials will be searchable, discoverable, and accessible long-term.[70] Academic and research libraries often look to existing metadata frameworks across various disciplines to define their protocol, such as the Federal Geographic Data Committee's Geospatial Metadata Standards for any geospatial studies[71] and Marine Metadata Interoperability for the field of marine science.[72]

Libraries are not the only entities focused on data management; individual researchers must have substantial knowledge of this area. As discussed in the previous mid-term impact trend, "Evolving Nature of the Scholarly Record," the formats of research and accompanying data are constantly expanding. Libraries now have a responsibility to educate researchers about how to select the proper medium to fit their findings — and to ensure that what is submitted can be stored and published in their databases. Cambridge University Library in the UK offers researchers guidelines for choosing different formats for their data, with an emphasis on long-term sustainability. They assert that the format used for data collection can be different than the one used to archive that data, and recommend that researchers wait until the project is completed to convert their materials to any new formats.[73] The University of Monash Library encourages their research community to also look to national agencies for digital file format best practice,[74] such as Standards Australia.[75]

Implications for Policy, Leadership, or Practice

When storing and publishing vast amounts of research materials, it is key to establish a consistent protocol to handle all types of data through metadata frameworks. This helps link together related resources and increases their discoverability. As such, academic and research libraries generally instate their own policies for research data management. The University of Oxford's Bodleian Library enforces a metadata policy based on commonly accepted standards and formats in the UK. However, they have built in flexibility by noting that any emerging initiatives in metadata creation are potential opportunities for enhancing search and discovery.[76]

Additionally, an increasing number of institutions have established open access systems. For example, Harvard University's open policy mandates that all metadata in their catalog must be accessible under broad use licenses; the library board's role is to resolve any policy disputes concerning interpretation and application of data.[77]

The Digital Curation Centre exemplifies leadership in this field as they are focused on building capacity, capability, and skills for research data management across the UK's higher education research community.[78] They routinely publish how-to guides and case studies, in addition to providing training opportunities for library and information science professionals. As the types of mediums for research and data expand over time, library leaders must strategize and build sustainable databases that can house enormous amounts of research materials in nearly any format. This year, the global Registry of Research Data Repositories officially merged with Databib to become an instrumental search tool for identifying and locating repositories for research data. The platform is open-access and touts long-term preservation of all research materials housed there and was created through a partnership between the Berlin School of Library and Information Science at Humboldt-University, the KIT Library at the Karlsruhe Institute of Technology, and several others.[79]

Many academic libraries have their own processes for storing and publishing research data with the goal of aiding researchers each step of the way. Stanford University Libraries' data management services were established to assist researchers with the organization, management, and curation of research data to ensure its long-term preservation and accessibility.[80] As part of this program, they provide a data management planning tool[81] as well as a repository for storing all research materials and metadata.[82] Similarly, University of Maryland Libraries design digital data management and archival plans with researchers and help them compose official methodologies for any grants they are writing.[83] Librarians there are known for their technical expertise in areas including the optimization of taxonomies, citing data, and addressing any intellectual property issues.

For Further Reading

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

Meeting the Requirements of the EPSRC Research Data Policy
go.nmc.org/req
(Sarah Jones et al., JISC, 27 March 2015.) This guide presents approaches to research data management based on compliance with the Engineering and Physical Sciences Research Council's research data policy. It can aid all universities in thinking about the research data lifecycle in a manner that goes beyond the requirements of a specific funder. > *Policy*

Digital Curation at ETH Zurich
go.nmc.org/zue
(ETH Bibliothek, accessed 18 July 2015.) Through the ETH Data Archive, ETH-Bibliothek provides an infrastructure for the medium and long-term storage of digital information such as research data, documents, or images. > *Leadership*

D:SWARM
go.nmc.org/dswa
The Saxon State and University Library Dresden are facilitating better data integration for libraries and other cultural heritage institutions with a web-based and open-sourced data management platform called D:SWARM. > *Leadership*

eRIC
go.nmc.org/eric
(eRIC Project, accessed 19 July 2015.) The eRIC (eResearch – Communication and Infrastructure) initiative is a collaboration between three university libraries with an aim to develop an integrated communication and data management infrastructure for accompanying the complete life cycle of scientific knowledge generation and transfer. > *Leadership*

Wicked Ways with Research Data Management
go.nmc.org/wicked
(The University of Sheffield, 23 July 2015.) The aim of the Wicked Ways project is to convene a network of leaders involved in tackling issues related to research data management, and to use an iterative, reflective, and participative process to construct a related open educational resource. > *Leadership*

RLUK Library in Focus: University of Warwick
go.nmc.org/warw
(Research Libraries UK, accessed 23 July 2015.) The University of Warwick is streamlining the management of their legacy printed stock on a collective basis by loading its holdings data on to WorldCat, a global network of data about library holdings and services.
> *Practice*

Increasing Value of the User Experience

Short-Term Impact 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 a company's services and products.[84] The term is commonly applied to assess computer-based exchanges with mobile devices, operating systems, and websites. Superior user experience has been largely attributed to the success of companies.[85] Easy navigation, digestible content, and practical features — among other components — are encompassed in effective website and database designs. The interface itself, however, is just one dimension of UX. Companies such as Amazon and Google are identifying patterns in users' online behaviors to better tailor search results at the individual level,[86] and 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. For libraries, which serve up countless e-publications, user experience is a relatively new area. In the post-Information Age, there has been so much focus on data management that only recently have library professionals shifted their attention to designing a high-quality experience with the aim of helping researchers and students navigate massive amounts of data, while also attracting new patrons.[87]

Overview

According to a study from eConsultancy, 88% of online customers are unlikely to return to a website after a negative initial experience.[88] A first impression is critical in the digital world, and nearly 100% of these gut reactions are design-related.[89] While UX is widely used to define virtual experiences, successful elements are based on 200 years of scientific knowledge about human behavior. InBound Marketing reports that key attributes to effective and engaging user interfaces include discoverability, desirability, accessibility, value, credibility, and usability.[90] Academic and research libraries do not have the same competitive advantage as technology giants that have long invested in top marketing firms and engineers to craft superior UX designs. However, libraries are rapidly adapting to this landscape, ensuring that their databases and websites are easier to navigate, and the research content housed there is more discoverable than ever before.[91]

Patrons are not the only ones who benefit from quality UX; library professionals also need systems and tools that are user-friendly. A recent article titled "The Systems Librarian" published in *Computers in Libraries Magazine* forecasts relentless consolidation as an imminent focus for libraries as major vendors such as Innovative expand their acquisitions. As a result, many Internet of Things-enabled and archival technologies have been streamlined with a more consistent user experience.[92] Several 2015 NMC Horizon Project Library Expert Panelists agree that streamlining the designs of the services and products they deploy from multiple technology vendors is a vital activity for transitioning this trend from short-term impact to long-term.[93] The tools that patrons interact with must be similarly streamlined. In Sweden, the Karolinska Institutet University Library website leads with all the content formats available, allowing users to quickly specify whether they prefer to search journals, apps, e-books, or encyclopedias. [94]

Libraries are also better organizing their databases to promote easy navigation. Last year, Cornell University Library launched a beta for a custom-built single search tool that supports their entire research community and quickly scans all of the library's resources through a highly accessible interface.[95] At universities, the user experience for students is often dictated by how well faculty develop and organize virtual content for their courses, and libraries are becoming instrumental in this process. Consultants at the Academic Technology Lab in Lathrop Library at Stanford University provide support for the design of instructional materials that leverage media and interactive presentations to engage learners.[96]

Implications for Policy, Leadership, or Practice

While there are no government policies mandating high-quality user experiences for websites and devices, libraries are developing helpful frameworks and guides. Yale University Library, for example, created web design guidelines to ensure standard typography, color, HTML mark-ups, and aliases are used across the university to maintain a consistent look and feel.[97] This strategy means that if a student understands how to navigate one web portal, interacting on another will be more intuitive. The *Weave Journal of Library User Experience*

is an open-access journal for library UX professionals and contains the latest research and guidelines on subjects including holistic and systemic web design and methods for seamless iBeacon integration.[98]

Being a leader in this field requires extensive knowledge of patron behaviors and needs. The North Carolina State University Library System regularly conducts UX studies to glean better data and insights that help them cater to their community.[99] Their Discovery Environment Usability Test, for example, enabled them to analyze the effectiveness of the university's search tools and tabbed interfaces at helping students find specific content.[100] In addition to testing with real people, they also developed fictional personas to mirror different categories of patron in advance of redesigning their website.[101] Many UX teams are increasingly housed in campus libraries. At the University of Michigan Library, the User Experience Department is part of the Library Information Technology Unit and their role is focused on interface design, user research, usability assessment, and accessibility.[102]

A major trend that has materialized in the UX space is responsive design. This approach translates to an optimized view and interactive experience of a website across a wide range of devices, including smartphones and tablets.[103] An increasing number of libraries are updating their websites to cater to the different ways in which their patrons will access their content. In Switzerland, ETH-Bibliothek's Heritage Collections website "ETHeritag" [104] now fits this emerging standard as it was recently converted to a more contemporary design that ensures a high-quality experience across mobile devices[105] — now matching the responsiveness of the library's flagship website.[106] Ithaca College Library's website includes social components and help features integrated throughout the website so that users can discern proper citations and receive support to pinpoint the exact articles they need for different disciplines and studies.[107]

For Further Reading

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

Evaluating Digital Services: a Visitors and Residents Approach
go.nmc.org/eval
(JISC InfoNet, 25 February 2014.) JISC offers an information kit on evaluating the digital services offered to library users. The kit seeks to help practitioners generate their own qualitative inquiries, to inform their own policy needs, and to frame the organization of library services and the policies that govern them. > *Policy*

Designing the Future of Libraries on the Web
go.nmc.org/d4d
(Designing for Digital, accessed 6 July 2015.) Designing for Digital is a two-day conference focused on user experience. The gathering provides hands-on workshops and informative sessions on user experience, discovery, design, and usability projects within and outside of libraries. > *Leadership*

EEXCESS
go.nmc.org/eex
(EEXCESS, accessed 20 July 2015.) EEXCESS aims to develop software tools to inject personal recommendations and innovative visualizations from library and cultural heritage databases into the user's habitual online environment, such as Wikipedia or WordPress. > *Leadership*

User Experience Stack Exchange
go.nmc.org/stack
(Stack Exchange, accessed 6 July 2015.) The Stack Exchange is building an online library of detailed answers to questions about user experience. Users ask questions about problems they are facing or answer questions on other users' problems, and the best answers get voted to the top. > *Leadership*

California Digital Library's User Experience Design Service
go.nmc.org/cdl
(University of California Digital Library, accessed 6 July 2015.) California Digital Library's (CDL) User Experience Design team helps to ensure CDL products and services are designed to meet users' needs. > *Practice*

The UX Moment: A Weave Digital Panel, Part One
go.nmc.org/momen
(Michigan Publishing, *Weave Journal of Library User Experience*, 2015.) In this panel discussion, librarians from nine institutions describe their user experience work, revealing the variety in both definitions of and the manner in which UX work is accomplished within various libraries. > *Practice*

Prioritization of Mobile Content and Delivery

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

The prevalence of mobile devices is changing the way human beings interact with information. By 2020, it is expected that 80% of the world's adult population will own a smartphone.[108] Mobile technology has transformed library patrons' expectations of when and where they should be able to access content and services, and the academic and research library community is starting to adjust their delivery to fit a variety of hand-held platforms. Libraries are spearheading the development of mobile-friendly websites, apps, catalogs, and e-books, as well as discovery tools that meet patrons where they are through SMS alerts and social media. Some libraries are furthering this trend by loaning devices such as tablets and e-readers to patrons, just as they would physical texts.[109] As mobile strategies continue to evolve, libraries are honing their focus on understanding user behavior in order to implement lasting solutions that will meet the needs of contemporary and future scholars.

Overview

The rise of mobile technology is changing the nature of discovery and research workflows, leading many libraries to adapt their strategies for the delivery of content and services. Responsive web design (RWD) is one way that libraries are accommodating their increasingly mobile patrons; optimized websites can fit multiple screen sizes, allowing users to perform tasks seamlessly across devices. As a result, students and faculty are becoming more accustomed to searching a library's catalog, reading abstracts and full digital content, and finding and saving references away from their desks and outside of the library's facilities through their mobile site or app.[110] Library researchers from Brigham Young University have found that there are benefits to choosing RWD for mobile delivery over other methods such as native mobile applications. A responsive website allows for all of the features to remain intact, no matter the device. This has streamlined the process for libraries as only one website needs to be maintained.[111]

Academic and research libraries are also adapting to new reading habits that favor small screens and formats.[112] While PDFs have been a common way to access digital content since the 1990s, they seem cumbersome when compared to the EPUB 3 format, or e-books, which are a viable option for reading on devices smaller than tablets.[113] Apps like BrowZine embody a mobile-centric approach to discovery, blending both worlds in a virtual newsstand that displays academic journals, PDF articles, and e-books, as well as social features for sharing, tracking favorites, and setting notifications when new articles are published. Experts in the field speculate that digital book formats will gradually dominate the academic space due to the advance of technology, the low cost of production, and simplicity of supply chain logistics, making this an important development to watch for libraries.[114]

The rapid growth of mobile technology is underlining the importance of recognizing patron behaviors and needs to inform design, and there are a number of research frameworks that have emerged to guide this transformation. The service design methodology was used by a team from Aalto University that was responsible for renovating a campus library into a future learning center; a crucial piece of this method leverages user profiles and focus groups to develop new services.[115] The library staff at the University of Illinois at Urbana-Champaign (UIUC) organized a two-day coding camp in order to decipher their expectations of library-focused mobile apps. Through this event, researchers gained a better understanding of how students conceive of library spaces, resources, and services, ultimately leading to products that reflect their real-life needs. Student-designed apps addressed the desires to build connections with their classmates, discover campus resources, and facilitate collaborative activities.[116]

Implications for Policy, Leadership, or Practice

Academic libraries are beginning to develop policies and strategies that are placing mobiles at the center of many transformative directives. The University of Alberta Libraries, one of the top 20 research libraries in North America, has underscored mobile development as a top priority for their 2012-2016 strategic plan.[117] The directive encourages further adoption of mobile technologies to connect users with the Libraries' discovery tools and collections. Simply developing policies to foster the uptake of emerging technologies

is not enough; these efforts must be bolstered by evaluation efforts. The University of Nevada, Las Vegas Libraries' latest strategic plan emphasizes the need to assess current mobile services and to continuously perform needs assessments, delineating the methods of measurement that will be used.[118]

Leadership communities are advancing this trend by facilitating the exchange of effective use cases and guidance. "Library Success: A Best Practices Wiki" invites library professionals from all over the world to contribute to the M-Libraries forum, which includes comprehensive lists of academic libraries that have mobile interfaces, apps, collections, tours, and SMS services among others.[119] The International M-Libraries Conference convenes experts in the field to share their knowledge and experience with mobile-centric innovations for academic and research libraries. The 2014 meeting featured a global community of librarians presenting on topics including app development, augmented reality, BYOD, and iPad lending programs.[120] Librarians can also benefit from the leadership discussions taking place within the International Librarians Network (ILN), the largest peer-mentoring program for library and information professionals in the world. Run by volunteers, the ILN is a free way to connect with a global community on innovative topics.[121]

Academic and research libraries are in the midst of directing in-depth studies to support the development of mobile platforms and services. Researchers from UIUC and Kyungsung University in South Korea conducted a comparative study to gain insights into the information seeking behaviors of college students to help librarians create new service models. Based on their data, the researchers learned that culture, language, and economy are all critical factors that differentiate how the two international populations use their mobile devices; yet, students from both schools still preferred to conduct research and consume information using their laptops over their smartphones.[122] A study based on the existing mobile services from Dhaka University Library (DUL) in Bangladesh found that students believe they benefit from SMS services that send text alerts for new resources, due date reminders, and overdue fees. This data confirmed the researchers' proposition that DUL should expand their adoption of mobile services to connect with visitors.[123]

For Further Reading

The following resources are recommended for those who wish to learn more about the prioritization of mobile content and delivery:

A Review of Bring Your Own Device on Security Issues
go.nmc.org/revie
(Morufu Olalere et al., *SAGE Open*, 10 April 2015.) The author reveals that security issues comprise the most significant challenges confronting BYOD policies, and that not enough work has been done in this area yet. > *Policy*

Developing Adaptable, Efficient Mobile Library Services: Librarians as Enablers
go.nmc.org/effic
(Lizzie Caperon, ARIADNE, 13 February 2015.) Research has led to the creation of a library mobile services toolkit by the University of Leeds to share best practices in developing mobile services that adapt to rapidly developing mobile technologies. > *Leadership*

Minrva Project
go.nmc.org/minr
(The University of Illinois Board of Trustees, accessed 27 July 2015.) The Minrva Project utilized several creative idea-generating projects to encourage innovation in app design by students from across the University of Illinois's campus toward an effective mobile library app. > *Leadership*

Bring Your Own Device (BYOD) at Emory Libraries
go.nmc.org/emo
(Emory Libraries & Information Technology, accessed 27 July 2015.) The Computing Center at Cox Hall and the Learning Commons at Woodruff Library provide integrated technologies, student technology support, and free technical support and assistance for all student-owned devices. > *Practice*

Report: New McGraw-Hill Education Research Finds More than 80% of Students Use Mobile Technology to Study
go.nmc.org/mcgr
(Brian Belardi, McGraw-Hill Education, 9 March 2015.) Feedback from a survey by McGraw-Hill suggests that students are tending toward shorter, more concentrated bursts of studying, rather than relying on long library sessions; 81% of students said they use mobile devices to study. > *Practice*

SLUB App for iPhone and Android Devices
go.nmc.org/slub
(SLUB Dresden, accessed 27 July 2015.) Through the SLUB catalog app, users have the ability to search through 70 million printed and digital books, magazines, and articles in different directories, and the inventory of the SLUB Dresden. > *Practice*

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 library.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.

Policy. While all of the featured challenges have important policy implications, two specific challenges are currently driving policy decisions in academic and research libraries. According to the expert panel, embedding libraries into higher education curriculum is a solvable challenge. Established policies are already guiding formal relationships between library staff and faculty. Based on standards set forth from the Council of Australian University Librarians, the University of Sydney's policy details the role that libraries must play in the design and delivery of the institution's programs that promote a greater understanding of information literacy among the student body.[124]

Also considered solvable due to the existence of clear policy precedents is the act of improving digital literacy for academic library staff and the university populations they serve. While this concept has previously been a concern for higher education institutions as new technologies emerge frequently, libraries and library-focused organizations have now become more involved in the administration of digital literacy activities and skills. The Association of College & Research Libraries created a framework that depicts a cluster of interconnected core concepts that organize ideas about information, research, and scholarship into a comprehensive structure. Library leaders can look to this framework to strengthen the policies that govern training around digital tools.[125]

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge.

Leadership. Leadership implications are common to all the challenges described in this section, but two will require visionary leadership. The first is considered by the expert panel as a crucial need to rethink the roles and skills of librarians — a transformation that is vital for the success of academic and research libraries. Fortunately, higher education institutions are beginning to recognize key knowledge that future librarians will need; at San Jose State University, the library and information science graduate program includes courses such as "Production of Knowledge and Content in Libraries," which imparts skills pertaining to the creative use of emerging technologies, including robotics and makerspaces.[126]

The second opportunity for extraordinary leadership was deemed a wicked challenge by the expert panel. Libraries are still trying to understand how they can most effectively embrace the radical changes needed to remain relevant, and are realizing that adopting more agile business models can help them through major service and operation transformations. Singapore Management University's paper, "Change Leadership in South East Asian Academic Libraries," highlights libraries across Asia that have adapted to more flexible models that put patrons at the forefront of their focus.[127]

Practice. Each of the six challenges identified by the expert panel presents numerous impediments for academic and research libraries. The rise of alternative avenues for information discovery, such as Google Scholar and Wikipedia, are providing competition to academic and research libraries. These platforms show no sign of declining, and successful libraries must familiarize themselves with them, rather than simply ignoring them. At the University of Houston, an annual event called Discovery Camp provides staff with training around the latest discovery systems so they can integrate them into their process and better guide patrons to the right resources.[128]

The second challenge is classified as a wicked one as it has been difficult to even articulate. Due to the speed at which new technologies emerge, library professionals often must adapt to a new tool before fully comprehending a previous one. Staying organized and up-to-date in this landscape requires ongoing training and professional development. This is especially a challenge in rural areas of India, where knowledge obsolescence is rampant among the information profession. At the local Caliber 2015 conference, librarians discussed the creation of a Library and Information Science MOOC to provide a standard syllabus for librarianship, promote the use of new technologies, and include a refresher course.[129]

The following pages provide a discussion of each of the challenges highlighted by the expert panel that includes an overview of the challenge, its implications, and curated recommendations for further reading on the topic.

Embedding Academic and Research Libraries in the Curriculum

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

While libraries have always supported academic institutions, there is a mounting case that librarians should play a more critical role in the development of information literacy skills. Historically, these types of programs have been implemented in "one-off" segments, which are experienced apart from a student's normal studies and often delivered in a one-size-fits-all method.[130] However, an increasing number of academic libraries are supporting a more integrated approach that delivers continuous skill development and assessment over time to both students and faculty.[131] This requires deeper involvement with departments and agreeing on common definitions of what capacities should be achieved, and the most effective pedagogical method. Librarians are tasked with broadening their role in the co-design of curriculum and improving their instruction techniques to work alongside faculty toward the common goal of training students to be savvy digital researchers.

Overview

The work of today's librarians is much different than that of their predecessors. While they are still information and research experts, they are increasingly expected to help faculty and students gain familiarity and skills with the latest research tools and practices,[132] a role that requires greater involvement in the core curriculum as an instructor. In the past, LIS programs have not included pedagogical theory and practice, which has been a challenge for universities that see the value of sustained information literacy training. Because digital media is offering new opportunities for interaction with subject matter, professors need more support developing assignments that take advantage of these new formats to engage learners. Consequently, there is a mismatch between what skills are required to develop an integrated instructional program and what knowledge and training librarians have when they finish their formal education.[133]

To compensate for this lack of training, librarians must rely on leadership communities to establish standards about this expansion into pedagogy. Yet, the usefulness of these guidelines are often debated. For example, this year ACRL updated their "Framework for Information Literacy for Higher Education," a cluster of six interconnected concepts that outline emerging expectations for librarians as they become more embedded into the instructional element of information literacy. For some libraries, this framework has been instrumental in developing a more integrated approach. At UMass Boston, teaching collaborations between librarians and faculty are guided by ACRL's framework as they design online and blended courses focused on these skills.[134] Some critics, however, believe that the new framework has replaced effective standards with jargon-heavy theoretical explanations that do not connect concretely with librarians.[135]

Fortunately, this issue is believed to be solvable because librarians and faculty already know that it will require extensive coordination between both groups to embed information literacy as a core component of the curriculum. The "teach the teacher" approach has surfaced as an effective solution because it helps librarians bring this training to the largest possible number of students through teaching faculty to integrate information literacy in their courses.[136] There remains, however, the challenge of ensuring that the nature of interaction between librarians and learners is profound enough to lead to real, measurable outcomes. In the article, "Embedded Collaboration: Hacking the System of One-Off Library Instruction," a faculty member from the Thompson Writing Program and a librarian from Duke University Libraries describe the problem of scaling successful models. While their collaboration proved effective for teaching digital research skills, there are not enough resources to ensure every department can implement this type of program.[137]

Implications for Policy, Leadership, or Practice

Formal institutional policies ensure that resources are allocated toward embedding literacy skills into the core curriculum. The University of Sydney has made a concrete statement about information literacy instruction, guided by standards from the Council of Australian University Librarians.[138] Their policy outlines the design and delivery of the programs, which are to be developed in association with staff as ongoing learning with explicit aims.[139] Similarly, the University of Alabama in Huntsville established an

information literacy policy based on ACRL's standards and offers curriculum design and assessment services for faculty that want to integrate these competencies into specific disciplines using hands on, collaborative assignments.[140] On a global level, UNESCO produced the report "Media and Information Literacy: Policy and Strategy Guidelines" to showcase existing national strategies and help legislators develop policies that lead to deeper development in this area.[141]

Organizations that establish best practices and offer continuous training are leading the effort to make libraries a sustainable source of instruction for the university. Librarians at the University of Arizona Libraries, for example, found that a key step in this transition required collaborating on a common instructional philosophy to help align themselves with their new roles. The document has since been shared with other departmental libraries and online via ACRL's blog.[142] The Chartered Institute of Library and Information Professionals (CILIP) organized a five-day residential course called "Pedagogy for Librarians," which offered participants from the UK a chance to work with a highly qualified teacher training team and earn a nationally recognized certification.[143] Meanwhile, library leaders from the University of Illinois at Urbana-Champaign are researching how LIS education can be improved to incorporate more study and practice of pedagogy.[144]

A number of institutions have implemented innovative approaches to embedding library instruction into the curriculum. At the University of Colorado Boulder, librarians work with teaching assistants (TAs) to coordinate small groups of students for information literacy training. Their data has shown that both TAs and students experience benefits from this method in honing their pedagogical and research skills.[145] Librarians from Marquette University's Raynor Memorial Libraries partnered with the English department faculty to implement a flipped classroom approach for first-year students. By focusing their efforts on creating a digital learning object as a cornerstone for instruction, librarians could maximize their time in the classroom to work alongside students.[146] At the University of Western Ontario, an e-learning collaboration between Western Libraries and the Faculty of Engineering resulted in the development of an online module which allowed students to improve their knowledge of information literacy through a blended learning format.[147]

For Further Reading

The following resources are recommended for those who wish to learn more about embedding academic and research libraries in the curriculum:

IFLA Media and Information Literacy Recommendations
go.nmc.org/medinf
(IFLA, accessed 29 July 2015.) IFLA urges governments and intergovernmental organizations, as well as private institutions and organizations, to pursue policies that advocate for media and information literacy. > *Policy*

Benefits of Librarian-Faculty Partnerships for Instruction
go.nmc.org/maryl
(University of Maryland Library, accessed 11 July 2014.) The University of Maryland encourages librarian-faculty partnerships to help integrate information literacy skills into university courses so students will not be daunted by the massive amount of resources available to them in the library. > *Leadership*

Data Literacy Instruction in Academic Libraries: Best Practices for Librarians
go.nmc.org/datlit
(Amanda Wanner, *Archival and Information Studies Student Journal*, 2015.) The author explores how libraries can play a role in taking advantage of open data policies to develop a data-driven mindset in faculty, students, and researchers. > *Leadership*

3D Print Technology Project Embedded Within the Curriculum
go.nmc.org/embe
(University of Wollongong, accessed 26 July 2015.) University of Wollongong Library facilitated student-focused workshops for developing and designing 3D models in the library's dedicated 3D printing lab.
> *Practice*

Degrees of Impact: Analyzing the Effects of Progressive Librarian Course Collaborations on Student Performance
go.nmc.org/degimpact
(Char Booth et al., *College & Research Libraries*, July 2015.) The Claremont Colleges Library conducted direct rubric assessment of Pitzer College first-year seminar research papers to analyze the impact of diverse levels of librarian course collaborations on information literacy performance in student writing. > *Practice*

Rethinking an Established Information Literacy Program: How Leveraging Assessment Data Can Improve Teaching and Promote Change
go.nmc.org/lever
(Katie Bishop and Eleanor Johnson, *Digital Commons*, March 2015.) Librarians at University of Nebraska Omaha developed assessment goals in tandem with changes in instruction pedagogy in a process that has fostered stronger communication and collaboration with faculty. > *Practice*

Improving Digital Literacy

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

With the proliferation of the Internet, mobile devices, and other technologies that are now pervasive in learning, the traditional view of literacy as the ability to read and write has expanded to encompass understanding digital tools and networked information. Lack of consensus on what comprises digital literacy is impeding many libraries from formulating adequate policies and programs that address the development of this competence for professional staff. Discussions among leaders have included the idea of digital literacy as being fluent with a wide range of digital tools for varied educational purposes, or as an indicator of having the ability to critically evaluate resources available on the web.[148] However, both definitions are broad and daunting for libraries to address. Supporting digital literacy will require programs that both address digital fluency training in librarians, along with the faculty and students they support on campus.

Overview

While this challenge is widespread in academic and research libraries, the 2015 NMC Horizon Project Library Expert Panel recognized it as solvable because a number of organizations are beginning to coalesce around shared definitions of digital literacy. The ALA Digital Literacy Task Force defines it as the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both technical and cognitive skills.[149] Similarly, Leeds Beckett University in the UK views digital literacy as a varied set of capabilities underpinned by digital technologies and computer literacy, which leads to the confident and critical use of information and digital technologies to enhance academic, personal, and professional development.[150] These related definitions are notable because they stress practices instead of tools.

ALA has also highlighted the evolving concept of digital literacy in light of developments in big data — vast virtual datasets that are difficult to process and analyze. Their 2015 "State of American Libraries Report" explains that big data poses new problems for academic librarians because their quantity and rate of accumulation require the development of new kinds of digital literacy skills.[151] Likewise, a researcher at the University of British Columbia recently published a paper "Data Literacy Instruction in Academic Libraries: Best Practices for Librarians," which discusses the challenges and opportunities of bringing data literacy into academic and research libraries. She concludes that data literacy instruction requires cross-institution collaboration, staff training or the appointment of a data librarian, and a comprehensive plan of action to provide continuous instruction throughout the student lifecycle.

The future of digital literacy in the library community is progressing beyond how to understand new technologies to how to think about technology in new and creative ways. Coding, for example, is increasingly perceived as an emerging literacy that will give professional staff and patrons the tools needed to define and create the technologies of the future. While not every student is going to pursue a career in computer science, at minimum, understanding how algorithms apply structured linear thinking to a variety of problems will be a key skill, even in non-technical fields.[152] Academic libraries have acknowledged that coding is expanding across various research disciplines and are offering intensive coding boot camps for students. Stanford University Libraries, for example, offered four weekend trainings for graduate students. Library staff taught them how to automate repetitive tasks, program in testable ways, and track and share their work.[153]

Implications for Policy, Leadership, or Practice

Governments and other organizations have developed helpful frameworks and guidelines to help students and staff learn skills for working in a digital society. The Obama Administration created the Digitalliteracy.gov portal for practitioners who deliver digital literacy trainings to improve the quality of these offerings. Additionally, the JISC "Developing Digital Literacies Programme" in Europe explored various institutional approaches to digital literacy development in higher education institutions.[154] JISC called for approaches that focus on the curriculum; use frameworks as tools for engagement; provide timely information, guidance, and support; develop partnerships, networks, and communities of practice; and embed digital literacies into professional development programs.[155] Library organizations have also been instrumental in creating

literacy standards. The Association of College & Research Libraries recently updated their "Framework for Information Literacy for Higher Education," which provides a cluster of interconnected core concepts that organize ideas about information, research, and scholarship into a comprehensive structure.[156]

In order for librarians and faculty to better integrate digital literacy into curricula, they must receive ongoing training that is suited for their busy schedules. Syracuse University's Project ENABLE, for example, provides free, foundational online training for library professionals, allowing them to find their library type and location to receive tailored content, which can be used for individual or group use.[157] The #hyperlibMOOC at San Jose State University provided a community-centered, large-scale professional development opportunity for library and information science professionals.[158] Based on feedback, professionals believed that the course helped them learn new ideas and skills while developing a network of like-minded practitioners.[159] Through the University of Rhode Island, librarians have the opportunity to pursue a graduate certificate in digital literacy, which focuses on building skills and competencies to participate in a contemporary read/write culture.[160]

Solving this challenge also requires better digital literacy support for students. The Deakin University Library in Australia plays an active role in delivering digital literacy initiatives, one of the university's eight graduate learning outcomes. The library collaborates with and advises academics and educational designers on how to engage students in more meaningful digital literacy activities and assessment tasks.[161] Additionally, the University of Wollongong delivers training directly to students through self-paced online workshops, face-to-face workshops, and online resources.[162] University of Salford Manchester librarians created the Skills for Learning Blog, which focuses on helping students build their digital literacy.[163] The most recent posts under the topic of digital literacy include "Learn to Use Sharepoint," "Three Easy Ways to Stay in Touch with University Life," and "Bring Your Own Device for Learning."[164]

For Further Reading

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

Guidelines for Professional Library/Information Educational Programs
go.nmc.org/infpro
(IFLA, accessed 1 August 2015.) IFLA has developed guidelines to provide library and information studies/science schools around the world with a set of preferred practices to use when establishing and running their educational programs. > *Policy*

Mapping Digital Literacy Policy and Practice in the Canadian Education Landscape
go.nmc.org/mapping
(Michael Hoechsmnan and Helen DeWaard, *MediaSmarts*, 30 March 2015.) There is considerable variance in digital literacy policies and implementation programs between provinces and territories in Canada. The goal of this report is to show Canadian educators and policymakers a comprehensive snapshot of digital literacy and to provoke informed debate on a variety of implementation models and pedagogical practices. > *Policy*

Bucks County Community College Digital Media Literacy Institute
go.nmc.org/bucksdig
(Bucks County Community College, accessed 19 July 2015.) Faculty participate in this four-day immersive learning experience led by the Instructional Technologies Liaison and Information Literacy Librarian to build their knowledge of digital literacy theory, along with their confidence in using digital tools. > *Leadership*

Digital Playspace at Massey University
go.nmc.org/digplayspa
(Massey University, accessed 31 July 2015.) The Library at Massey University is collaborating with the Teaching and Learning unit to build a Digital Playspace for academic and professional staff that will provide informal learning opportunities as well as facilitated training to improve digital literacy. > *Leadership*

Lyons New Media Centre Internship Program
go.nmc.org/lyons
(The Lyons New Media Centre, accessed 20 July 2015.) The Lyons New Media Centre at Mills Library is a media space that offers a structured yearlong internship program to train students and staff in image manipulation, illustration, video production, and web development. The program then places participants in on-campus and community environments to directly apply their new skills. > *Practice*

Manage the Device Deluge | Professional Development
go.nmc.org/devdel
(Jennifer Koerber, *Library Journal*, 1 June 2015.) Ongoing professional development should be based on both staff and patron needs. Surveys, self-evaluations, and annual reviews can help determine what skills staff members already have, while brief surveys, occasional "gadget counting" in library buildings, and informal qualitative data gathering will help determine the primary needs of patrons. > *Practice*

Competition from Alternative Avenues of Discovery

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

Before the rise of the Internet, libraries were widely perceived as the ultimate gateways to knowledge. They served as central locations to discover new information, compile research, and consult with librarians to find the most helpful resources. In the past two decades, as the Internet has expanded, so has the array of academic content made easily accessible to people. This shift has not only impacted how people research, but also where they do it. Performing a simple web search on a topic, for example, conjures countless pages of relevant articles, reports, and media, and today's users have grown accustomed to the ease of single-search tools, many of which are adapting to mobile responsive platforms.[165] Furthermore, advancements in the semantic web are refining research results and enabling data to be shared across applications.[166] Emerging Internet technologies are fostering changes in patron behavior, challenging libraries to either adapt to the new expectations defined by current discovery practices or risk becoming obsolete over time.

Overview

According to a faculty survey conducted by Ithaka S+R, the perception that libraries are portals for information is declining.[167] The Internet has made academic knowledge ubiquitous, enabling people to seamlessly pursue their curiosities, expand their research, and disseminate their work like never before. As a result, single-search inquiries have revolutionized discovery systems, or "next-generation catalogs," and archival institutions are struggling to rival online platforms that are providing easy ways to search for free academic and scholarly content. At a time when 83% of college students regularly use their smartphones, discovery is happening anywhere and anytime that is convenient for the user.[168] Academic and research libraries are in the difficult position of having to compete with highly relevant online environments such as Wikipedia, Google Scholar, and Academia.edu, which users can access freely, regardless of institutional affiliation.

Meeting patrons where they are through their mobile devices is one way libraries can address this challenge, yet there are an abundance of underlying issues that impede the effort to employ and improve discovery services. A recent white paper authored by the E-Data Quality Working Group of the OCLC pinpointed poor-quality data as one major obstacle to discovery and access for academic and research libraries. Through their in-depth analyses of e-resource workflows at McGill University, the University of Toronto, and the University of Maryland, researchers found that discrepancies in bibliographic metadata and data holdings lead to breakdowns in communication paths between the content supply chain and stakeholders. As a result, librarians find it more difficult to present timely and relevant resources to students and faculty.[169]

Complicating library-led discovery are the competitive relationships between vendors and content providers, which have led many librarians to question whether search results presented to users are neutral.[170] In a seminal study on how undergraduates use contemporary discovery tools, researchers from Bucknell University and Illinois Wesleyan University determined that students need more training in research methods in order to go beyond default search settings and evaluate their search results, a feeling shared by a growing number of library professionals.[171] According to the most recent Ithaka S+R US Library Survey, the majority of library deans and directors responded that the main function of the library is to help undergraduates develop research, critical analysis, and information literacy skills. Furthermore, the number of respondents who agreed that it is important that the library be seen as the first place that users go to discover content has declined.[172]

Implications for Policy, Leadership, or Practice

In order for libraries to continue serving as portals of discovery, leading organizations are developing policies to help improve the implementation of emerging online systems. In 2014, NISO's Open Discovery Initiative published a set of best practices and recommendations that encourage transparency in discovery.[173] Focused on improving communications and clarity between libraries and major vendors, the guidelines intend to establish concrete protocol and expectations regarding data transfer and metrics for building a central data index.[174] In a more comprehensive publication, "The Future of Library Resource Discovery," NISO has

highlighted the need for longer-term strategies that anticipate disruption and drive systemic change; for example, the shift toward open access could drastically transform the landscape of scholarly content and access, and the emergence of semantic data technologies could redefine the nature of discovery and exploration.[175]

In the past year, there have been key movements and collaborations that are changing the essence of discoverability in the scholarly community. LIBER, Europe's largest network of research libraries, authored and launched the "Hague Declaration on Knowledge Discovery in the Digital Age," a petition that promotes agreement about how to best enable access to facts, data, and ideas for 21st century dilemmas including climate change, natural resource management, and globalization.[176] The goal is to change global perceptions of copyright law so that people view strictly copyrighted materials as barriers to the open exchange of knowledge needed for a healthy society.[177] Europe is also home to the European Library, a portal to the collections and data of Europe's national and research libraries.[178] With the mission of being the open data hub for library data in Europe, the European Library has over 24 million pages of full-text content, 18 million digital objects, and 119 million bibliographic records within Europe.[179]

To be savvy facilitators of the discovery process, library professionals must embrace emerging research and the promise of new technologies. A number of librarians have paved the way for discussion through "Exchanges," a collaborative blog hosted by Wiley where leaders in the field share their findings of studies that assess the effect of discovery systems on usage of scholarly information.[180] Every year the University of Houston coordinates Discovery Camp, an annual event that helps librarians explore the functionality of emerging discovery systems so they can empower users to find the right resources.[181] There is also emphasis at the departmental level on training students to use discovery tools strategically. At the University of North Alabama, undergraduate biology students must complete Biological Literature, a required course that features several one-hour library sessions, discussions, and homework assignments that foster database search skills and critical thinking in tandem with scientific writing.[182]

For Further Reading

The following resources are recommended for those who wish to learn more about competition from alternative avenues of discovery:

EBSCO Policy for Metadata Sharing & Collaboration with Discovery Service Vendors
go.nmc.org/ebpol
(EBSCO Industries, Inc, 2015.) The details in this document describe the first phase in EBSCO's metadata sharing policy, which is to provide metadata from databases representing more than 80% of the EBSCO database usage worldwide, as well as substantially improved linking for the full text articles. > *Policy*

Discovery Services and the User Experience
go.nmc.org/discexp
(*Library Journal*, 23 April 2015.) Ex Libris, *Library Journal*, and ER&L teamed up for an online webcast that covered topics related to how libraries can assess the user experience after implementing new discovery services. > *Leadership*

5 Things Google Scholar Does Better than Your Library Discovery Service
go.nmc.org/googschol
(Aaron Tay, *Musings about Librarianship*, 16 July 2015.) The author argues that Google Scholar is more efficient at facilitating information and resource discovery than libraries and provides more relevant results. > *Practice*

Discovery Tools, a Bibliography
go.nmc.org/disctools
(Discovery Tools Bibliography, accessed 1 August 2015.) This bibliography pulls from the hundreds of publications and communications related to information discovery tools and provides an overview of librarians' experiences and sentiments on the subject. > *Practice*

Measuring Our Relevancy: Comparing Results in a Web-Scale Discovery Tool, Google & Google Scholar
go.nmc.org/relev
(Elizabeth Namei and Christal A. Young, ACRL, 2015.) The University of Southern California (USC) Libraries' conducted a quantitative study to gather evidence to determine how well USC's discovery system performed in returning relevant results for known items. > *Practice*

Use and Usability of a Discovery Tool in an Academic Library
go.nmc.org/useusa
(Scott Hanrath & Miloche Kottman, *Journal of Web Librarianship*, 23 February 2015.) The investments made by libraries in discovery systems call for a sustained program of assessment using multiple modes of evaluation, including user testing and usage analysis, applied in concert to improve the user experience. > *Practice*

Rethinking the Roles and Skills of Librarians

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

The influx of data and digital resources involved in learning and research is challenging the capabilities of libraries. It is no longer enough for librarians to manage the flow and organization of print materials; ALA reports that academic libraries are hiring professionals with experience in emerging 21st century skills such as data mining and web development.[183] Campus libraries are also uniquely situated to provide technological and instructional support for faculty and students as technology advances. Many libraries are in the midst of rearranging their organizations, resulting in the creation of new departments, positions, and responsibilities for library professionals. Indeed, more than half the advertised positions in recent years have been for newly created or significantly redefined roles.[184] There is a clear hiring trend that emphasizes finding more functional specialists that have a strong digital or technology background. The challenge is in building capacity for these new specialized roles and providing sufficient training along the way.

Overview

Some have predicted a declining demand for librarians as the Google search culture has proliferated; questions such as where to locate a specific book can be answered in seconds by simply checking online. However, librarians still play a key role in educating students, faculty, and researchers about all of the information that is at their disposal.[185] With an abundance of new databases and formats for scholarly records, the continuous curation and organization of digital educational materials is vital. The head of research and reference services at Duke University Libraries asserts that contemporary librarians should be able to understand the needs of the research community as well as to select and make easily accessible the resources that support their work. Anyone fulfilling this role must seamlessly traverse the physical, conceptual, and digital realms.[186]

According to the Information School at San Jose State University's (SJSU) report, "Emerging Career Trends for Information Professionals," more than half of all library job listings in Summer 2014 required significant technical skills or were completely technology-focused — a 32% increase from the postings in 2013.[187] The report also notes that 70% of 2014 library position listings explicitly required a Masters in Library Science or Library Information Science.[188] Unfortunately, Forbes reported that this Masters is the worst degree for return on investment, with the median pay of a library professional being less than $60,000 USD.[189] While that statistic does not paint the full picture of the opportunities in the field, it can be perceived as a drawback for students planning their careers. South African researchers are conducting a study to pinpoint the non-traditional skills that contemporary librarians in the region will require. The preliminary findings reveal that they must foster service environments that embrace social media, open access, and emerging ICT.[190]

In addition to being digitally savvy, academic library staff also have a responsibility to support alternative models of higher education, such as online and blended learning, which are materializing on campuses everywhere. Developed by ACRL, the 2015 anthology *New Roles for the Road Ahead* contains essays about how libraries and librarians can prepare for the future. The essay, "Evolution in Higher Education Matters to Libraries," recommends a new role referred to as a creative learning specialist; this position entails skills in instructional design and technology, along with the ability to work with faculty to identify cutting-edge pedagogies and assessments that effectively integrate research skills into the formal learning process.[191] The authors caution that libraries that do not adapt to new higher education models, making these organizational shifts and hiring capable staff, are at risk of becoming obsolete.

Implications for Policy, Leadership, or Practice

While some individual academic libraries are documenting information about evolving expectations for staff, it often takes large-scale organizations to establish major policy precedents. The Council of Australian University Librarians' (CAUL) mission is to influence information policies and practices in higher education across the continent.[192] They have generated strategic directions that outline anticipated roles of librarians in the development of quality, sustainability, and innovation in information management at institutional and national levels; CAUL provides members with opportunities and resources for adapting to the 21st century landscape, including techniques

for contributing to virtual learning environments, and professional development opportunities around research data management.[193] The strategies CAUL has created are informing policy discussions, and they maintain a repository of their responses to relevant government policies and activities.[194]

When hiring for new positions, libraries are generally looking for people with long-term ambitions to grow with the role. However, it is difficult to anticipate future needs from students, faculty, and universities as a whole. The Association of Research Libraries has long been a leader in the field, launching the 2030 Scenarios program to engage their vast membership in envisioning and anticipating library futures.[195] Potential developments are crowdsourced by library experts and can be used to inform the design of new staff infrastructure and positions. In an uncertain future, there is at least one absolute — technology will continue to evolve, and libraries must stay up to date to remain relevant. Library and information science graduate programs are taking note as courses such as "Production of Knowledge and Content in Libraries" at SJSU promote skills in the creation of makerspaces and understanding robotics among aspiring library professionals.[196] At Kent State University, user experience design is one of the four disciplines that can be studied by students enrolled in the library and information science graduate school.[197]

As universities deliver more virtual learning experiences, library staff members are addressing technology knowledge gaps among faculty. The Georgetown University Library has hired full-time videographers to work on Technology-Enhanced Learning, an initiative that allows them to leverage their knowledge of media and learning outcomes to help faculty create engaging videos for online environments.[198] While libraries are welcoming non-traditional skills, there is still a pressing responsibility to provide professional development opportunities to expand the knowledge of new and current staff. At the University of Saskatchewan Library in Canada, a community of practice was created around staff leadership development in which participants routinely convene to share best practices and challenges. Members consist of staff at every level, including managers, supervisors, and front-line staff.[199] On a larger scale, the National Library of Medicine invokes the Pathways hiring process, which includes robust training for staff in the form of face-to-face workshops and lynda.com tutorials.[200]

For Further Reading

The following resources are recommended for those who wish to learn more about rethinking the roles and skills of librarians:

Core Values of Librarianship
go.nmc.org/coreval
(American Library Association, accessed 21 July 2015.) Core values inform ALA policy initiatives in critical areas including access, confidentiality and privacy, democracy, diversity, service, and social responsibility. > *Policy*

Liaison Librarians Embrace New Roles in Publishing Collections Showcased in Digital Commons @ Brockport
go.nmc.org/brock
(Digital Commons, 31 March 2015.) In this article, the Digital Repository Specialist at the College at Brockport offers guiding principles and examples of how collaborative staffing has worked for the college library. > *Leadership*

Syracuse University's Competency Library
go.nmc.org/syra
(Syracuse University, 28 July 2015.) This guide aims to help all library staff members define important workplace behaviors that are essential to achieve their strategic goals. > *Leadership*

Changing Role of Academic Librarians in Open Access Environment
go.nmc.org/changing
(Intekhab Alam, *Journal of Library & Information Science*, December 2014.) This paper describes how librarians are tasked with new roles due to the evolution of open access and digital technologies. Their daily activities now often include supporting the management of authors' rights, administering and promoting the use of institutional repositories, and using bibliometric tools and other journal quality indicators. > *Practice*

Is it Time to Re-envision the Role of Academic Librarians in Faculty Research?
go.nmc.org/ree
(Barbara Brydges and Kim Clarke, *Library Connect*, 15 July 2015.) The findings of this study suggest that many faculty members are not receiving the research support they want or need. The authors consider how librarians could actively offer to collaborate in research, which would result in co-authorship opportunities. > *Practice*

Organizing the Liaison Role: A Concept Map
go.nmc.org/organ
(Judith E. Pasek, Association of College & Research Libraries, 2015.) The author argues that four elements of proactive library customer service — visibility, relevance, usefulness, and timeliness — are interrelated and of equal importance in the implementation of liaison services. > *Practice*

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. Compounding this challenge is the need to adapt to the rapidly evolving landscape of technology and to understand its impact on patron behaviors.[201] Once patron needs have been identified, libraries are tasked with revising or building new infrastructure to support more effective research practices, yet the change in focus on integrating innovations seems to be at odds with traditional modes of thought that govern academic and research libraries. Library leadership will require radically different thinking to provide adequate and sustainable support for new initiatives and business models. In order to be effective, this type of thinking will need to extend across the entire organization from the top down — from deans and directors to librarians, support staff, and new hires.

Overview

In an age when technology is shaping patron expectations, the concept of libraries as custodians of print books and journals is no longer relevant. Their digital transformation has been in the public spotlight, often riddled with controversial reactions. In 2014, the dismissal of several library directors at liberal arts institutions made the news as their opinions of how change should be managed to best cater to patrons clashed with university administration agendas.[202] Interviews with the discharged directors illuminated the lively debate over which campus entity is the best equipped to manage the abundance of information that the web and new technologies have made more accessible. Some feel that libraries could be merged with IT departments because the storage and dissemination of electronic assets calls for highly technical expertise.

In order to effectively prepare for changes, this challenge is requiring leaders to better define what the future library looks like. The *Libraries and the Academy* journal article, "Imagine! On the Future of Teaching and Learning and the Academic Research Library," forecasts that these centers for higher learning will become increasingly active, experiential environments where social, participatory, and collaborative interactions are at the forefront.[203] This vision is supported by progress in emerging technological developments such as makerspaces and location intelligence — discussed later in this report. As a result, library leadership and missions must prioritize the continuous creation of innovative offerings. UCLA Library's Teaching and Learning Services developed seven strategies that anticipate future scenarios, including positioning students at the center of all work and cultivating imagination to support modern pedagogies like inquiry-based learning.[204]

While embracing significant changes in academic libraries calls for a concerted effort between library leadership and university administration,[205] attitude also plays a major role. The ALA paper, "Individual Adaptation: Interdisciplinary Perspectives on Personal Identity and Learning During Organizational Change," reveals that reflective practice should be standard in any industry, and library leadership can especially benefit from it. The idea is that people who reflect on their actions and connect them with their own philosophies develop the self-awareness needed to cope with complex scenarios.[206] This could take the form of activities such as blogging and engaging in virtual communities of practice. On the other hand, the director of the law library at Georgetown University asserts that personnel who are unwilling to adapt to changes may harbor negative attitudes with good reason. For example, staff are frequently given insufficient time to implement a new technology, or feel singled out because they are not educated about how changes impact their colleagues.[207]

Implications for Policy, Leadership, or Practice

There is a general lack of formal policies that govern library protocol for change management. However, individual libraries are setting important policy precedents as they formalize their goals and objectives in ways that support the successful transformation of services and infrastructure. Cal Poly Pomona's "Strategic Plan: 2014-2019" emphasizes the need for library models that strengthen connections between campus constituencies, departments, and divisions to also align with the university's overarching mission in addition to fostering technology-rich physical and virtual spaces.[208] In Australia, the University of Tasmania is developing

"Library Vision 2025" to prepare for the next decade of evolving research, student, and community needs. Among the top considerations are conducting evidence-based evaluation of the quality and performance of all library services.[209]

Advancing positive changes in libraries requires clear visions for effective infrastructures that reflect larger societal and workplace trends. Singapore Management University (SMU) published "Change Leadership in South East Asian Academic Libraries," which explored how libraries in Asia are moving to more agile business models.[210] The paper juxtaposes the 20th and 21st century work environments, demonstrating the shift from organization-centric library infrastructure to a more people-oriented focus. Libraries are no longer just competing for market share, but are also generating brand new markets and services for their patrons, which requires flexibility and creativity. SMU Libraries developed five core strategies for being nimble, including an institutional directive to dissent and experiment. Of course, putting these kinds of principles into action entails substantial training. The Association of College & Research Libraries developed an online course called "Managing Change in Academic Libraries" to help library supervisors navigate their staffs through change by examining the most common reactions and how to address them.[211]

While planning for and implementing service overhauls and renovations, libraries are facilitating opportunities to incorporate student voices in these changes. In Canada, the University of Guelph McLaughlin Library recently had to accommodate the housing of a 1.2 million volume collection when it was originally designed to support a 300,000 volume collection — all while ensuring there was sufficient space for student work and research. Based on their community's perspectives, gleaned through surveys, focus groups, and open forums, McLaughlin Library devised a plan to create 40% more study space, including active learning instruction areas and a research collaboratory.[212] When developing their new library, Wilfrid Laurier University leadership recognized the need to incorporate technology-enhanced spaces that support multimedia production needs of students and faculty. They ultimately designed an infrastructure that supports fast-paced connectivity and learning any time of day.[213]

For Further Reading

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

Academic Libraries Look Toward the Future
go.nmc.org/looktow
(Lisa Peet, *Library Journal*, 1 July 2015.) Library leaders convened at the ALA 2015 annual conference to discuss the state of academic libraries in a time of flux. This article highlights implications for policy around the influential roles of cross-discipline collaboration, instructional scaffolding, and support of and access to open resources. > *Policy*

Cultivating Global Library Leadership
go.nmc.org/cultiv
(Arabella Advisors, January 2015.) This report documents library leadership programs around the world, highlights important trends, and provides recommendations for improving the state of leadership capacity building for librarians internationally. > *Leadership*

Transforming Library Services at One of Nigeria's Leading Academic Institutions: It's Not Business as Usual
go.nmc.org/services
(*Library Connect*, 23 July 2015.) This interview sheds light on the process that Ahmadu Bello University Library carried out to institute an ambitious plan for transforming library services to reposition the library for the 21st century global educational dynamic. > *Leadership*

Why the Academic Library Should Lead Higher Ed Change
go.nmc.org/whythe
(Joshua Kim, *Inside Higher Ed*, 12 March 2014.) This article argues that libraries can leverage their experience with change management, strong cross-campus relationships, and their centralized physical presence at the heart of the institution to lead the way through higher education transformation. > *Leadership*

The Factors Influencing American Academic Library Directors' Approaches to Setting Goals for Change in the Information Age
go.nmc.org/factors
(Zhixian Yi, *White Clouds*, 2014.) This study examines significant factors influencing the approaches academic library directors use to set goals for change in the information age. > *Practice*

War and Peace: New Library Coordinator Checks In
go.nmc.org/warpeace
(Ed Brennen, UMass Lowell, 28 July 2015.) UMass Lowell Libraries seeks to balance access to top-notch collections, while reconfiguring existing space to promote active learning, study, and research. One key to their success will be the launch of the Eastern Academic Scholars' Trust, which is designed to ensure that even infrequently used print materials are retained and readily available for faculty and students. > *Practice*

Managing Knowledge Obsolescence

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

Simply staying organized and current presents a challenge to academic and research libraries in a world where information, software tools, and devices advance at a strenuous rate.[214] New developments in technology are presenting exciting opportunities for libraries, and their potential for improving the quality of operations and services is undeniable. However, it can be overwhelming for library staff to keep up with the ever-changing landscape; just as they are able to master one technology, it seems a new version launches. An explosion of user-created content is also giving rise to ideas and opinions on a multitude of topics, but following the hundreds of available authorities means sifting through a mountain of information more frequently than most library staff can manage. There is a need for effective tools and filters for finding, interpreting, organizing, and retrieving the data that is the most relevant and insightful.[215] Additionally, societal changes and financial pressures are transforming the work of academic and research librarians, requiring greater agility and a constant pursuit of absorbing new technologies and skills.[216]

Overview

The 21st century has been characterized by rapid changes brought about by technological advancements, requiring librarians to reassess the knowledge base necessary to remain relevant and effective.[217] Some researchers believe that the challenge of working through a continuous flow of new technology and information resources is exacerbated by differing attitudes and rates of adoption. A recent article from University of Pennsylvania's Wharton School depicts the struggle between how students and university staff approach the use of new tools and resources. The current generation of students who were born using technology experiences the digital world from a personal integrated perspective. Conversely, faculty and instructors who are more familiar with analog tools and traditional workflows view technology from a professional context. This gap is escalating the need for professional development and training opportunities for staff, including library professionals.[218]

Researchers from Nova University in Lisbon are gaining a better understanding of knowledge obsolescence in the library and information field. Their recent study was based on 12 career biographies of library professionals working in Portugal since the 1970s and 1980s, and revealed that obsolescence occurs when new ways of working are needed because of changes in information processes and tasks. They also discovered that these situations are cyclical in nature and happen when a person transitions from one stage of their career to another. The study urges the development of organizational performance models that support emerging roles and competencies in order to improve institutional performance.[219]

Further complicating this challenge is the notion that librarians are in limited control of the organizational change that is occurring in academic libraries around the world, due to the superabundance of information and financial pressures. An *Inside Higher Ed* article explains that librarians are having difficulty planning for the knowledge and skills needed because the future is uncertain. While library professionals are experts in managing information, research and curriculum trends are driving library transformation, which require the involvement of different stakeholders across campus. The author argues that although library directors are responsible for adapting to a changing information environment, effective leaders need to create the conditions where they can collectively stimulate action, rather than focus on predetermine outcomes.[220] Budget concerns are also shaping this challenge as decreased funding for acquisitions means a shift from librarians managing content to managing access, such as moving to electronic subscription models — rather than building physical collections.[221]

Implications for Policy, Leadership, or Practice

While policy solutions to this challenge are elusive at universities, public libraries are taking steps on the long-term development of their spaces and staff, which could have implications for academic and research libraries. The British Library developed the strategic plan "Living Knowledge: The British Library 2015-2023,"[222] calling for renewed and sustained investment in the UK's knowledge infrastructure. Although there is already traction around embracing digital resources, there is also an increase in physical visitor traffic, requiring libraries

to address both areas of need. In order to support the research community surrounding them, library professionals must continuously develop and hone their own research skills.[223] Albert S. Cook Library at Towson University in Maryland encourages these opportunities; they have publicized the key components, which include emerging technology training and mentorship programs.[224] There is still a pressing need, however, to formalize these practices into policies that mandate adequate support for professional growth.

In light of growing austerity measures in libraries, leaders are developing processes to ensure library professionals remain effective in their positions. At the 2015 Association of College & Research Libraries conference researchers presented the paper, "Dare to Perform: Using Organizational Competencies to Manage Job Performance," which provided a framework for addressing knowledge obsolescence. The authors argue that competency-based hiring and evaluation can ensure that organizations are prepared to properly recruit, evaluate, and set professional development benchmarks for library professionals. While the framework can be effective, the researchers concede that designing and keeping competencies current across positions and divisions can be challenging because of how quickly they evolve.[225]

Increasingly, libraries are looking to online learning environments as a solution to ensuring library professionals remain current. Syracuse University's School of Information Studies was one of the first to create a MOOC for librarians. Their New Librarianship Open Online Course signaled a shift in the approach to library practice. Building upon the *Atlas of New Librarianship* book, the course sought to explore a new vision for librarianship where knowledge is created through conversation, going beyond finding library-related applications of information technology and the Internet.[226] In India, obsolescence and the depreciation of knowledge is seen as a major challenge in the information profession, especially in the rural northeast where they lack infrastructure and educational opportunities. At the Caliber 2015 conference, two librarians shared their vision for a Library and Information Science MOOC. Titled the "LISc MOOC," the researchers believe that this platform can help provide a unified syllabus for librarianship, a refresher course, encourage the use of IT in older professionals, and stay current with new developments across the continent.[227]

For Further Reading

The following resources are recommended for those who wish to learn more about managing knowledge obsolescence:

Policy Revolution! Initiative
go.nmc.org/policyrev
(American Library Association, accessed 1 August 2015.) The Policy Revolution! Initiative has three major goals: to develop a national policy agenda; to initiate and deepen national stakeholder interactions based on policy priorities; and to build library advocacy capacity. > *Policy*

Implementing a Culture of Creativity: Pop-up Making Spaces and Participating Events in Academic Libraries
go.nmc.org/cultcrea
(Megan Lotts, *College & Research Libraries*, February 2015.) Libraries are transforming their spaces to incorporate participatory activities that engage patrons, inspire and stimulate creativity within the scholarly community, and further impact the world outside the university. > *Leadership*

It Takes a University to Build a Library
go.nmc.org/ittakes
(Dane Ward, *Inside Higher Ed*, 21 April 2015.) University libraries are developing into more multifaceted centers designed to support a wide variety of student learning and faculty research activities. This article describes important perspectives that can help library directors, staff, and faculty at an institution. > *Leadership*

Students, Faculty Engage with Streaming Video | ALA Annual 2015
go.nmc.org/studeng
(Lisa Peet, *Library Journal*, 9 July 2015.) ALA's Video Round Table hosted a session at the ALA Annual Conference to examine student and faculty engagement with streaming video, and the concerns surrounding it. This article focuses on the popularity of video and how faculty and librarians are learning a new set of applicable rules and skills. > *Leadership*

Colorado State Library Expands Online Training Site
go.nmc.org/csl
(Matt Enis, *Library Journal*, 23 July 2015.) The Colorado State Library is building out its Library Creation & Learning Centers website, which is a free online resource for library staff that provides interactive technology and customer service training modules, and curated links to digital creation software. > *Practice*

The Role of Information Literacy in Higher Education
go.nmc.org/roleinfolit
(Abdelhamid Nfissi and Aziz El Hassani, *Morocco World News*, 21 July 2015.) The expanding wealth of information resources available online is cementing the need for libraries to help students build skills and understand the resources they will forever rely on in achieving their lifelong learning goals. > *Practice*

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 informational management. While many of the technologies considered were not developed solely for academic and research libraries, they have clear applications in the field.

The technologies, 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 technologies that are expected to achieve widespread adoption in one year or less; mid-term technologies that will take two to three years; and far-term technologies, 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 library.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 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 above, to 12 technologies 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 library.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.

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 aids and be quite adaptable for use in academic and research libraries. These technologies find their ways into libraries 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. 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 of the 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, make them more capable and useful, and often easier to use as well.

- **Internet technologies** include techniques and essential infrastructure that help make underlying network technologies more transparent, less obtrusive, and easier to use.
- **Learning technologies** are developed expressly for learning and include tools adapted from other purposes to form strategies that make them useful for learning.
- **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 into 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 technologies highlighted by the 2015 Horizon Project Library Expert Panel, who agree that they have the potential to foster real changes in academic and research libraries, particularly in the development of progressive services for research, information management, content delivery, and learning. 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
- 3D Video
- Drones
- Electronic Publishing
- Quantified Self
- Robotics
- Tablet Computing
- Telepresence
- Wearable Technology

Digital Strategies
- Bring Your Own Device (BYOD)
- Flipped Classroom
- Location Intelligence
- Makerspaces
- Preservation/Conservation Technologies

Internet Technologies
- Bibliometrics and Citation Technologies
- Cloud Computing
- Semantic Web and Linked Data
- Syndication Tools

Learning Technologies
- Adaptive Learning Technologies
- Digital Badges
- Learning Analytics
- Mobile Learning
- Online Learning
- Open Licensing
- Virtual and Remote Laboratories

Social Media Technologies
- Crowdsourcing
- Online Identity
- Social Networks

Visualization Technologies
- 3D Printing
- Augmented Reality
- Information Visualization
- Volumetric and Holographic Displays

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

Makerspaces

Time-to-Adoption Horizon: One Year or Less

The turn of the 21st century has signaled a shift in the types of skillsets that have real, applicable value in a rapidly advancing world. Creativity, design, and engineering, or in a word — invention — has become the hallmark of innovation on campuses across the globe. As such, many academic and research libraries have renovated or repurposed space to accommodate makerspaces, areas where students and faculty can access tools, materials, and the expertise to make things outside of their curricular objectives. The driving force behind makerspaces is rooted in the Maker movement, a following comprised of artists, tech enthusiasts, engineers, builders, tinkerers, and anyone else with a passion for making things.[228] There is growing understanding across the higher education community that makerspaces and making activities effectively engage learners in creative, higher-order problem solving through self-directed design, construction, and iteration.[229] During a time when academic libraries are undergoing significant transformation, the addition of makerspaces is solidifying the library's position as a hub where students and faculty can access, create, or engage in hands-on projects across departmental lines.

Overview

Makerspaces, also referred to as hackerspaces, hack labs, or fabrication labs ("Fab Labs"), are community-oriented workshops where tech enthusiasts meet regularly to share and explore electronic hardware, manufacturing and mechanical tools, and programming techniques.[230] Much of the hype around this cultural trend burgeoned around the advent of MakerBot printers, affordable rapid-prototyping technology that requires a DIY mentality to assemble, operate, and replicate.[231] Tools that are commonly found in makerspaces include laser cutters, soldering irons, Arduinos and Raspberry Pi computers, saws and drills, and circuitry gadgets, as well as analog tools such as Legos and sewing devices. The value of these spaces is also inherent in community members who provide a resource of expertise. Makerspaces are places where anyone, regardless of age or experience, can exercise their ingenuity to construct tangible products.

Widespread support behind makerspaces in education is growing as an abundance of student-led examples of research and innovation are surfacing on the global radar. Through their campus Fab Lab, learners at La Universidad de Alicante in Spain collaborated on a humanitarian project to prototype shelters for rapid installation using innovative materials and designs. Upon completing their work, they were asked to present their scalable model to the United Nations.[232] In Sweden, student researchers at the makerspace of Umeå University's Arts Campus are working on +Project, a federally sponsored 3D printing initiative to develop cellulose-based building materials for homes. The project will culminate in the founding of a training center for sustainable building and administration, and the learners plan to showcase their work at the World Expo in 2018.[233]

Makerspaces and fabrication labs have gained considerable traction in the higher education community, but in many cases, these facilities are attached to specific departments, allowing only those students and faculty to enter. University libraries are in the unique position to offer a central, discipline-neutral space where every member of the academic community can engage in creative activities. Beyond fulfilling this emerging need, libraries are also constructing makerspaces to reinforce their role as a vital part of the research community and a hub for productivity. A survey conducted by the University of Miami found that projects carried out in academic library makerspaces compared to other makerspaces have a more digital focus, resulting in the production of websites, photos, programs, apps, and games. Furthermore, the author of the study highlighted that the nature of activities in an academic library makerspace are geared toward meeting curricular objectives rather than autonomous exploration, a trend that may change over time.[234]

Relevance for Academic and Research Libraries

The introduction of makerspaces into academic libraries is inspiring a mode of learning that has immediate applications in the real world. Aspiring inventors and entrepreneurs are taking advantage of these spaces to access tools that help them make their dreams into concrete products that have marketable value. Funded by a federal grant, the new makerspace in Tuscarawas

Library at Kent State University was established as a key part of the entrepreneurial ecosystem that the campus is developing with the university's Office of Business and Community Center. The space is equipped with a 3D printer, vinyl cutter, touchscreen presentation monitor, and electronics and robotics kits, in addition to other tools that will allow students to develop and test their ideas. With support from the Ohio Small Business Development Center, student makers will also have access to business workshops that will help them find the capital to launch their refined products via the university's Tolloty Technology Incubator.[235]

The vast potential of having a widely accessible, 24-hour multidisciplinary workshop has convinced many institutional leaders to reimagine their academic libraries to include laboratory-like environments. The Fab Lab at the University of Texas Arlington (UTA) Libraries is a place for project-based learning that will help graduates get ahead with their competitive technological skills.[236] Built with an emphasis on encouraging collaboration across STEAM disciplines (science, technology, engineering, the arts, and mathematics), the Fab Lab was presented as a way of breaking down departmental silos, and as a result, offers first- and second-year students a chance to engage in engineering activities regardless of their declared major. The FabLab@UTA Libraries is the first MIT-affiliated Fab Lab in North Texas, and it serves students on campus as well as online, plus K-12 populations in the fourth largest metropolitan area in the US — the DFW Metroplex.[237]

Library makerspaces contribute to an academic community's capacity to capitalize on students' potential by offering access to cutting-edge tools, often times through relationships with local partners. Established in cooperation with Technical University Dresden and several Fraunhofer IWU, SLUB Dresden is the first major makerspace in a German academic library.[238] The space allows students to make use of 3D printing and modeling technologies for prototyping with smart^3 materials, which are substances that can adapt autonomously to changing environmental conditions.[239] At the Information School of the University of Washington, graduate students of LIS have focused their capstone projects on building sustainable models of pop-up makerspaces for a nearby public library. Successfully piloted at Kitsap Regional Library, their BiblioTEC makerspace aims to engage young adults in STEM learning.[240]

Makerspaces in Practice

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

Creative Media Studio
go.nmc.org/cms
At California State University, Northridge, Oviatt Library's Learning Commons is a creative space offering equipment, software, peer-based assistance, and workshops to all students for the development of creative media projects. > *Practice*

IDeATe @ Hunt
go.nmc.org/ideate
IDeATe, Carnegie Mellon University's Integrative Design, Arts and Technology Network, built extensive collaborative makerspace facilities in the Hunt Library to support student projects, including a digital fabrication shop, a physical computing lab, and an interactive media black box. > *Practice*

LibraryLab at HTW Chur
go.nmc.org/liblab
The University of Applied Sciences HTW Chur in Switzerland is installing a makerspace called LibraryLab in which students are using 3D visualization technologies and other digital tools. > *Practice*

Makerspace at Kenan Science Library
go.nmc.org/kenan
UNC Chapel Hill University Libraries' Research Hub created a makerspace to enable students, staff, and faculty to explore emerging technologies and to foster a creative community with 3D printers, Arduino and Raspberry Pi kits, and more. > *Practice*

For Further Reading

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

Biohackerspace, DIYbio, and Libraries
go.nmc.org/biohack
(Bohyun Kim, *ACRL TechConnect Blog*, 10 February 2015.) An outcrop of the maker movement, DIYbio, has led to biohackerspaces, which have potential to drive future innovation in biotechnology and life sciences. > *Leadership*

Libraries & Maker Culture: A Resource Guide
go.nmc.org/inlib
(Libraries & Maker Culture, accessed 30 July 2015.) This resource created at the University of Michigan provides examples of how makerspaces are being incorporated into academic libraries. > *Leadership*

Making Makerspaces Work on Campus
go.nmc.org/makin
(Melissa Delaney, *EdTech Magazine*, 11 February 2015.) This article explores the concept of makerspaces in academic libraries and how this is a period of experimentation in which libraries are learning from each other. > *Practice*

Online Learning

Time-to-Adoption Horizon: One Year or Less

Online learning refers to both formal and informal educational opportunities that take place through the web. This topic experienced a surge of interest with the rise of massive open online courses in 2012, and has since been garnering greater acceptance as a mode of learning that can complement face-to-face instruction in blended learning approaches or stand on its own. As leaders have gained a better understanding of this field, they have been conducting numerous related online learning experiments; educators are becoming more comfortable testing various levels of integration in their existing courses, and many believe that online learning can be an effective catalyst for thoughtful discussion on all pedagogical practice.[241] Indeed, online learning is undergoing a sea change, with every dimension of the process open for reconceptualization.[242] Academic and research libraries are poised to play a major role in defining and helping facilitate future incarnations of online learning by guiding campus faculty. Furthermore, libraries' own digital offerings can be enhanced as more research is being conducted about the promising impact of virtual instructional design and delivery platforms for the research community.

Overview

The number of higher education students enrolling in online courses, along with the impact of online learning on academia, continues to grow each year. The 2014 Babson survey, "Grade Level: Tracking Online Education in the United States," found that online enrollment growth has far exceeded overall higher education enrollment. Furthermore, nearly 71% of academic leaders report online learning as critical to their long-term strategy, and 74% claimed that online learning was the same as, or superior to, face-to-face instruction.[243] In this environment, academic and research libraries are playing a key role in helping universities plan and facilitate their burgeoning online learning programs. In fact, the Association of College & Research Libraries has been studying the library's expansion into distance education initiatives for over 20 years.[244] As online learning continues to gain traction in higher education, university library departments and their personnel are evolving to accommodate the need for more specialized, sustained support.

Academic and research libraries have housed valuable expertise and resources in online learning for some time now. Many universities offer workshops and tutorials about virtual instruction methods through educational technology-focused departments that reside in the library. For example, faculty at the University of Oregon (UO) can consult the UO Libraries' Center for Media and Educational Technologies to get help with classroom technology design and to produce digital assets such as videos to incorporate in their online courses.[245] There are some institutions that include online learning as an essential piece of the library's long-term vision; Victoria University (VU) Library's four-year strategic plan highlights their commitment to working deeply with VU's colleges to support the latest virtual learning methodologies and the implementation of blended learning frameworks that integrate library resources and services into the curriculum.[246]

Open online education has significantly influenced the role of the library. With the rapid expansion of free online courses, experts believe that eventually people will not distinguish between whether a degree program was earned online or in person.[247] This notion has major implications for libraries as they plan for the future, especially now that many are taking the lead to ensure privacy, content sharing, intellectual property, and accreditation concerns are addressed in the planning stages for MOOCs. Additionally, libraries are turning to online learning to train their own staffs. LIS programs and university libraries have developed a number of online opportunities and materials to support professional development and continued education for librarians.[248] Pennsylvania State University Libraries published "MOOCs for Learners" and "MOOCs for Educators," which are research guides that support students and faculty as they embark on these types of learning experiences.[249]

Relevance for Academic and Research Libraries

Current research about online learning points to the many benefits of blended learning models to reshape the student experience and expand access to quality educational opportunities.[250] Academic and research libraries are supporting the development of online learning approaches, assisting with media production,

connecting special collections to courses, curating content for content for courses, and more.[251] Library-based online learning services are helping alumnus increase their skills, validate their professional development, and connect with a larger network of alumni.[252] At the University of South Florida St. Petersburg, for example, the Nelson Poynter Memorial Library offers a variety of instructional technology resources, including support services to faculty, instructional design consulting, and professional development in the form of workshops and trainings for online faculty.[253]

The role of academic libraries in the age of online learning has spurred the creation of a number of large-scale online courses about information literacy and topics in library information science. The library at the FernUniversität in Germany played a key part in the production process of the university's MOOC, "Discover the Island of Research," intended to serve college researchers.[254] San Jose State University's iSchool MOOC, "The Emerging Future: Technology Issues and Trends," trained participants to think like futurists by working through an abundance of readings, recorded lectures, and online videos.[255] Empire State College and the University at Albany partnered to create a ten-week constructivist MOOC on metaliteracy.[256] One of the most notable aspects of this MOOC was the badging component used; librarians created quests, challenges, and other activities using digital badges in order to motivate more learners to complete the ten-week online course.[257]

Many academic libraries have produced digital assets to enhance learning, providing access to educational resources and services online, while maintaining and supporting physical collections in their building.[258] For example, students at Argosy University can access an online library from the Campus Common, allowing for full-text searches in over 350 databases, as well as e-book access and interlibrary book loans.[259] Additionally, libraries often create online library skills modules, including the University of New South Wales Library, where they provide introductions to the library and its available resources, including overviews of learning management systems, lecture recording systems, and exterior sites such as iTunesU.[260] Academic librarians are also creating new online content in the form of audiobooks using LibriVox,[261] where volunteers record chapters of books in the public domain that are then released back out onto the Internet via YouTube, such as *Critias* by Plato.[262]

Online Learning in Practice

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

E-libraries Transform Scholarship in Myanmar
go.nmc.org/myan
In Myanmar, online resources have been in high demand, with tens of thousands of downloads since the beginning of the e-library project led by the international NGO Electronic Information for Libraries. The e-library provides instant access to resources across all disciplines for an unlimited number of students at seven local universities. > *Leadership*

JISC InfoKit: Using Digital Media in New Learning Models
go.nmc.org/flipblen
JISC created an information kit to provide guidance on best practices for using digital media as part of new learning models, including flipped classroom and other blended learning approaches. > *Leadership*

Faculty Member Launches New Tool for Digital Learning
go.nmc.org/newtool
Research professors from the Syracuse University iSchool teamed up with a recent graduate of the master's degree program in Library and Information Science, School Media to create an online learning resource that uses a digital art tool called DoodleBook to convey scientific concepts. > *Practice*

For Further Reading

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

Privacy Toolkit
go.nmc.org/toolk
(American Library Association, accessed 27 July 2015.) This document offers guidance for libraries as they draft, adopt, or revise privacy and confidentiality policies for students to access online course and library materials. > *Leadership*

Information Literacy Defined in Flex
go.nmc.org/inflex
(Kristin M. Woodward, Association of College & Research Libraries, March 2015.) The author describes how librarians at the University of Wisconsin-Milwaukee collaborated with faculty to embed online services into three degree programs and an undergraduate certificate. > *Practice*

The Roles that Librarians and Libraries Play in Distance Education Settings
go.nmc.org/theroles
(Amanda Corbett and Abbie Brown, *Online Journal of Distance Learning Administration*, Spring 2015.) This article identifies various library services that are essential to online learners and online education settings and explores potential new roles that libraries can play in the future. > *Practice*

Information Visualization

Time-to-Adoption Horizon: Two to Three Years

Information visualization is the graphical representation of technical, often complex data, designed to be understood quickly and easily. Popularly called "infographics," this type of media is highly valuable in the age of ubiquitous knowledge, and the people who create it are equally desired by organizations seeking to share messages that make an impact.[263] This format is particularly compelling for academic and research libraries as it enables researchers and scientists to present complex findings in ways that are easier to comprehend than raw datasets. A well-designed infographic can illuminate facts buried in the pages of a dense report or text, or interpret a detailed concept, such as an underground transit system, with clarity and simplicity. The modern age is embracing the power of design to engage and inform audiences through infographics, and social media is the vehicle to take them viral, making information more relevant and accessible on a global level.[264] For researchers and students, the study of information visualization covers a number of valuable skills relating to data analysis, design thinking, and contextual, inquiry-based exploration[265] — in addition to the technical capacities required to carry out ideas using creative software.

Overview

While information visualization is an emerging technology development for academic and research libraries, it is an area rich in history. Early incarnations include 19th century maps of weather patterns and 20th century depictions of the human metabolism at work, among many other examples.[266] As long as scientists have been collecting data on people and the environments around them, there has been a need to display important findings to both educate and engage the public. As gatekeepers of vast amounts of this research, libraries are tasked with storing, publishing, and disseminating visual representations of data. The advent of online academic journals,[267] e-books, and other digital platforms are enabling libraries to broadly share these visualizations. As a result, researchers can scan a graphic to immediately discern whether the findings it represents are useful for their own studies before delving into all of the data associated with it.

The growth of information visualization signals a larger movement away from text-heavy presentations towards image-centric strategies — a trend that has been perpetuated in nearly every facet of communication. Contemporary web design, for example, favors the use of photographs and videos to maximize the impact of messaging.[268] People want to be able to digest information quickly so they can move on to the next activity;[269] this is especially true for academics and researchers who are often under tight grant deadlines. Although libraries have long been recognized for providing access to books, reference materials, and other text-based mediums, the transition to digitizing their catalogs has opened new doors to what published research outputs can look like. Furthermore, low-cost or free tools are now readily available for anyone to build infographics and other visualizations,[270] which has become an important digital literacy skill for libraries and librarians to hone.[271]

Ultimately, one of the most promising benefits of information visualizations is that they enable viewers to instantly recognize connections and patterns that could take hours to determine from raw data and text alone. This has been particularly true in the business sector, where company leaders are constantly looking to find correlations between operating conditions and business performance so they can adjust their projects and models for maximum growth.[272] Additionally, unlike print materials and many journal articles, infographics can be updated constantly as new data is entered with digital tools such as Piktochart.[273] This means as a research project progresses, the visualization can be altered to mirror new findings and then re-disseminated. As a result, libraries are poised to offer the most current information to their patronage.

Relevance for Academic and Research Libraries

With information visualization positioned two to three years away from mainstream adoption, libraries are well-suited to lead the way for it on their campuses. This development is widely viewed as a facet of digital and data literacy — an area where libraries have long been purveyors of effective instruction. Duke University Libraries have dedicated an entire section of their website to information visualization, offering

tutorials on using software and designing effective content.[274] The Data Visualization Services department is responsible for introducing patrons to mapping and GIS software. Additionally, they host a weekly event called Duke Visualization Friday Forum, in which faculty, staff, and students share their research and applications of information visualization methodologies.[275]

More university libraries are educating their research communities on how to select and create the best possible visualizations and infographics. In Canada, University of Toronto's Map & Data Library curates and synthesizes notable resources for information visualization development, breaking down the difference between high and low interaction graphics in both the public and private sectors.[276] As information visualizations increase in usage, libraries also have a responsibility to house them online in sustainable ways. The German National Library of Science and Technology (TIB Hannover) conducts projects and studies around data visualization and improving access to non-textual materials.[277] As such, they have partnered with the Joint Committee of the German Research Foundation to build an information infrastructure called the Centre of Expertise for Research Data from the Earth and Environment, or "KomFor," that stores visual information.[278]

While a wide array of platforms already exists for researchers to create information visualizations, including Tableau,[279] ArcGIS Online,[280] and Datawrapper,[281] there is also an opportunity for libraries to create their own tools to support their communities' unique needs. MIT Libraries has been a pioneer in this area — especially for open access visualization. Their Simile Widgets are free and open-source, enabling students, faculty, and researchers to create web pages for sorting rich visualizations, create timelines for temporal information, and more.[282] Visualizations can also be applied to enhancing the physical objects that libraries encompass. The Munich Digitisation Centre of the Bavarian State Library and the Fraunhofer Heinrich Hertz Institute recently developed the 3D-Explorer system so that books and manuscripts can all be viewed three-dimensionally without special glasses.[283] Indeed, more libraries are beginning to build large screens and visualization walls to support more immersive explorations of historic events.

Information Visualization in Practice

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

CURVE: Collaborative University Research & Visualization Environment
go.nmc.org/curve
CURVE, a project to create a technology-rich discovery space in Georgia State University Library, is leveraging an immersive, high-resolution touch wall and multiple high-end workstations as well as unique visualization hardware and software. > *Leadership*

Virtual Paul's Cross Project
go.nmc.org/vpcp
The Virtual Paul's Cross Project at North Carolina State James B. Hunt Library allows users to experience John Donne's sermon for Gunpowder Day in Paul's Churchyard in 1622 through a visual model that combines depictions of St Paul's Cathedral together with accurate measurements of foundations, elevations, and spatial configurations of objects. > *Practice*

Visualization Studio at University of Calgary
go.nmc.org/vis-stud
Visual analytics at the University of Calgary is supported by a 34.5 million pixel visualization wall housed and managed in the Taylor Family Digital Library, University of Calgary's central library. > *Practice*

For Further Reading

The following resources are recommended for those who wish to learn more about information visualization:

Data Visualization: Do It Right, But Only If You Need To
go.nmc.org/datvisu
(Tom Groenfeldt, *Forbes*, 7 July 2015.) This article describes how interactive graphics allow users to zero in on the information they need in a way that text may not as easily permit. Researchers benefit from using visual depictions to interpret data for focusing in on specifics they want to learn from a dataset and when portraying their findings to others. > *Leadership*

So You Want To Be A Data Visualization Librarian?
go.nmc.org/soyou
(Christina Czuhajewski, *Hack Library School*, 4 June 2015.) The author sits down with four visualization specialists who work within the University of Michigan Library system to learn what their jobs entail. Librarians are more often specializing in data analytics and visualization as the demand grows for visualization needs related to multiple disciplines. > *Practice*

Using Data Visualization to Find Insights in Data
go.nmc.org/findin
(Data Journalism Handbook, accessed 28 July 2015.) This chapter breaks down how to visualize data, analyze and interpret it, and document findings. > *Practice*

Semantic Web and Linked Data

Time-to-Adoption Horizon: Two to Three Years

The semantic web infers the meaning, or semantics, of information on the Internet using metadata to make connections and display related information that would otherwise be elusive or altogether invisible. In the 1960s, the Library of Congress developed and released the first protocol for linked metadata, the machine-readable cataloging format, or MARC, as it is commonly known. Advances in these standards and search engine analytics are connecting library catalog systems on the Internet, and using linked data to help users uncover and delve into content that is, for all practical purposes, hidden in the Deep Web.[284] Semantic searching most frequently applies to scientific inquiries, allowing researchers to gather an abundance of relevant, credible information without using a dozen search tools, each with their own precise filters. Furthermore, advancements in semantic web are generating new ways of data contextualization; the result is deeper personalization and more comprehensive views of bodies of research. These emerging Internet technologies have the potential to revolutionize research, unearth troves of scientific knowledge, and transform the way academic stakeholders pursue purposeful investigations.[285]

Overview

Sir Tim Berners-Lee originally advanced the vision for the semantic web, believing that it could help people solve complex problems by presenting connections between seemingly unrelated concepts.[286] This concept has become more important considering the exponential growth of the Internet, which more than doubles in size every two years.[287] According the IDC, from 2013 to 2020, the amount of networked data will grow by a factor of ten — from 4.4 trillion gigabytes to 44 trillion.[288] Popular search engines can only touch about 10% of the Internet; the remaining 90% are websites not indexed because most of this data is located in library catalogs in formats that cannot be searched, or guarded in secure areas that cannot be accessed by bots.[289] To surface content from the Deep Web, researchers are implementing standards, or resource description frameworks (RDF), that make human-readable information understandable and reusable by search tools that scour the metadata assigned to webpages.[290]

The trend toward openness for academic content is paving the way for more direct search routes and interfaces. Linked open data is an essential development in the semantic web; this standard for networked information is also organized by an RDF, contains a unique resource identifier address, and is accessible using hypertext transfer protocol (HTTP), but it pertains exclusively to openly licensed collections. Openness has been a key pursuit of cultural institutions and libraries around the world, including Europeana, a massive online source of European cultural artifacts.[291] The Europeana Data Exchange Agreement regulates their licensing framework by requiring data providers and aggregators to provide Europeana the right to publish metadata under Creative Commons CC0 1.0 Public Domain Dedication. As a result, every digital artifact is indexed, searchable, and carries a rights label that describes its copyright status.[292]

The library community is poised to make great strides with semantic web technologies, as evidenced by recent endeavors involving BIBFRAME, a protocol that is largely considered to be the next generation standard for assigning and managing bibliographic metadata. The BIBFRAME model replaces MARC with a new scheme that caters specifically to academic and research libraries.[293] An innovative precursor in the private sector paved the way for BIBFRAME to take root; in 2011, Google, Microsoft, Yahoo, and Yandex established schema.org, a collaborative effort to promote a common vocabulary for web pages that would make them easier to find and search.[294] Published for public view and use via GitHub, the collection of RDFs made accessible by schema.org has set the standard for open sharing that will drive the development of BIBFRAME. With strong library science, straightforward ontologies, and powerful search tools, the best possible research results could one day be as easy as a simple Google search.

Relevance for Academic and Research Libraries

Academic and research libraries are in a unique position to benefit from the increased exposure and contextualization that semantic tools offer. Library catalogs can increase access to valuable resources if their metadata is an interoperable part of the semantic web and not siloed in separate ontologies and databases.[295]

Researchers at the Institute for the Study of the Ancient World (ISAW) recently described the process they undertook to establish Online Coins of the Roman Empire, a comprehensive, easy-to-search collection of archeological monetary objects. With hundreds of thousand of coins recorded, and more added every day, the Institute faced the issue of cataloguing a vast diversity of content, sourced from various schematic backgrounds. As a result, ISAW's researchers developed a discipline-specific approach for linked data which connects all artifacts relating to Roman numismatics, and can link multiple examples of a given type of coinage from various contexts.[296]

Technological advances are driving libraries to go beyond managing collections from their own websites to integrate semantic web features into sites and services more frequently accessed by users. The idea is to create an unobstructed way for students and researchers to find and connect with meaningful and relevant information, derived from as many credible sources as possible. A number of institutions are creating shareable tools that embed bibliographic metadata into everyday research practices and workflow. Developed by the University of Oxford's e-Research Centre, OntoMaton is an open source widget that brings searchable tagging and ontology lookup to Google spreadsheets. These new features for annotation support research and the analysis of data as a collaborative activity, which can happen across disciplines and be performed by scientists located anywhere in the world.[297]

The promise of the semantic web is being realized in a variety of academic disciplines. The LinkedUp Project, a collaborative research effort sponsored by the EU's Seventh Framework Programme and led by Leibniz University Hannover, is tracking many of these emerging uses through its annual showcase.[298] This scholarly contest has attracted major competitors in the field of linked data, including the International Institute of Social History, Amsterdam, which has developed a visual interface that uses linked and associated data from primary and secondary resources to help historians decipher meaningful data trends in national labor conflicts over the past 700 years.[299] Similarly, AGRIS, a search engine developed by the Food and Agricultural Organization of the United Nations, uses linked data protocol to centralize information about agriculture, allowing users to access data from its repository and external sources from one entry point.[300]

Semantic Web and Linked Data in Practice

The following links provide examples of the semantic web and linked data in use that have direct implications for academic and research libraries:

Linked Data for Libraries (LD4L)
go.nmc.org/LD4L
The LD4L project is a collaboration of the Cornell University Library, the Harvard Library Innovation Lab, and the Stanford University Libraries to create a Scholarly Resource Semantic Information Store model. > *Leadership*

Linked Data Service of the German National Library
go.nmc.org/linkserv
The German National Library is building a linked data service that will permit the semantic web community to use the entire stock of national bibliographic data, including all authority data. > *Practice*

Semantic Web at the Bibliothèque National de France
go.nmc.org/bibl
Open data project "data.bnf.fr" aims to make the data produced by the French National Library more useful. It gathers various library and external resources on pages devoted to a specific author, work, or subject. > *Practice*

UNLV Linked Open Data Project
go.nmc.org/unlv
The Linked Open Data Project is developing a common process for transforming metadata into linked data, and to publish data in the Linked Open Data Cloud to improve discoverability and connections with other related data sets. > *Practice*

For Further Reading

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

Ending the Invisible Library | Linked Data
go.nmc.org/ending
(Matt Enis, *Library Journal*, 24 February 2015.) University libraries and leaders are leveraging semantic technology, linked data, BIBFRAME vocabularies, and schema.org vocabularies to better meet library patrons on the open web. > *Leadership*

From Documents to Data
go.nmc.org/fromdoc
(David Stuart, *Research Information*, August 2015.) This article describes how a controlled vocabulary reduces natural language ambiguity and has potential to transform information retrieval and discovery. > *Practice*

On Seams and Edges
go.nmc.org/seams
(Tim Sherratt, Australian Library and Information Association, accessed 26 July 2015.) The author exams user data from Trove — a platform created by National Library of Australia to help users find Australian resources by bringing together content and metadata from libraries and other organizations. > *Practice*

Location Intelligence

Time-to-Adoption Horizon: Four to Five Years

Location intelligence refers to the mapping of the geographic relationships associated with data. Resources including GIS are used to provide individuals and organizations with information about how people are interacting with various applications and services based on their location.[301] Smartphones and tablets are naturally driving the proliferation of this technology because of their built-in location-sensitive sensors and other features. A growing facet of location intelligence in libraries is location-based services (LBS) which provide content that is dynamically customized according to the user's location. New location intelligence technologies are extending that capability into buildings and interior spaces with remarkable accuracy. A recent compelling development for location-based services is the advent of indoor geolocation,[302] which is providing library patrons with very specific information tailored to their exact location within a library, allowing fine-tuned information or services to be accessed from their exact location in 3D space, so that even different floors of a building can be identified.

Overview

Location-based services digitally pinpoint the physical position of an object or individual through Wi-Fi cellular networks, RFID, and most recently, Bluetooth Beacons technology. The popularity of this topic in the consumer sector can be attributed to how location-based services help strengthen two-way communication between people and business. For users, location-based services conveniently provide information or recommendations pertaining to their surroundings, such as campus maps.[303] LBS also enable businesses to target customers with promotions that are relevant to their geographic area.[304] The proliferation of smartphones and tablets, equipped with built-in GPS and an array of sensors, has accelerated the use of location-based services. According to Pew Research Center, 74% of adult smartphone owners leverage LBS to obtain directions and other information. Additionally, many of the leading social media apps, including Facebook and Instagram, constantly prompt users to include their location.[305]

Location intelligence is also ripe for innovation in the library sector. With an increasing number of students bringing their own devices with them to campus,[306] LBS-enabled mobile apps can enrich the library experience through a number of ways. They can send reminder notifications, if a student is in proximity of the library, that a book has arrived or is due to be returned soon or provide recommendations on specific books or exhibits that may be of interest, to them, based on the student's previous visits. Additionally, location intelligence could promote new library services such as a makerspace, provide guided tours of facilities, or offer students assistance if they remain in an area for an excessive amount of time, indicating that they might require help.[307]

When coupled with analytics about patrons' habits and movements, location-based services foster methods for understanding how library spaces are being used. Researchers at Delft University of Technology studied indoor positioning to estimate the occupation of buildings in order to make better-informed decisions about future building use and staffing decisions. Using passive WiFi monitoring to detect wireless signatures from student and faculty smartphones, they identified how often the same people visited the library, how much time they spent inside, and when they did so. The researchers found that weekday afternoons proved to be the peak time of visitor occupation.[308] As the future of this technology unfolds, it will be less about discerning an individual's location and more about understanding user behavior and delivering helpful information to them before they even ask for it.

Relevance for Academic and Research Libraries

Many libraries have responded to patrons bringing their own mobile devices to campus by integrating location intelligence into mobile apps. The University of Illinois Urbana-Champaign, for example, experimented with LBS services to help improve the college experience. As the result of a university-wide app building competition, students developed the Study Buddy app, which assists individuals in locating where their classroom peers are studying. It enables a student to form a study group at a campus location, such as a library, and then share their coordinates with others. The library team that assisted in the project helped source location and course data that made the check-in features possible. They also used their VuFind library catalog account login and

authentication tool to ensure that only those enrolled in a course could gain access to location data, alleviating privacy and safety concerns.[309]

While many location intelligence projects are underway in businesses and museums, this topic falls on the far-term horizon mainly because it is still in the pilot phase at many academic and research libraries. Bluetooth Beacon technology is garnering the interest of mobile app developers looking to gain entry into the library market. Library app developers Capira Technologies and BluuBeam are two companies that recently launched micro-location information services for pushing targeted messages to Bluetooth-enabled phones. BluuBeam has been working with libraries to push out event notifications, such as upcoming computer training courses, and news about specific library areas, allowing library patrons to save information and share it with their social network. Capira Technologies is currently beta-testing a new beacon feature that connects to an integrated library system, enabling integrated self-checkout and patron record notifications. In addition to pushing notifications to patrons, the team envisions sending collections information such as photographs or artifacts.[310]

The next wave of location intelligence technology for libraries is expanding the possibilities for indoor navigation. Researchers at Aalto University have developed an infrastructure-less indoor navigation system based on computer vision techniques. They took two-dimensional photos of the Aalto Computer Science Building Library and made a three-dimensional point cloud to construct a navigation mesh of the library's interior space. A library visitor can locate their positioning by taking a photograph of the area they inhabit with their smartphone and then enter a destination to get visual instructions on how to navigate to that specific space.[311] Similarly, researchers at the University of Nevada, Reno have developed NAVATAR, a mobile app for helping users who are blind navigate spaces such as libraries without the requirement of large infrastructure investments. It works by triangulating a user's location through smartphone sensors, digital maps, and the confirmation of the presence of a physical landmark such as hallways intersections or water fountains.[312]

Location Intelligence in Practice

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

Measure the Future
go.nmc.org/measfuture
The Knight Foundation's Measure the Future is a project to build open tools for using open-source hardware and software, combined with online tutorials, in order to teach libraries how to use simple sensors that can collect location-based data about building usage to benefit the user experience of their patrons. > *Leadership*

Georeferenced Maps at British Library
go.nmc.org/bluk
The British Library's Georeferencer project is crowdsourcing location data to make a selection of its vast collections of maps fully searchable and viewable using popular online geotechnologies. Users can quickly create an overlay of historic maps on current mapping and compare the past with the present. > *Practice*

WolfWalk
go.nmc.org/wolfwalk
Librarians at North Carolina State University have leveraged the capabilities of W3C Geolocation API specification to build location-aware mobile websites using open standards. Their mobile app, WolfWalk, includes a campus map that links to historical information and photographs from the university's digital collections. > *Practice*

For Further Reading

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

10 Ways Location-Based Marketing Will Evolve in 2015
go.nmc.org/10way
(Larry Alton, *Huffington Post*, 7 January 2015.) More sophisticated navigation and mobile ordering are among the ten opportunities libraries can leverage to enhance their services and better cater to patrons' needs. > *Leadership*

The Eureka Moment: Location Intelligence and Competitive Insight
go.nmc.org/eurek
(*Forbes*, 2015.) This report describes how the evolution of GIS tools has democratized access to geospatial data and the insights it can provide. Real-world location intelligence use cases from the public and private sectors are presented. > *Practice*

It's Time to Wire Your Business for Indoor Location-Based Search
go.nmc.org/itstime
(Brett Relander, *Entrepreneur*, 21 October 2014.) The author highlights the ways in which indoor GPS benefit both business and customers. While the article is geared towards the retail industry, there are implications for libraries, such as better tracking of resource usage and reaching patrons through their mobile devices.
> *Practice*

Machine Learning

Time-to-Adoption Horizon: Four to Five Years

Machine learning refers to computers that are able to act and react without being explicitly programmed to do so.[313] Practical speech recognition, semantic applications, and even self-driving cars all leverage machine learning via data systems that not only intake, retrieve, and interpret data, but also learn from it. To do this, the machine must make a generalization, using algorithms to respond to new inputs after being "trained" on a different learning data set — much like a human learns from experiences and uses that knowledge to respond appropriately in a different encounter. In this sense, machine learning is widely considered by many as a step towards human-like artificial intelligence (AI). Recent incarnations of machine learning in the education space include a university-developed telescope that can automatically detect significant changes pointing to supernova occurrences.[314] The software Xapagy improvises dialog and plot moves in stories fed to it by users. Another compelling use of machine learning is the ability to automatically sift through big data and discern important meanings.[315] While machine learning in libraries is still some years away, the potential of data management systems that can adapt and learn on their own is driving research around the world.

Overview

In 1950, Alan Turing designed a test to measure the abilities of computers with the premise that machines can only be perceived as authentically learning if they cannot be distinguished from humans. In 2014, for the first time researchers programmed a computer named Eugene that had analysts wondering if the Turing test had finally been passed. While subsequent research showed that Eugene came tantalizingly close, it did not come so close as to be truly mistaken for a person, as Turing had predicted would one day be the standard for artificial intelligence.[316] For as long as computers have been in use, scientists and university researchers have explored the possibilities for artificial intelligence to advance to such a state that machines can be free thinkers, anticipating and engaging in activities without supervision. Reaching this human-like level of AI has tremendous advantages for automating processes such as driving a car or instantly analyzing vast amounts of data. However, machine learning has been publicly greeted with a fair share of controversy as concerns of robot sentience threatening human lives have driven blockbuster movies and television shows.

Science fiction aside, the field of machine learning has gained traction in recent years, especially through progress in the construction of neural networks.[317] Interconnected artificial neurons send data to each other, and the computer-based network provides each connection between neurons with a weight, which transforms as the network identifies new relationships over time. The significance is that this network can adapt to a huge volume of information and activate corresponding outputs.[318] In the future, researchers could leverage this kind of technology at libraries to surface key themes and outcomes of studies, rather than navigating endless amounts of data. Major companies such as IBM are already spearheading development in this area. A research group at IBM is currently testing "Numenta," software designed to mirror the human brain as closely as possible. Initially the technology has been used to analyze satellite images of crops to pinpoint malfunctioning field equipment.[319]

Universities and campus libraries have been incubators for the latest machine learning research and technology development as it relates to solving major local and global challenges. At the Israeli Institute of Technology, a computer science student is working on a breakthrough tool that authentically analyzes sentiment in text messages, emails, and social media posts.[320] In combination with merging keyword searches and grammatical structures, the student applied algorithms to more than 5,000 posts that could be considered humorous or tongue-in-cheek, as well as more ordinary and sensible posts. The accuracy of the technology has been impressive thus far, and the ultimate goal is to help the police and other service organizations better identify people that pose a threat to themselves or society, based on the text they are sharing.

Relevance for Academic and Research Libraries

An increasing number of companies are already making use of machine learning to create self-service data preparation software that learns and makes improvements based on users' interactions.[321] Because libraries

house large data sets that pertain to publications and research materials, artificial intelligence could be particularly helpful for mining all related data and adjusting library services and information outputs in real time. Individual researchers who do not have the time to wade through vast amounts of data on their own, for example, could employ library tools that apply machine learning strategies to pinpoint key themes and observations. An example might be a researcher that poses a question about how different age groups respond to specific weather patterns, and receives a near instantaneous summary of comprehensive scientific and anecdotal analysis. Indeed, machine learning can afford new opportunities for cataloging data and metadata to make relevant research easier to organize and discover.

Additionally, academic library staff often manage a host of critical university support features that can be aided by AI. Deakin University in Australia recently partnered with IBM to leverage Watson — a cognitive computer with superhuman expertise. Watson technology is now accessible for all students and faculty through an individualized dashboard that enables users to seamlessly ask questions and receive immediate feedback, tailored to their personal profiles.[322] Machine learning can also be considered an important component of semantic applications and linked data, which help libraries more easily manage and disseminate key information about academic works. Journal articles and research reports can be dense, and computer algorithms are poised to help users make sense of the material at hand. Collaborative research conducted across three continents by Southwest University in China, University of Sydney, and University of Memphis has produced an AI system designed to automatically generate specific trigger questions from citations for academic writing.[323]

There is also an opportunity for libraries to support faculty and researchers exploring AI as world-class institutions such as Carnegie Mellon,[324] Duke University,[325] University of Toronto,[326] and University of Washington[327] tout robust machine learning departments. Ambitious student forays into the development of machine learning systems have included "StudentLife," an app designed by Dartmouth College students that can estimate grade point averages within nearly one-fifth of a point by measuring contributing factors such as sleep and exercise.[328] On a larger scale, these kinds of tools have the potential to predict major outcomes, giving people an opportunity to better prepare themselves for everything from bad traffic to economic crises. Programmers are increasingly leveraging advanced AI to map past data and project future events, which is directly informing the kinds of research that take place in libraries across the world.[329]

Machine Learning in Practice

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

Cornell Natural Language Processing Group (NLP)
go.nmc.org/cnlp
Cornell University NLP researchers work on a diverse set of projects in and machine learning, including information extraction and sentiment analysis. > *Leadership*

InFoLiS II - Integration of Research Literature and Data
go.nmc.org/infolis
The InFoLiS project has been developing algorithms for detecting and resolving references to research data in social science publications using text analysis and machine learning. A public API will allow users to embed the algorithms into their own systems and web applications. > *Leadership*

Criteo Dataset Part of an edX Machine Learning Course
go.nmc.org/criteo
(Criteo, 22 July 2015.) Criteo, a performance marketing technology company, released an anonymized public machine learning dataset, pulled from real-world applications, to the open-source community to support academic research and innovation in distributed machine learning algorithms. > *Practice*

For Further Reading

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

A Pioneer of Web Search and Machine Learning Brings Industry Know-How to the World of Academic Research
go.nmc.org/else
(Antonio Gullí, *Elsevier*, 1 May 2015.) Elsevier is leveraging machine learning to provide the infrastructure to support the researchers and users who need to access data from all kinds of scientific publications. > *Leadership*

Hacking the Humanities
go.nmc.org/hackhum
(Elias Muhanna, *The New Yorker*, 7 July 2015.) A literature professor discovered that algorithms can be used to study what makes a certain piece of text identifiably the product of a person, place, or time, from the perspective of syntax and vocabulary. > *Practice*

How to Machine-Learn Meaning in a Visual Social World
go.nmc.org/visworld
(Seth Grimes, *Breakthrough Analysis*, 12 July 2015.) Image analysis processing for feature extraction, coupled with machine learning techniques for pattern recognition, can uncover a visual's content, meaning, and emotion. > *Practice*

The 2015 NMC Horizon Project Library Expert Panel

Larry Johnson
Co-Principal Investigator
New Media Consortium
United States

Lambert Heller
Co-Principal Investigator
TIB Hannover
Germany

Andreas Kirstein
Co-Principal Investigator
ETH-Bibliothek Zurich
Switzerland

Rudolf Mumenthaler
Co-Principal Investigator
HTW Chur
Switzerland

Franziska Regner
Co-Principal Investigator
ETH-Bibliothek Zurich
Switzerland

Samantha Adams Becker
Lead Writer and Researcher
New Media Consortium
United States

Michele Cummins
Research Manager
New Media Consortium
United States

Bryan Alexander
Bryan Alexander Consulting
United States

Micah Altman
MIT
United States

Dale Askey
McMaster University Library
Canada

Oren Beit-Arie
Ex Libris
International Organization

Achim Bonte
Saxon State and University Library Dresden
Germany

Melissa Bowles-Terry
University of Nevada, Las Vegas
United States

Marwin Britto
University of Saskatchewan
Canada

Diane Butler
Rice University
United States

Mimi Calter
Stanford University Libraries
United States

Patrick Danowski
IST Austria
Austria

Kyle Dickson
Abilene Christian University
United States

John Dupuis
York University Libraries
Canada

Jacqueline Fritz
Bucks County Community College
United States

Rurik Thomas Greenall
Computas AS, Norway
Norway

David Groenewegen
Monash University
Australia

Annemarie Haar
California College of the Arts
United States

Anthony Helm
Dartmouth College
United States

Lisa Hinchliffe
University of Illinois, Urbana-Champaign
United States

Susan Hines
Chadron State College
United States

Sandra Hirsh
School of Information at San Jose State University
United States

Jan Howden
University of the West of Scotland
United Kingdom

Jefrina Jamaluddin
Taylor's University
Malaysia

Kevin Johnson
Osaka YMCA International School
Japan

Mylee Joseph
State Library of New South Wales
Australia

Melanie Klöß
Hochschul- und Kreisbibliothek Bonn-Rhein-Sieg
Germany

Ellyssa Kroski
New York Law Institute, Blog iLibrarian
United States

Brian Lavoie
OCLC
United States

Joan Lippincott
Coalition for Networked Information
United States

Suqing Liu
Peking University Library
China

Jake Orlowitz
Wikimedia Foundation
United States

David Parkes
Staffordshire University
United Kingdom

Geoff Payne
La Trobe University Library
Australia

Paolo Romano
European Documentation Centre-Università degli studi "Magna Graecia" Catanzaro Italy
Italy

Shawna Sadler
Deakin University
Australia

Frank Scholze
KIT Library Services
Germany

Pongracz Sennyey
St. Edward's University
United States

Lindley Shedd
The University of Alabama Libraries
United States

Paul Signorelli
Paul Signorelli & Associates
United States

Edlef Stabenau
TU Hamburg Harburg Library
Germany

Erik Stattin
Karolinska Institutet University Library
Sweden

Michael Stephens
School of Information at San Jose State University
United States

Aaron Tay
Singapore Management University
Singapore

Guus van den Brekel
University Medical Center Groningen, Central Medical Library
The Netherlands

Keith Webster
Carnegie Mellon University
United States

Janice Welburn
Marquette University
United States

Chengyu Zhang
Tsinghua University Library
China

Endnotes and Links

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ISBN 978-0-9962832-4-3

T 512-445-4200
F 512-445-4205
E communications@nmc.org

nmc.org

1250 Capital of Texas Hwy South
Building 3, Suite 400
Austin, TX 78746