Mapping the Current Landscape of Research Library Engagement with Emerging Technologies in Research and Learning:

Introduction, Methodology, and Cross-Cutting Opportunities

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This is the second installment of a forthcoming report, *Mapping the Current Landscape of Research Library Engagement with Emerging Technologies in Research and Learning*, that will be published in its entirety by late spring 2020.

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Executive Summary [published March 26, 2020]
Introduction, Methodology, and Cross-Cutting Opportunities [published April 2, 2020]
Facilitating Information Discovery and Use
Stewarding the Scholarly and Cultural Record
Advancing Digital Scholarship
Furthering Learning and Student Success
Building and Managing Learning and Collaboration Spaces

Introduction

The generation, dissemination, and analysis of digital information is a significant driver, and consequence, of technological change. As data and information stewards in physical and virtual space, research libraries are thoroughly entangled in the challenges presented by the Fourth Industrial Revolution:[1] a societal shift powered not by steam or electricity, but by data, and characterized by a fusion of the physical and digital worlds.[2] Organizing, structuring, preserving, and providing access to growing volumes of the digital data generated and required by research and industry will become a critically important function. As partners with the community of researchers and scholars, research libraries are also recognizing and adapting to the consequences of technological change in the practices of scholarship and scholarly communication.

Technologies that have emerged or become ubiquitous within the last decade have accelerated information production and have catalyzed profound changes in the ways scholars, students, and the general public create and engage with information. The production of an unprecedented volume and diversity of digital artifacts, the proliferation of machine learning (ML) technologies,[3] and the emergence of data as the "world's most valuable resource,"[4] among other trends, present compelling opportunities for research libraries to contribute in new and significant ways to the research and learning enterprise. Librarians are all too familiar with predictions of the research library's demise in an era when researchers have so much information at their fingertips. A growing body of evidence provides a resounding counterpoint: that the skills, experience, and values of librarians, and the persistence of libraries as institutions, will become more important than ever as researchers contend with the data deluge and the ephemerality and fragility of much digital content.

This report identifies strategic opportunities for research libraries to adopt and engage with emerging technologies,[5] with a roughly five-year time horizon. It considers the ways in which research library

values and professional expertise inform and shape this engagement, the ways library and library worker roles will be reconceptualized, and the implication of a range of technologies on how the library fulfills its mission. The report builds on a literature review covering the last five years of published scholarship—primarily North American information science literature—and interviews with a dozen library field experts, completed in fall 2019. It begins with a discussion of four cross-cutting opportunities that permeate many or all aspects of research library services. Next, specific opportunities are identified in each of five core research library service areas: facilitating information discovery and use, stewarding the scholarly and cultural record, advancing digital scholarship, furthering learning and student success, and building and managing learning and collaboration spaces. Each section identifies key technologies shaping user behaviors and library services, and highlights exemplary initiatives.

Underlying much of the discussion in this report is the idea that "digital transformation is increasingly about change management"[6]—that adoption of or engagement with emerging technologies must be part of a broader strategy for organizational change, for "moving emerging work from the periphery to the core,"[7] and a broader shift in conceptualizing the research library and its services. Above all, libraries are benefitting from the ways in which emerging technologies offer opportunities to center users and move from a centralized and often siloed service model to embedded, collaborative engagement with the research and learning enterprise.

Endnotes

1. Klaus Schwab, "The Fourth Industrial Revolution: What It Means, How to Respond," World Economic Forum, January 14, 2016, https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

2. Donna Ellen Frederick, "Libraries, Data and the Fourth Industrial Revolution," Data Deluge Column, *Library Hi Tech News* 33, no. 5 (July 4, 2016): 9–12, https://doi.org/10.1108/LHTN-05-2016-0025.

3. "ML is a subset of the larger field of artificial intelligence (AI) that 'focuses on teaching computers how to learn without the need to be programmed for specific tasks,' note Sujit Pal and Antonio Gulli in *Deep Learning with Keras*. 'In fact, the key idea behind ML is that it is possible to create algorithms that learn from and make predictions on data.'"—James Furbush, "Machine Learning: A Quick and Simple Definition," O'Reilly, May 3, 2018, https://www.oreilly.com/ideas/machine-learning-a-quick-and-simple-definition.

4. "The World's Most Valuable Resource Is No Longer Oil, but Data," Leaders, *The Economist*, May 6, 2017, https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data.

5. The definition of emerging technologies developed by Rotolo, Hicks, and Martin "identifies five attributes that feature in the emergence of novel technologies. These are: (i) radical novelty, (ii) relatively fast growth, (iii) coherence, (iv) prominent impact, and (v) uncertainty and ambiguity."—Daniele Rotolo, Diana Hicks, and Ben R. Martin, "What Is an Emerging Technology?," preprint, submitted February 13, 2015, last revised January 4, 2016, https://arxiv.org/abs/1503.00673.

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Methodology

The research for this report included a literature review and semi-structured interviews with experts in the library field. The author performed a review of library literature, focusing on publications appearing within the past five years. The literature review included publications that summarized and speculated on current and future technology trends in general, as well as case studies and theoretical treatments of a range of specific technologies and their adoption in the cultural heritage sector. The author conducted semi-structured interviews with a dozen library community experts, including library deans and directors and information science faculty members, in fall 2019. The author asked the interviewees to reflect on the potential impacts of emerging technologies, the most compelling examples of library adoption, pitfalls and challenges of adopting new technologies, and the future of library services in the information age.

This report is structured around five key library roles: facilitating information discovery and use, stewarding the scholarly and cultural record, advancing digital scholarship, furthering learning and student success, and building and managing learning and collaboration spaces. The report addresses both the implications of emerging technologies on the changing needs and behaviors of library constituents, and the adoption of emerging technologies within academic and research libraries. Therefore, each section begins with a brief landscape overview that discusses a number of relevant societal and technological shifts and their implications for aspects of the library mission. Next, each section identifies strategic opportunities for libraries to engage with and adopt emerging technologies to enhance and develop services, form new partnerships, and continue to support the research and learning mission of their institutions. The discussion of each strategic opportunity includes concrete, current examples from academic and research libraries. Each section concludes with a summary of key takeaways. Readers will find that some sections of this report have less extensive coverage. Uneven coverage generally reflects the fact that

library engagement with emerging technologies in each of these areas is also uneven, at least as measured in the published literature.

A glossary at the end of the report defines selected terms that may be unfamiliar to the reader, that have ambiguous usage in common speech, or that have a specific meaning within the context of this report.

Cross-Cutting Opportunities

A number of opportunities emerged from the literature and expert interviews that transcend any one area of research library services. These cross-cutting opportunities relate to the technologies that have already seen the most widespread or productive engagement and adoption within research libraries, the societal trends that are shaping research and learning activities most profoundly, and the ways in which both technological and societal shifts intersect with the research library's identity and mission.

Engage with Machine Learning to Improve Research, Learning, and Scholarly Communication

Machine learning, the sub-discipline of artificial intelligence (AI)[1] that "uses collections of examples to train software to recognize patterns, and to act on that recognition,"[2] has demonstrated a remarkable ability to match (and outpace) human performance on certain well-constrained but complex tasks, and is already incorporated into a range of common systems and devices. The term AI has taken on a life of its own; it is frequently invoked as an umbrella term for ML, natural language processing (NLP), expert systems, and related technologies that approximate human cognition. The casual use of the term AI often erases the distinction between substantive applications (for example, pattern and image recognition) and speculative and unproven uses (for example, prediction, reasoning, formulating original ideas).[3] In the interests of specificity and precision, this report makes an effort to identify specific technologies (such as ML) where possible, while recognizing that some initiatives invoke AI even when the scope of their activities focuses on a specific sub-technology.

As the near-term applications of ML and related technologies shape the ways in which scholars create and engage with information, students learn and study, and communities interact with their built environments, research libraries will be profoundly implicated, given their role as creators, sources, and stewards of information

and as educators. Many of the experts interviewed for this report identified ML as the most significant emerging technology for research libraries given its implications for the entire research and learning enterprise. This view is consistent with others in the field,[4] and reflected in a flurry of activity in cultural heritage and scholarly communications applications of ML. As ML approaches the peak of inflated expectations,[5] library experiments have proliferated. These tend to be one-off or first-of-a-kind projects that leverage ML in service of digital scholarship (for example, machine-generated metadata, natural language processing of large text corpora), with varying degrees of success. With a few notable exceptions, libraries are not yet systematically engaging with ML in ways that recognize its transformative potential across the full range of academic and research library services and activities. None of the 25 research-intensive libraries surveyed for a 2018 study mentioned ML or AI in their strategic plans.[6]

To move from ad hoc to strategic engagement with ML, libraries can cultivate a nuanced understanding of its affordances, limitations, and risks, and differentiate the genuine accomplishments of ML and related technologies from AI hype. Princeton University computer science professor Arvind Narayanan provides a simple litmus test to distinguish genuinely useful applications of AI and ML from problematic and unproven uses.[7] AI has shown demonstrable success for perception-related tasks (for example, facial recognition, medical diagnosis from images). It is making progress on tasks related to automating judgment (for example, spam detection, grading essays). However, Narayanan describes the premise that AI can be used for predictive analytics, especially predicting social outcomes (such as predicting criminal recidivism or job success), as "fundamentally dubious." Further, AI tools remain easy to fool and manipulate. They can be easily co-opted by bad actors for purposes never envisioned by their creators;[8] they can be gamed and manipulated for commercial or political gain. ML's reliance on human judgement and human-assembled training data make it particularly susceptible to problems of bias.[9]

The potential applications of AI and ML to research library workflows are myriad, from describing resources to providing reference services. Strategic investment in ML, informed by the ways emerging technologies have transformed user needs, can help libraries streamline longstanding processes. Perhaps more importantly, it can reinvent the ways in which they carry out their missions. For instance, ML's facility with tasks related to classification and pattern recognition and generation make it particularly germane to information discovery. A number of research libraries have initiatives underway that apply ML, computer vision, natural language processing, and other techniques to automate description of large-scale digital collections[10] and enhance discovery, access, and analysis systems.[11]

Principles of human-centered ML encourage librarians to "design an intelligent information system that respects the sources, engages critical inquiry, fosters imagination, and supports *human* learning and knowledge creation."[12] Human-centered AI does not replace human agency, human creativity, or human judgment. Rather it augments capacity, opens up new avenues of discovery, and enhances human potential by balancing high levels of automation with high levels of human control.[13] Libraries' longstanding interest in human-computer interaction for information retrieval and discovery, and the recent emphasis on user experience design in libraries, provide groundwork for research library involvement in the human-centered ML tools scholars need to create and engage with digital content. The entities such as labels, tags, and metadata generated by ML require infrastructure for preservation, and new approaches to metadata display that thoughtfully and ethically unite machine- and human-generated information.[14]

Finally, several libraries are leading critical discourse and educational efforts on their campuses around the implications, ethics, and future of ML.[15] Research libraries also have opportunities for field-level collaboration. For example, libraries could assemble the large volume of validated and labeled training data that drive ML algorithms in ways that aim to recognize or mitigate bias and that are sensitive to

the specific needs of cultural heritage materials.[16] The US national AI strategy includes several points of engagement for libraries, including: understanding and addressing the ethical, legal, and societal implications of AI; developing shared public data sets and environments for AI training and testing; and measuring and evaluating AI technologies through standards and benchmarks.[17]

Bolster Services That Recognize the Centrality of Data to the Research Enterprise

Big or small, textual, numeric, or visual, in support of the humanities, science, or interdisciplinary research, digital data and structured knowledge have become essential and ubiquitous scholarly inputs and first-order outputs.[18] Research libraries play a key role in data generation, dissemination, discovery, analysis, and stewardship and can contribute to realizing the vision of a FAIR (findable, accessible, interoperable, and reusable) data environment that advances open scholarship.[19] Over the next decade, cultivating a FAIR data ecosystem will require significant investment, creating myriad opportunities for libraries. Research libraries can contribute to FAIR data by describing structured data; building and providing access to machine-actionable and ML-ready data sets that facilitate computationally driven research; collaborating with domain experts to develop descriptive standards and ontologies that support disciplinary and multi-disciplinary research by humans and machines; and maintaining reuse-driven repository infrastructure.[20] Research libraries are developing services that are attuned to the needs of scholars working with very large data sets as well as the long tail of smaller, heterogeneous, unique, and often labor-intensive data sets that support research across the disciplinary spectrum. In their role as educators, librarians are also well positioned to cultivate data fluency and the technology skills required for data-driven research methods.[21]

The rise of data as both "scholarly output"[22] and input has expanded research library roles in facilitating access to data collections as source material, and providing solutions for long-term data stewardship.

Libraries recognize that "data is the currency of science," and that "[t]o be able to exchange data, communicate it, mine it, reuse it and review it is essential to scientific productivity, collaboration and to discovery itself."[23] Research libraries have responded by licensing data sets for research, providing curated access to publicly available data, offering guidance on intellectual property laws relevant to the use and reuse of data, and providing the infrastructure for use-and-reuse-driven data repositories. Libraries recognize that data stewardship increasingly requires access to the code and computing environments used to produce or analyze data, and are developing solutions to ensure that data is saved with this critical context.

Research libraries are also applying FAIR data principles to one of their most valuable troves of digital information: library digital collections. Making library collections machine-actionable enables new forms of inquiry and gives new life to one of the library's foundational services: collection stewardship. Some of the most innovative digital scholarship work uses computational processes to derive new insights from vast troves of digital and digitized content held in library collections. Machine-actionable collections enable researchers to go beyond simple information retrieval, treating collections (including their metadata, full-text, and relationships) as the input for powerful computational processes. Initiatives such as the Collections as Data project encourage cultural heritage institutions to thoughtfully develop digital collections (licensed, purchased, and unique) that support "computationally-driven research and teaching."[24]

The clear and urgent need for data services has led many libraries to hire dedicated data librarians and build data services portfolios and data repositories. Still, a 2017 survey found that around a quarter of R1 universities (doctoral universities with the highest level of research activity) had no dedicated data librarians on staff and that the average number of data librarians at R1 institutions was slightly over two.[25] The next several years may see libraries redefining roles and adding new positions in these areas to meet demand for data services, growing capacity for creating and sustaining machine-actionable collections,

and contending with large volumes of data that the library collects and manages.

Integrate the Library's Services and Collections with the Networked Environment

Researchers operate in geographically distributed, interdisciplinary, networked environments. Scholarly communication has also become diversified and disaggregated. The idea that research library services and infrastructure will also become increasingly outwardly focused, interoperable, and collaborative permeated the literature and the discourse of experts interviewed for this report. The formulations of library as platform, inside-out-library, and interoperable library, all allude to this central concept.

Research libraries are leveraging emerging technologies to make their services and collections interoperable and more seamlessly integrated into the lives and work of their constituents. For example, research libraries are ensuring that their unique digital collections—including digitized special collections, institutionally published content, and expert profiles—are interoperable with web-scale and federated discovery tools, by creating harvestable, machine-readable metadata, and associating them with persistent identifiers. The research library's role in information management is being reenvisioned: no longer solely a steward of a unified local collection, the library becomes the facilitator of a networked suite of open and extensible tools, resources, and services. Building local research collections will eventually diminish in importance, while curation and facilitated access to information become critical.[26] As research praxis routinely crosses institutional and geographic boundaries, research libraries also have opportunities to act consortially or outside of their local framework to maximize their impact. Research libraries could, for example, develop coordinated models of research data stewardship in which individual institutions assume responsibility for a segment of data (such as data defined by domain or type) based on local strengths and capacity.[27] Conversely, libraries could contribute their expertise to initiatives

that are not affiliated with or hosted by their (or any) campus, such as specialized "data communities."[28]

Cultivate Privacy Awareness and Privacy Services

Emerging technologies are redefining expectations of privacy and creating tensions around the ethical use of personal data. The ease of constant surveillance is facilitated in physical space by Internet of Things (IoT) technologies that collect continuous streams of data, and in virtual space by the collection of digital analytics by campus and third-party systems. ML tools can process this data with remarkable speed and precision, making genuine data de-identification nearly impossible. As students and scholars come to expect (data-driven) personalized digital services and as campuses expect to reap the benefits of large-scale data analytics, libraries will have critical choices to make. Research libraries can play a key role in helping their communities develop a nuanced understanding of privacy in physical and digital space. In their own work, libraries can commit to transparent policies on data collection, retention, and use, as well as conscious, thoughtful management and control of personal information. This includes negotiating vendor agreements that protect reader privacy,[29] offering trade-offs between privacy and personalization where appropriate,[30] and establishing boundaries around library participation in campus-wide data-collection efforts.[31]

A genuine commitment to privacy may become one of the research library's fundamental distinguishing features;[32] many libraries are working to provide (physical and virtual) spaces that consciously minimize and make transparent the ways in which users may be tracked or their data collected. Libraries have an opportunity to position themselves as leaders in privacy education and privacy-aware approaches to personalization, learning analytics, and the use of tracking technologies on campus. A core component of user-centered library services will be positioning users at the center of discussions about the ethical use of user data and the implementation of tracking devices, algorithmic decision-making tools, and other potentially

invasive technologies in libraries. At least two libraries—the New York Public Library and the University of Colorado Boulder—have formalized their commitment to privacy by creating a dedicated privacy officer position.[33]

Libraries are also scrutinizing their existing practices to ensure they align with commitments to protecting user data. Libraries' active and passive collection of user data—which may be identifiable, sensitive, and valuable—as well as their role as stewards of trustworthy information, profoundly implicates them in privacy and cybersecurity issues. Despite libraries' best intentions, they may be collecting and retaining data in ways that present risks to users or allow data collection by third-party platforms, which can expose user data to disclosure "by legal means, by hacking, or by human error."[34] Libraries can work internally and with their campus partners to determine their level of tolerance for data collection by external vendors, and negotiate licenses in ways that mitigate these risks.

On campus, libraries have an opportunity to position themselves as leaders in data-governance initiatives (which often have implications for student privacy), and collaborators in campus-wide privacy education and privacy-aware approaches to personalization, learning analytics, and the use of tracking technologies on campus.

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