Chapter 7

Data 101: Learning and Keeping Current in Data Management Skills

Abigail Goben and Rebecca Raszewski

Introduction

Most librarians are responsible for developing their own skill sets in order to prepare themselves for providing new services at their institution, and data management has become a new area where librarians can retool. While many of the skills needed directly correlate to library skills, data management offers unique challenges and a new vocabulary to master. This chapter provides overviews of the impetus for data management education and of self-directed learning theories. Application of these theories, as well as recommended resources, are reviewed for five areas of research data management self-education: foundational material; hands-on experience; data instruction and information literacy; community awareness and engagement; and looking beyond the library. By identifying their learning style and also the type of material sought, librarians can more effectively target their self-education data management activities.

Driving Policy and Background Literature

For many libraries in the United States, the impetus for developing research data management support came from a new trend emerging from federal funder policies. While biomedical librarians will be familiar with the National Institutes of Health (NIH) Public Access Policy[1] that was set forth in 2008, which requires NIH funded researchers to deposit finished copies of their articles into PubMed Central, the policy does not address research data as a separate or additional object.

---

[1] National Institutes of Health, "Revised Policy on Enhancing Public Access to Archived Publications Resulting from NIH-Funded Research."

The primary policy change bringing this to the fore came from the National Science Foundation (NSF) two years later,[2] when the various directorates began to universally require a two-page data management plan with all grant applications. This policy was followed by the Office for Science and Technology (OSTP) Memorandum,[3] which instructed federal agencies to expand access to the research they funded, including data. During 2014-2015, responses from many federal agencies to the OSTP have been published.[4] Many expand upon their present data policies and practices, like the NIH response.[5]

While these policies can be identified as specific drivers, the interest and focus in research data and the increasing role for librarians has been emerging over the past decade in response to overall changes in research and the scholarly communication landscape. Christine Borgman's book, *Scholarship in the Digital Age: Information, Infrastructure, and the Internet,*[6] is a foundational work in this area, providing a thorough overview and evaluating how research has been changing in the 21st century. Borgman's audience, which includes librarians, other information professionals, and the general research community, is confronting changing policies and social issues surrounding the research enterprise. Her book provides a framework of policies and practices around research that are evolving and what changes will need to be adopted.

---

[2] National Science Foundation, "Dissemination and Sharing of Research Results."
[3] Holdren, "Memorandum for the Heads of Executive Departments and Agencies: Increasing Access to the Results of Federally Funded Scientific Research."
[4] Whitmire et al., "A Table Summarizing the Federal Public Access Policies Resulting from the US Office of Science and Technology Policy Memorandum of February 2013."
[5] National Institutes of Health, "National Institutes of Health Plan for Increasing Access to Scientific Publications and Digital Scientific Data from NIH Funded Scientific Research."
[6] Borgman, *Scholarship in the Digital Age*.

Anna Gold and Dorothea Salo provide the librarian's perspective and identify emerging opportunities to engage with the framework Borgman has established. Gold's two-part article[7] identified a rising focus on cyberinfrastructure and big data, and outlines emerging areas for librarians' skills to be applied including bioinformatics, archival datasets, social science, and geographic information systems (GIS). Salo[8] approached the topic from the reskilling perspective—shifting librarian mindsets from carefully curated digital collections in the face of a poorly managed research data onslaught. While raising concerns regarding staffing and funding models, as well as the cultural shift, Salo is emphatic that these are roles librarians can and should embrace.

<p align="center">An Overview of Self-Directed Learning</p>

Librarians who need to develop their data management skills will be practicing aspects of self-directed learning (SDL), an adult education learning theory. SDL has been described as both a learner attribute and as a process. This learning process is usually controlled by the individual, as opposed to an instructor guiding the individual through formalized instruction. SDL is not an all-or-nothing process; every learner will experience different degrees of SDL, whether they are in a traditional lecture-style course led by an instructor or a self-paced module. SDL is also not done in isolation, as self-directed learners may share or discuss what they have learned with others, including an instructor or their peers.[9] SDL is unlike academic learning, which typically moves from the introductory to the more complex in "a systematic stepwise fashion."[10]

---

[7] Gold, A., "Cyberinfrastructure, Data, and Libraries, Part 1: A Cyberinfrastructure Primer for Librarians"; Gold, A., "Cyber Infrastructure, Data, and Libraries, Part 2."

[8] Salo, "Retooling Libraries for the Data Challenge."

[9] Merriam and Bierema, "Self-Directed Learning."

[10] Spear, "Beyond the Organizing Circumstance: A Search for Methodology for the Study of Self-Directed Learning."

The earliest SDL models were linear in design, assuming the learner went through a series of steps to achieve goals. Tough offered the first comprehensive description of SDL and referred to it as "self-planned learning."[11] His study on 66 individuals' learning projects found that learners planned 70% of all their learning projects. These learners also used 13 steps that presented key decision-making points about their learning. These steps included decision-making on what detailed knowledge and skills to learn; the specific activities, methods, or equipment needed; when to begin the actual learning activities; estimating current level of knowledge, skill, or progress; and taking steps to increase motivation for learning.[12]

Knowles, who is known for the adult learning theory Andragogy Theory, based his assumptions about adult learners on SDL.[13] The adult learner's maturity would guide the individual into being self-directed. Knowles' principles of andragogy also focused on SDL by involving the adult learners in planning and evaluating their instructions. This is because adult learning is usually problem-centered rather than content-oriented, which means instead of learning content in a particular subject area, their learning is more skills focused. Their experience provides the basis for their learning activities, and adults are mostly interested in subjects that are relevant to their job or personal life. His description of self-directed learning had six steps: climate setting, diagnosing learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.[14]

---

[11] Tough, *The Adult's Learning Projects: A Fresh Approach to Theory and Practice in Adult Learning*.

[12] Merriam and Bierema, "Self-Directed Learning"; Ellinger, "The Concept of Self-Directed Learning and Its Implications for Human Resource Development."

[13] Knowles, *The Adult Learner : A Neglected Species*.

[14] Spear, "Beyond the Organizing Circumstance: A Search for Methodology for the Study of Self-Directed Learning."

Interactive models about SDL developed later and primarily focused on the learning process. Spear and Mocker interviewed 78 self-directed learners, who had not completed high school requirements, about their self-education experiences.[15] Spear and Mocker discovered that instead of SDL being preplanned, it came from opportunities from the learner's own environment, past or new knowledge, or chance occurrences. SDL usually happened based on circumstances that may have influenced how they organized their learning. These SDL projects may occur from information gathered from one activity that may apply to another.[16] Unlike the linear theories presented in this chapter, Spear thought that a successful learning project would involve taking different learning activities and putting them together to determine what is the most important to what has been learned.[17]

Another example of an interactive SDL model is by Brockett and Hiemstra, whose framework for understanding self-directed learning has been modified over time.[18] The Personal Responsibility Orientation (PRO) model was "designed to recognize both the differences and similarities between SDL as an instructional method and learner self-direction as a personality characteristic."[19] The model both distinguishes between the SDL process and the individual learner and acknowledges how they are used together in SDL. Personal responsibility is seen as the model's central concept, and the individual is viewed as owning their thoughts and actions. Although the individual may not have control of the environment, the individual has control of her response as a learner and the responsibility for accepting the consequences of the actions as a

---

[15] Spear and Mocker, "The Organizing Circumstance: Environmental Determinants in Self-Directed Learning."
[16] Spear, "Beyond the Organizing Circumstance: A Search for Methodology for the Study of Self-Directed Learning."
[17] Merriam, Caffarella, and Baumgartner, "Self-Directed Learning."
[18] Brockett and Hiemstra, "A Conceptual Framework for Understanding Self-Direction in Adult Learning."
[19] Ibid.

learner. In 2012, Brockett and Hiemstra reconfigured and updated their framework, renaming it the Person Process Context (PPC) Model.[20] In the PPC model, the person, process, and context intersect with self-directed learning being in the middle, making sure all three are equally important, even if one of these will have a greater role in the individual's self-education. The context refers to the environment and sociopolitical climate. Making the context equivalent to the process and the person makes the PPC model distinct from the PRO model.

The last example is Garrison's Model, which has three overlapping dimensions: self-management (task control), self-monitoring (cognitive responsibility), and motivation (entering and task). Self-management situates the learners within the social context and is the degree to which the learners assumes control of the environment so they can meet their goals. It also involves the learners' management of their learning materials. Self-management is not done in isolation; it is seen as a collaborative experience between the teachers and learners. Self-monitoring is the ability of the learners to monitor their cognitive and metacognitive processes associated with reflective practice and critical thinking. They are taking responsibility for their learning, integrating their new-found skills with their previous knowledge. Motivation is what keeps learners engaged in self-directed learning. Within the learners' motivations, Garrison differentiates "between the process of deciding to participate (entering motivation) and the effort required to stay on task and persist (task motivation)".[21] Learners should internalize the tasks and goals that are given to them for their own needs.

---

[20] Hiemstra and Brockett, "Reframing the Meaning of Self-Directed Learning: An Updated Model."
[21] Garrison, "Self-Directed Learning: Toward a Comprehensive Model."

SDL has also been specifically studied in the workplace. One example is Clardy's research on vocationally-oriented SDL projects (VO SDLP).[22] These projects could be influenced by either the employee's motivation or organizational factors. Clardy interviewed 56 employees from six different kinds of organizations. Out of the 109 learning projects that were mentioned, 90 projects met the criteria of a VO SDLP. Four types of projects were identified: induced, synergistic, voluntary, and scanning. An induced VO SDLP occurs due to performance job standards, such as needing to learn a new system to do one's job. Voluntary VO SDLPs are based on the employee's own initiative instead of a work requirement. Synergistic VO SDLPs can happen from a combination of the employee's motivation to learn and the workplace's influence. A scanning VO SDLP is defined as ongoing searching for information as a way to keep current.

It is advantageous for librarians to identify the style that is most closely aligned with their preferred learning method in order to most successfully engage in self-education. Once they have identified their style, librarians can choose from the formats and resources mentioned below and determine the learning opportunities that will best meet their needs.

<div align="center">Foundational Data Management Skills</div>

For many librarians, a broad overview and introduction to data management is necessary to help frame future self-education. A number of introductory opportunities exist for librarians. While the majority of opportunities in this section are freely available, ideas for those seeking to develop a formalized, data management specialization will also be covered. The opportunities covered in this section can apply to either linear or interactive SDL models.

---

[22] Clardy, "Learning on Their Own: Vocationally Oriented Self-Directed Learning Projects."

Several curricula have been developed as educational tools for librarians seeking self-education, as well as lesson plans in a more classroom-type structure for background and foundational information. These resources provide an introduction to the data life cycle, data management plans, and best practices. It should be noted that these curricula were originally developed several years ago, and there has been a large amount of change in funding agency and institutional policies in the interim. While updated material has been added to some curricula, such as additional case studies, the efficacy of these curricula is slightly lessened in this respect. The NIH-funded New England Collaborative Data Management Curriculum (NECDMC)[23] and the NSF-funded DataOne Curriculum[24] both grew in response to the NSF data management plan requirement. Another excellent curriculum is MANTRA from the UK.[25]

The Lamar Soutter Library at University of Massachusetts Medical School, which co-created and manages the NECDMC, has become a leader in educating librarians on data management and training librarians in teaching data management. Additionally, since 2009, they have sponsored the University of Massachusetts and New England Area Librarian e-Science Symposium[26] and hosted the e-Science Portal. The symposium's goal is for librarians to understand federal research funding agencies' data management policies, help them gain skills for managing human research data, and see examples of how universities developed their institutional data repositories. Archived presentation materials and videos are available.[27] The

---

[23] Lamar Soutter Library - University of Massachusetts Medical School, "New England Collaborative Data Management Curriculum."
[24] DataONE, "DataONE Education Modules."
[25] University of Edinburgh, "MANTRA: Research Data Management Training."
[26] "University of Massachusetts and New England Area Librarian E-Science Symposium."
[27] University of Massachusetts and New England Area Librarians, *eScience Symposium Channel*.

Lamar Soutter Library also hosts an e-Science Portal,[28] which draws together subject experts to provide a curated compilation of resources across data management and the research environment. Librarians who prefer to be self-motivated in their SDL may find that these types of resources and curricula will meet their needs.

Librarians who need more formal data management education should consider a post-baccalaureate or post-master's certificate in data management. Data science certificates are available at schools such as Indiana University, but these types of programs may be geared towards librarians with a background or interest in programming rather than data management. Librarians could also consider contacting a library school to see if they can audit a data management course. These more structured educational opportunities will be appropriate for those who prefer something like Tough's linear model for their SDL.

Those who are seeking a more structured educational opportunity but not a certificate could consider training at the Inter-university Consortium for Political and Social Research, (ICPSR), a unit of the Institute for Social Research at the University of Michigan. ICPSR hosts a fee-based workshop on Curating and Managing Research Data for Re-use.[29] This five day workshop uses ICPSR social science and United Kingdom Data Archive data collections for case studies, tracking the datasets through data assessment, review, processing, and curation. Attendees also learn about data review and preparation, confidential data management, digital repository requirements, and more.

---

[28] University of Massachusetts Medical School, "E-Science Portal for New England Librarians: A Librarians Link to E-Science Resources."
[29] Inter-university Consortium for Political and Social Research, "Course Descriptions."

The Medical Library Association (MLA)[30] has offered several data management continuing education opportunities for either individuals or in a group setting. These opportunities usually provide continuing education credits for those interested in earning Academy of Health Information Professional (AHIP) points. The MLA annual meeting usually has fee-based, continuing education data management courses that may be held before or after the annual meeting. Those who cannot attend the annual meeting may also find data management offerings at MLA chapter meetings. MLA has also sponsored data management webinars that can be viewed at libraries that offer to host the webinars for free. Those who cannot attend in person can view the recordings for a fee. Those seeking group educational activities at their institutions or planning chapter meetings should browse the MLA Educational Clearinghouse,[31] which lists several current data management courses. Librarians may also find additional educational opportunities at conferences held by the Association of College and Research Libraries (ACRL),[32] the American Library Association (ALA),[33] and the Special Libraries Association (SLA).[34] There may also be regional, data-themed conferences for librarians who cannot attend a national conference.

For learners looking for other online continuing education or who cannot travel for this type of education might consider Library Juice Academy.[35] This vendor offers online professional development courses for librarians that allow them to earn continuing education units. Library Juice Academy offers an asynchronous research data management course that can be completed within a month. When the course is not being offered during a given month, the

---

[30] Medical Library Association, "MLA : Home Page."
[31] Medical Library Association, "MLA Educational Clearinghouse."
[32] American College of Research Libraries, "Association of College & Research Libraries."
[33] American Library Association, "American Library Association."
[34] Special Libraries Association, "Special Libraries Association."
[35] Library Juice Academy, "Library Juice Academy Courses."

course can be offered as a special session for a group. This course could meet the needs of a variety of self-directed learners, from those who want a structured class to those who want more of an interactive engagement with their classmates.

Hands-On Data Management

As outlined in the SDL interactive models, part of SDL will lie in participating with research data management actively. This may be accomplished through learning to use tools for data management activities or going through the workflow, which would apply in Clardy's article on VO SDLP. However, what may be most impactful is curating a dataset. Self-educators may find it useful to find a dataset that is particularly meaningful to them to curate and use as their sample through the data lifecycle and their self-education process. For librarians, this may mean looking at patron interaction statistics, circulation and electronic resources' usage statistics, or other administrative data that has lasting value and may not presently be regularly analyzed past a routine report. As we have outlined in a recent case study,[36] it is valuable to work through the data lifecycle with a library dataset because the librarian has immediate context with the data.

By examining a familiar dataset, librarians are able to engage more confidently with the research data management aspect of the new material and identify with the challenges and questions researchers may face. Using library data can also make it easier to explore software tools without having to also potentially struggle with understanding the context of the data. For librarians learning together in a group with a variety of different areas of subject matter expertise, working with a dataset from the library field creates common ground and helps prevent confusion. Finally, using library data may result in the unexpected benefit of improved workflows for the library staff— librarians who learn from using their own data may be able to

---

[36] Goben and Raszewski, "The Data Life Cycle Applied to Our Own Data."

improve capture or handling of the data, implement data management far earlier in the pipeline, and prevent inconsistencies or other data analysis issues.

<div align="center">Data Instruction and Information Literacy</div>

During the self-education process or after gaining foundational knowledge, librarians may wish to teach data literacy and research data management skills to students, staff, and faculty. Data Information Literacy (DIL) shares many similarities to information literacy skills that librarians are already using in their teaching. The primary DIL resource is the Data Information Literacy Project,[37] which was developed by librarians at Purdue, the University of Minnesota, the University of Oregon, and Cornell. Their work, funded by the Institute of Museum and Library Services (IMLS), was targeted at creating resources for librarians teaching primarily graduate students and researchers about best practices in both creating and consuming data. The book of case studies that has emerged from the project[38] may be of particular interest to librarians determining what audiences to target or those looking for curriculum ideas. This volume also includes recommendations for assessing DIL instruction.

The Data Management Plan Tool (DMPTool), created consortially and hosted by the California Digital Library may also be helpful to librarians who are preparing for data instruction.[39] The software was designed to guide researchers through creating a DMP that would meet the new NSF requirements. To that end, it has specific templates for each NSF directorate and also continues to be updated to include templates for the NIH, IMLS, and several other funders and foundations as new policies are adopted. Each template guides the researcher through areas to consider and points out questions they may wish to answer prior to grant

---

[37] "Data Information Literacy."
[38] Carlson and Johnston, *Data Information Literacy*.
[39] California Digital Library, "Data Management Planning Tool."

submission. Updates including the ability to have multiple authors on a DMP, technological capability to allow universities to link to the DMPTool in order to allow researchers use their institutional log in, and improved opportunities to share and read DMPs have further enhanced this tool both for researchers and for education. Because there is no limit to the type or number of DMPs that can be created, students can work through examples for different kinds of datasets in a controlled environment and identify areas where further exploration or answers may be needed before tackling formal grant applications.

<div align="center">Engaging with the Community</div>

The data librarian community offers the self-educator the opportunity to participate with literature, societies, conferences, and social media. After gaining foundational knowledge through curriculum or literature, librarians are prepared to engage with current trends, identify new opportunities, and collaborate (or commiserate) with other data librarains about the challenges of working with research data management in the library setting.

Presently, there is no one specific peer-reviewed journal identified as the leader for research data management as a subject of study. Instead, research, case studies, editorials, and book reviews are published in a variety of journals that target science, technology, engineering, and mathematics (STEM) librarians and also scholarly communication librarians. Table 5.2 includes a selection of journals that may be of particular interest to biomedical librarians interested in working with research data management.

<Insert Table 5.2 here>

A number of professional library organizations have increased their focus on data management as the topic has grown in popularity and importance to the profession. Many host conference sessions, online and in-person education, and listservs or other communication

channels that allow the community to engage with each other and collaborate to develop new resources. Among these organizations, the most targeted towards research data management is the Research Data, Access, and Preservation (RDAP)[40] subsection of the Association for Information Science and Technology (ASIS&T). RDAP holds a two-day conference each spring, specifically addressing the needs, emerging opportunities, and challenges for librarians and information professionals focused on research data. The listserv is the other primary outlet for this group. As previously mentioned, MLA also continues to provide continuing education for biomedical librarians working with research data. Other library organizations with groups that address research data management include ACRL, SLA, and the Association of Research Libraries (ARL).[41]

While traditional types of professional engagement like conference attendance and participation in listservs has helped create community, engagement in the data librarian community has also grown through different forms of social media. As these platforms are frequently subject to change, it is challenging to provide a specific list of users or accounts to follow. On Twitter, searching the *#datalibs* hashtag will assist in identification of who is presently discussing this topic. Another project built recently to bring the community together is the DataQ project, which describes itself as "a collaborative platform for answering research data questions in academic libraries." [42] Also sponsored by IMLS, this project brings both common and unusual topics together for review by interested librarians and provides a forum for advice from experts in the field.

---

[40] RDAP, "RDAP: Research Data Access & Preservation Summit."
[41] Association of Research Libraries, "Association of Research Libraries."
[42] DataQ, "Welcome to DataQ."

Beyond the Library

Though most librarians will be focused on serving their library, the expanding interest in data brings new opportunities for librarians to develop new skillsets and take on new roles working with research data. Data science (further discussed in chapter 7 of this book) can be broadly defined as an interdisciplinary field that is seeking to identify answers to myriad questions drawing on the increasing amounts of available data. Data visualization (further discussed in chapter 13 of this book) seeks to present data in charts, graphs, and images that provide both impact and are easily understood. These fields have specific degree and certificate programs and a defined skill set beyond the research data management targeted in this chapter. However, basic familiarity will be beneficial for those interested in going beyond academia and further understanding the vocabulary of the field.

A librarian looking for a transitional text between librarianship and data science could consider reading *The Accidental Data Scientist*.[43] Working within the framework of librarianship, Affelt identifies the relationship between the two fields and outlines the opportunities for librarians who are interested in further engagement. She also provides vocabulary to clarify the topic. O'Neil and Schutt's text *Doing Data Science: Straight Talk from the Frontline*[44] is another helpful book that provides further foundation in data science. It provides an in-depth outline of the field including practical applications from fields where data science is most heavily used, including finance, engineering, journalism, and data visualization.

After reviewing the literature but perhaps before seeking out a formal program, free or low cost self-education in the area of Massive Open Online Courses (MOOCs) can provide a

---

[43] Affelt, Amy, *The Accidental Data Scientist*.
[44] *Doing Data Science*.

bridge between librarianship and data science. Coursera[45] provides free MOOCs on data-related topics from universities, with the fee-based option to receive a certificate upon successful completion of the course. A MOOC like Johns Hopkins' data science specialization[46] may be a consideration for those who want a free or low-cost option outside of formal library education. The specialization, which can be taken for a certification, includes a series of nine month-long courses, ending with a capstone project. Other courses providers include Lynda[47], a fee-based learning website many academic institutions use, and Udacity.[48] These online courses often assume a higher level of statistical knowledge or coding capability than most library-targeted education, so introductory courses in those areas may be needed first.

Finally, as with library professional organizations, there are a number of data-focused professional organizations for engaging with the community and the research. While RDAP, described above, is primarily made up of data librarians, its parent organization ASIS&T spans information science, computer science, technologists, linguists, and educational specialists. The Research Data Alliance (RDA)[49] is an international organization that promotes the cross-disciplinary sharing of data and has Libraries for Research Data Interest Group.

Conclusion

As librarians continue to develop data management services, self-education and continuing education will be important aspects of preparation. Fortunately, traditional library skills will still serve librarians doing this work, and there are many resources that can aid learners who want to gain new skills. After exploring their self-education style and finding the

---

[45] Coursera, "Coursera -Free Online Courses From Top Universities."
[46] Johns Hopkins University, "Launch Your Career in Data Science."
[47] Lynda.com, "Lynda.com."
[48] Udacity, "Udacity."
[49] Research Data Alliance, "RDA-Research Data Sharing without Barriers."

best resources to meet their individual needs, librarians can become part of a rich network of data-interested and or data-supporting librarians.

<div align="center">Pearls</div>

- Identify the best learning style for you as the self-directed learner. This will help you to choose resources that will best meet your needs

- Choose a combination of both foundational and current/networking

- Educational opportunities for learning about data management exist in several different formats. These can be taken in person or online.

<div align="center">Recommended Reading:</div>

Borgman, Christine L. 2012. "The Conundrum of Sharing Research Data." *J Am Soc Inf Sci Technol* 63 (3): 1059–78. doi:doi: 10.1002/asi.22634.

Borgman, Christine L. 2015. *Big Data, Little Data, No Data: Scholarship in the Networked World*. Cambridge, MA: MIT Press.

Briney, Kristin. 2015. *Data Management for Researchers: Organize, Maintain and Share Your Data for Research Success*. Exeter, United Kingdom: Pelagic Publishing.

Goben, Abigail, and Rebecca Raszewski. 2015. "The Data Life Cycle Applied to Our Own Data." *Journal of the Medical Library Association: JMLA* 103 (1): 40.

Gold, A. 2007a. "Cyberinfrastructure, Data, and Libraries, Part 1: A Cyberinfrastructure Primer for Librarians." *D-Lib Magazine* 13 (9/10). doi:doi:10.1045/september20september-gold-pt1.

———. 2007b. "Cyber Infrastructure, Data, and Libraries, Part 2." *D-Lib Magazine* 13 (9/10). doi:doi:10.1045/july20september-gold-pt2.

Goodman, Alyssa, Alberto Pepe, Alexander W. Blocker, Christine L. Borgman, Kyle

    Cranmer, Merce Crosas, Rosanne Di Stefano, et al. 2014. "Ten Simple Rules for the Care

    and Feeding of Scientific Data." *PLoS Comput Biol* 10 (4): e1003542.

    doi:10.1371/journal.pcbi.1003542.

Salo, Dorothea. 2010. "Retooling Libraries for the Data Challenge." *Ariadne*, no. 64.

    http://www.ariadne.ac.uk/issue64/salo.

Bibliography

Affelt, Amy. *The Accidental Data Scientist: Big Data Applications and Opportunities for*

    Librarians and Information Professionals. Medford, NJ: Information Today, Inc., 2015.

American College of Research Libraries. "Association of College & Research Libraries," 2015.

    http://www.ala.org/acrl/.

American Library Association. "American Library Association," 2015. http://www.ala.org/.

Association of Research Libraries. "Association of Research Libraries." Accessed September 29,

    2015. http://www.arl.org/.

Borgman, Christine L. *Scholarship in the Digital Age: Information, Infrastructure, and the*

    Internet. Cambridge, MA: MIT Press, 2010.

Brockett, Ralph G., and Roger Hiemstra. "A Conceptual Framework for Understanding Self-

    Direction in Adult Learning." *Self-Direction in Adult Learning: Perspectives on Theory,*

    Research, and Practice, 1991, 18–33.

California Digital Library. "Data Management Planning Tool," 2015. https://dmptool.org/.

Carlson, Jake, and Lisa R. Johnston, eds. *Data Information Literacy: Librarians, Data and the Education of a New Generation of Researchers*. West Lafayette, IN: Purdue University Press, 2015.

Clardy, Alan. "Learning on Their Own: Vocationally Oriented Self-Directed Learning Projects." *Human Resource Development Quarterly* 11, no. 2 (2000): 105–25. doi:10.1002/1532-1096(200022)11:2<105::AID-HRDQ2>3.0.CO;2-5.

Coursera. "Coursera -Free Online Courses From Top Universities," 2015. https://www.coursera.org/.

"Data Information Literacy." Accessed September 29, 2015. http://www.datainfolit.org/.

DataONE. "DataONE Education Modules," November 12, 2012. https://www.dataone.org/education-modules.

DataQ. "Welcome to DataQ," 2015. http://researchdataq.org/.

Ellinger, Andrea D. "The Concept of Self-Directed Learning and Its Implications for Human Resource Development." *Advances in Developing Human Resources* 6, no. 2 (2004): 158–77. doi:10.1177/1523422304263327.

Garrison, D. R. "Self-Directed Learning: Toward a Comprehensive Model." *Adult Education Quarterly* 48, no. 1 (1997): 18–33. doi:10.1177/074171369704800103.

Goben, Abigail, and Rebecca Raszewski. "The Data Life Cycle Applied to Our Own Data." *Journal of the Medical Library Association: JMLA* 103, no. 1 (2015): 40–44. doi:10.3163/1536-5050.103.1.008.

Gold, A. "Cyberinfrastructure, Data, and Libraries, Part 1: A Cyberinfrastructure Primer for Librarians." *D-Lib Magazine* 13, no. 9/10 (2007). doi:10.1045/september20september-gold-pt1.

———. "Cyber Infrastructure, Data, and Libraries, Part 2." *D-Lib Magazine* 13, no. 9/10 (2007). doi:10.1045/july20september-gold-pt2.

Hiemstra, R., and R. G. Brockett. "Reframing the Meaning of Self-Directed Learning: An Updated Model," 155–61. Saratoga Spring, NY: SUNY Empire State College, 2012.

Holdren, John P. "Memorandum for the Heads of Executive Departments and Agencies: Increasing Access to the Results of Federally Funded Scientific Research." *Office of Science and Technology Policy, Executive Office of the [US] President, The White House*, February 22, 2013. http://www.whitehouse.gov/sites/default/files/microsites /ostp/ostp_public_access_memo_2013.pdf.

Inter-university Consortium for Political and Social Research. "Course Descriptions." Accessed September 21, 2015. http://www.icpsr.umich.edu/icpsrweb/content/sumprog/ courses.html.

Johns Hopkins University. "Launch Your Career in Data Science," 2015. https://www. coursera.org/specializations/jhudatascience.

Knowles, Malcolm S. *The Adult Learner : A Neglected Species*. 4th ed. Building Blocks of Human Potential. Houston: Gulf Publishing Co, 1990.

Lamar Soutter Library - University of Massachusetts Medical School. "New England Collaborative Data Management Curriculum," 2015. http://library. umassmed.edu/necdmc/index.

Library Juice Academy. "Library Juice Academy Courses." Accessed September 21, 2015. http://libraryjuiceacademy.com/courses.php.

Lynda.com. "Lynda.com," 2015. http://www.lynda.com/.

Medical Library Association. "MLA Educational Clearinghouse." Accessed September 21, 2015.

    http://cech.mlanet.org/.

———. "MLA : Home Page," 2015. http://mlanet.org/.

Merriam, Sharan B., and Laura L. Bierema. 2014. \iAdult Learning: Linking Theory and

    Practice. The Jossey-Bass Higher and Adult Education Series. San Francisco: Jossey-

    Bass.

Merriam, Sharan B., Rosemary S. Caffarella, and Lisa Baumgartner. "Self-Directed Learning."

    In *Learning in Adulthood: A Comprehensive Guide*. San Francisco: Jossey-Bass, 2007.

National Institutes of Health. "National Institutes of Health Plan for Increasing Access to

    Scientific Publications and Digital Scientific Data from NIH Funded Scientific

    Research," February 2015. http://grants.nih.gov/grants/NIH-Public-Access-Plan.pdf.

———. "Revised Policy on Enhancing Public Access to Archived Publications Resulting from

    NIH-Funded Research," January 11, 2008. http://grants.nih.gov/grants/guide/notice-

    files/NOT-OD-08-033.html.

National Science Foundation. "Dissemination and Sharing of Research Results." *US NSF -*

    About, November 30, 2010. http://www.nsf.gov/bfa/dias/policy/dmp.jsp.

O'Neil, Cathy, and Rachel Schutt. *Doing Data Science: Straight Talk from the Frontline*.

    Sebastopol, CA: O'Reilly Media, 2013.

RDAP. "RDAP: Research Data Access & Preservation Summit," 2015.

    https://www.asis.org/rdap/.

Research Data Alliance. "RDA-Research Data Sharing without Barriers." Accessed September

    21, 2015. https://rd-alliance.org/.

Salo, Dorothea. "Retooling Libraries for the Data Challenge." *Ariadne*, no. 64 (2010). http://www.ariadne.ac.uk/issue64/salo.

Spear, George E. "Beyond the Organizing Circumstance: A Search for Methodology for the Study of Self-Directed Learning." *Self Directed Learning: Application and Theory*, 1988, 199–222.

Spear, George E., and Donald W. Mocker. "The Organizing Circumstance: Environmental Determinants in Self-Directed Learning." *Adult Education Quarterly* 35, no. 1 (1984): 1–10. doi:10.1177/0001848184035001001.

Special Libraries Association. "Special Libraries Association." *Special Libraries Association*, 2015. http://www.sla.org/.

Tough, Allen M. *The Adult's Learning Projects: A Fresh Approach to Theory and Practice in Adult Learning*. Austin, TX: Ontario Institute for Studies in Education, 1979. http://ieti.org/tough/books/alp.htm.

Udacity. "Udacity," 2015. https://www.udacity.com/.

University of Edinburgh. "MANTRA: Research Data Management Training," September 10, 2014. http://datalib.edina.ac.uk/mantra/.

"University of Massachusetts and New England Area Librarian E-Science Symposium." Accessed September 17, 2015. http://escholarship.umassmed.edu/escience_symposium/.

University of Massachusetts and New England Area Librarians. *eScience Symposium Channel*, n.d. https://www.youtube.com/user/UMeScienceSymposium.

University of Massachusetts Medical School. "E-Science Portal for New England Librarians: A Librarians Link to E-Science Resources," 2015. http://esciencelibrary.umassmed.edu/index.

Whitmire, Amanda, Kristin Briney, Amy Nurnberger, Margaret Henderson, Thea Atwood,

Margaret Janz, Wendy Kozlowski, Sherry Lake, Micah Vandegrift, and Lisa Zilinski. "A

Table Summarizing the Federal Public Access Policies Resulting from the US Office of

Science and Technology Policy Memorandum of February 2013," April 9, 2015.

http://figshare.com/articles/A_table_summarizing_the_Federal_public_access_policies_r

esulting_from_the_US_Office_of_Science_and_Technology_Policy_memorandum_of_F

ebruary_2013/1372041.