Developing Data Services Skills in Academic Libraries

Justin Fuhr

Research data services are increasingly offered by academic libraries. As a result, librarians may need to upskill to provide data services and build capacity. This study measures the current level of data services skills of academic librarians and explores preferred methods of continuing education. An online survey was circulated asking respondents to self-assess data skills in four categories. The results capture a baseline of self-assessed data skills and show statistical significance between the percentage of time a librarian provides data services and higher levels of technical skill sets. The findings support the hiring of data librarians in academic libraries offering data services and providing training for librarians who provide any level of data services.

Introduction

Library and information studies (LIS) has long emphasized continuing education as the field moves quickly and regularly adopts new services. Librarians may need to acquire new skills to offer newly adopted services to their users. Professional development is especially relevant in new areas of academic librarianship where librarians may not already have the skill sets required to adequately provide services.

One new area of academic librarianship is research data services, or simply, data services. Tenopir et al. define data services as "services that address the full data lifecycle, including the data management plan, digital curation (selection, preservation, maintenance, and archiving), and metadata creation and conversion."[1] An academic librarian requires a varied skill set to provide data services, which may include data mining, metadata knowledge, technical details of repository hardware and software, programming and software expertise, legal and policy knowledge, library instruction, and research consultations, among others.

Increasingly, digital research data are produced in research postsecondary institutions. As more and more digital data are produced, it is important to manage and organize data, so it remains accessible in the future. Studies have shown there has been growth of data services in academic libraries during the past decade.[2] Tenopir et al. recognize some institutions hired specialized data librarians to provide library data services; however, other librarians have found themselves reassigned to this role, with variable amounts of time spent providing data services. In these cases, it is sensible to provide librarians with training to enhance existing skill sets.

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Using an online survey of academic librarians, this study measures the current level of data services skills of academic librarians. Additionally, this paper explores the preferred method of professional education in support of academic librarians providing data services.

Literature Review

Data Services as an Emerging Area of Academic Librarianship

Managing research data has come to the forefront of academic library services as more research data are created digitally and postsecondary institutions adopt and are receptive to new ideas and trends like the open science movement. Academic librarians have positioned themselves to offer these services at the same time as data services are adopted by many postsecondary institutions. Researchers have described how academic librarians are integral to providing research data services.[3] Pryor and Donnelly recognized early the role librarians could play in data services.[4] They describe the 2008 Research Data Management Forum where attendees envisioned four data-related roles: data librarians alongside data creators, data scientists, and data managers.

LIS researchers make a convincing case for academic librarians to provide research data services, and many academic libraries have demonstrated that librarians can confidently provide data services.[5] There is a recognition that academic librarians, who have long provided services to find and access research outputs, are a natural fit to manage inputs such as data.

As research data services picked up momentum in academic libraries, Tenopir, Birch, and Allard's seminal Association of College and Research Libraries' (ACRL) survey was published.[6] The survey invited library directors of ACRL institutions to respond and provide a baseline of what data services were offered in the early 2010s and what services would be offered in the future. While a very small number of institutions were offering data services at the time, the authors found a quarter to a third planned to do so in the near future. Tenopir et al. also found the majority (71.1%) of data services providers were subject-area liaison librarians, compared to dedicated data librarians (5.8%).

Just a year later, Tenopir, Sandusky, Allard, and Birch published results of a survey sent to librarians working at Association of Research Libraries (ARL) member libraries.[7] While they found almost 75 percent of libraries do not offer data services, the majority of survey participants responded that they believe they have the skill set to support such services moving forward.

The growing prevalence of academic library data services is shown in large empirical studies and institutional analyses, undertaken to determine the extent of academic library data services in the early 2010s,[8] and in a follow-up analysis in Tenopir, Sandusky, Allard, and Birch, using the same data from the study undertaken by Tenopir et al. in 2012.[9] In their 2014 survey, Tenopir et al. found close to 83 percent of North American academic libraries plan to offer data services by 2016. However, only 31 of 99 libraries offered data services training to library staff.

Subsequent studies have shown continued research data services offered in academic libraries.[10] In particular, the 2019 ACRL white paper by Tenopir et al. finds data services growing and acts as a follow-up study to the 2012 study by Tenopir, Birch, and Allard. The authors find 44.1 percent of respondent libraries are not providing any research data services. This is down from 60 percent of libraries not providing any data services in 2012, meaning a considerably higher percentage of libraries are offering these services when compared with the previous survey. Tenopir et al. divide data services into two categories: informational and consultative services (such as consulting with faculty about data management plans)

and technical and hands-on services (such as managing data repositories). Like the results from their 2012 survey, in 2019 libraries more commonly offer informational and consultative data services compared to technical and hands-on services. The same conclusion is found in Cox et al.[11] The study analyzed data from two international surveys and found technical data services are lacking in comparison to consultative services. This is important to keep in mind as we explore training required for academic librarians to provide data services.

Challenges in Providing Data Services

With research data services becoming more common, there remain significant challenges to overcome. As with any newly emerged service, it is inevitable that there is a period of transition. Authors have noted lack of skill and confidence;[12] financial limitations such as equipment costs;[13] inadequate staffing;[14] and little to no institutional support.[15]

Among these challenges, ensuring that academic librarians are trained and possess an appropriate skill set is a particularly significant challenge. Research has been undertaken to determine what competencies are needed to provide full, mature academic library data services. With actionable competencies, training can be provided to bridge skill gaps that exist. Federer has completed work to develop data services competencies, which aids librarians who wish to develop their skill set in this area.[16] Along with a list of competencies, Federer found two clusters of survey participants emerging: *subject specialists* (specializing in a specific subject and focusing on a smaller number of tasks) and *data generalists* (range of tasks that work broadly across disciplines).

At the Arizona State University Library, as they implemented robust research data services, the library created an internal Research Services Working Group to develop their own data management competencies for library staff. In addition to the competencies, Harp and Ogborn describe a supportive work environment conducive to educating their library staff as instrumental in successfully delivering their research data services to their users.[17]

Federer et al. reviewed the Medical Library Association's Data Services Competency framework, which prepares librarians to provide data services.[18] The competency framework includes five performance indicators: applies principles of data literacy; establishes and advances data services; supports research data best practices across the data lifecycle; applies knowledge of research methods, research ethics and rigor, and open science practices; and provides training and consultation for data-related topics.

Another perspective to consider, in addition to assessing librarians' data services skills, is evaluating the researcher's skills and ensuring that best practices are followed. This can be especially challenging when providing data services, as a researcher's willingness, openness, and skillfulness will determine how effective services are, no matter how skilled the data librarian. Borghi et al. provide a succinct overview of evaluating researcher expectations and ease of use of managing data.[19] Additionally, Borghi et al. provide easy-to-use materials so researchers can embed proper data management practices throughout the research lifecycle.

Bridging the Research Data Services Skill Gap

Useful solutions emerge from the literature to bridge research data services skill gaps. Attebury suggests "activities that include the characteristics identified by participants as contributing to meaningful or transformational activities. These include sustained and interactive activities with opportunities for reflection."[20] However, given the time and cost investment in such learn-

ing activities, these may be restrictive. Practical approaches also need to be considered, which take into consideration time and financial cost. Training formats predominantly delivered at two stages of a librarian's career, pre- and postgraduation, are reviewed below: 1) LIS graduate school programs (pregraduation) and 2) workshops, courses, and conferences (postgraduation).

LIS Graduate School Programs

Some researchers suggest reforming LIS graduate school programs to provide additional opportunities for research data services training. Lyon suggests two ways LIS programs can do this: 1) define core competencies for research data services to add to the current curriculum; and 2) analyze LIS program applicants for background in STEM fields.[21] Lyon echoes this sentiment in later work in addition to suggesting embedding students in a lab.[22] This is repeated in Lyon and Brenner, who suggest immersive experiences and practicums for graduate students interested in research services.[23]

In addition to her work in developing data services competencies, Federer suggests MLIS graduate students should be afforded the opportunity to take relevant data-related courses throughout their programs.[24] "Library schools and professional organizations should…stay up to date on trends," Federer states, "in this rapidly evolving field to ensure that their curricula and continuing education programs are suitable to prepare information professionals to take on new data librarian roles."[25] Heidorn also recommends data services training should take place in LIS graduate programs. He lists the University of Illinois, University of North Carolina, and the University of Arizona among the postsecondary institutions that offer this training.[26]

Ma, Stahl, and Knotts' excellent scoping review of an updated curriculum for the current health information professional includes data management among the nine roles that health sciences librarians engage in.[27]

Though data-related courses are not offered at every ALA-accredited institution, librarians involved with the Research Data Management Librarian Academy created a document listing 163 data-related courses available throughout North American, Asia Pacific, and European postsecondary institutions offering LIS graduate programs.[28]

Workshops, Courses, and Conferences

Workshops can be useful to have a group of library workers receive a large amount of training in a relatively short period of time. However, one drawback for workshops is that a short period of time does not lend itself to learning in-depth and complex topics. One example of a data-focused workshop is a 2008 full-day workshop offered by Michael Witt (Purdue University) and Melissa Cragin (University of Illinois at Urbana-Champaign) on institutional data repositories.[29] Southall and Scutt describe a two-part workshop offered for library staff at the University of Oxford.[30] The workshop is intended to train library staff in the general principles of contemporary data services.

Jake Carlson (University of Michigan) and Lisa Johnston (University of Minnesota) launched the Data Information Literacy (DIL) initiative in 2011.[31] The initiative's goal was to develop data competencies for graduate students. At the 2015 Research Data Access and Preservation (RDAP) Summit, the DIL team shared ideas on how to educate all ranges of users (undergraduate and graduate students; faculty), rather than focusing solely on graduate students, in data literacy. Initiatives such as DIL could be modified for an audience of library staff to improve their data literacy and to provide data services in their libraries.

In 2016, a course was developed at the University of California, Berkeley Libraries to train their library staff in not only general data principles, but putting them in context into different subject areas and delivered by subject liaison librarians.[32] The authors conclude the course was very successful, suggesting that other academic libraries would do well to offer something similar, depending on data services capacity, finances, and time.

Read et al. describe a pilot program for training medical librarians in data services to implement these services in their libraries.[33] Educational modules were provided to participating librarians and were given the option to train in providing data interviews, teaching an introductory research data management session, and instructional strategies for data classes. Overall, the pilot was successful and provides a model for other librarians looking to implement services in their library.

Federer and Qin review a 1.5-day workshop offered by the National Library of Medicine (NLM) in 2019 entitled "Developing the Librarian Workforce for Data Science and Open Science."[34] Fifteen librarians and faculty attended, with a variety of expertise in both subjects, with the goal of developing training for a library workforce in both data services and open science.

In addition to the NLM workshop, the NLM, with support from the National Network of Libraries of Medicine Training Office, offers the online course, "Research Data Management on Demand," consisting of four standalone classes.[35] There is also the Research Data Management Librarian Academy (RDLMA), a collaboration among Elsevier, Harvard Medical School, Harvard Library, Simmons University, Boston University, Brown University, Massachusetts College of Pharmacy and Health Sciences University, Northeastern University, and Tufts University.[36] Finally, Library Carpentry (https://librarycarpentry.github.io/) is another important training initiative focused on educating librarians in data skills, specifically technical skills, presented in a bootcamp format.

Conferences are also an important mode of training in data services. Examples focused on data services includes the Research Data Access & Preservation (RDAP) Summit, the International Association for Social Science Information Service & Technology (IASSIST) Conference, and Qualitative and Quantitative Methods in Libraries (QQML).

Though competency frameworks and training initiatives for data services are coming into view as data services matures, the literature does not include self-assessment of current data services skills on which to benchmark the success or failure of current and future training opportunities.

Aims

This paper measures the current level of self-described data services skills of academic librarians. Taking academic librarians' current levels of skill, this paper then explores the preferred method of professional education to support academic librarians providing data services.

The results of this research study will be of interest to academic librarians providing data services, academic library administrators, institutions increasing their data services capacity, and graduate students considering data librarianship as a potential career path.

Methods

For this study, library data services are defined as library services to manage researcher data, whether that is informational or technical in nature.[37] The study is directed toward, but not limited to, academic librarians providing data services. This study was open internationally to

respondents, but respondents came from one of four geographic regions: Canada, the United States, the United Kingdom, and Australia.

Data Collection and Analysis

A 22-question survey was developed and administered in LibWizard, the survey module of LibApps software. The survey, including a full list of surveyed skills, is available in appendix A. Survey questions were developed in consultation with research data management librarians and a review of the literature to identify key competencies, discussed in further detail below. A survey was chosen as the data collection tool, as the researcher wanted to reach as many respondents as possible using standardized questions. The survey is intended to be a census, by surveying a large population of academic librarians from Canada, the United States, and abroad.

The survey consists of Likert-scale, multiple-choice, and short-answer questions, in three sections. The first section of the survey collected demographic information. Multiple-choice and short-answer questions were used to collect information, such as what type of library the respondents work for, their location, current job title, and what percentage of time is spent doing data-related work. In the second section, Likert-scale questions were used to measure the respondent's self-assessment of specific data services competencies. Lisa Federer's article[38] was consulted to develop a portion of the competencies and develop the four top-level categories: general data services, programming languages and software, library instruction, and soft skills. Within each of the four top-level categories are associated skills, such as data mining and data curation in the general data services category, and oral communication and management and leadership within soft skills.

In the third and final section, Likert-scale questions were also used to measure how important different professional development initiatives were to respondents. Examples include self-directed learning, mentorships, workshops, webinars, and conferences. Short-answer questions were used to gather additional information about the respondent's self-assessment of data skills and professional development initiatives.

The study has been approved by the University of Manitoba's Research Ethics Board. After completing the survey, respondents were invited to enter a draw for a $50 (CDN) Amazon gift certificate by submitting their email address.

The author identified potential avenues for survey invitations and decided listservs would reach the most potential respondents. The survey was circulated on listservs as identified by the author as key listservs in the subject area (DataLibs, CANLIB-Data, Code4Lib, CdnLIS-L, univers@IFLA, ScholComm [ALA], Research Metrics list [ALA], dss-rdm_dg, MEDLIB-L, CANMEDLIB) and social media (Twitter, LinkedIn) over a period of two months beginning February 20, 2020. The survey data was analyzed using regression analysis in R. A model was run for each of the four skill set categories, with the following variables: geographic regions (Canada, United States, United Kingdom, and Australia), percentage of time spent providing data services, time spent in their current role, and time spent in the LIS field.

Results

Respondent Demographics

In total, 120 respondents participated in the survey. Not all respondents filled out every question on the survey. As the survey was circulated over listservs and social media, the response rate is unknown.

On average, the respondents (n = 120) reported that they have five years of experience in their current role. The mean years of experience for respondents (n = 120) in the information studies field is 12. Respondents (n = 106) are from one of four geographic regions: 47.5 percent of respondents are from the United States, 33.3 percent are from Canada, 5 percent are from the United Kingdom, and 2.5 percent are from Australia. Fourteen (11.7%) respondents have an unknown country of origin.

Out of 120 respondents, 85 percent work at an academic library, 7 percent work at a hospital library, 3 percent work at a government library, with the remaining 5 percent of respondents working at scientific research organizations, technology companies, and specialized libraries.

FIGURE 1
Type of Library Where Survey Respondents Work
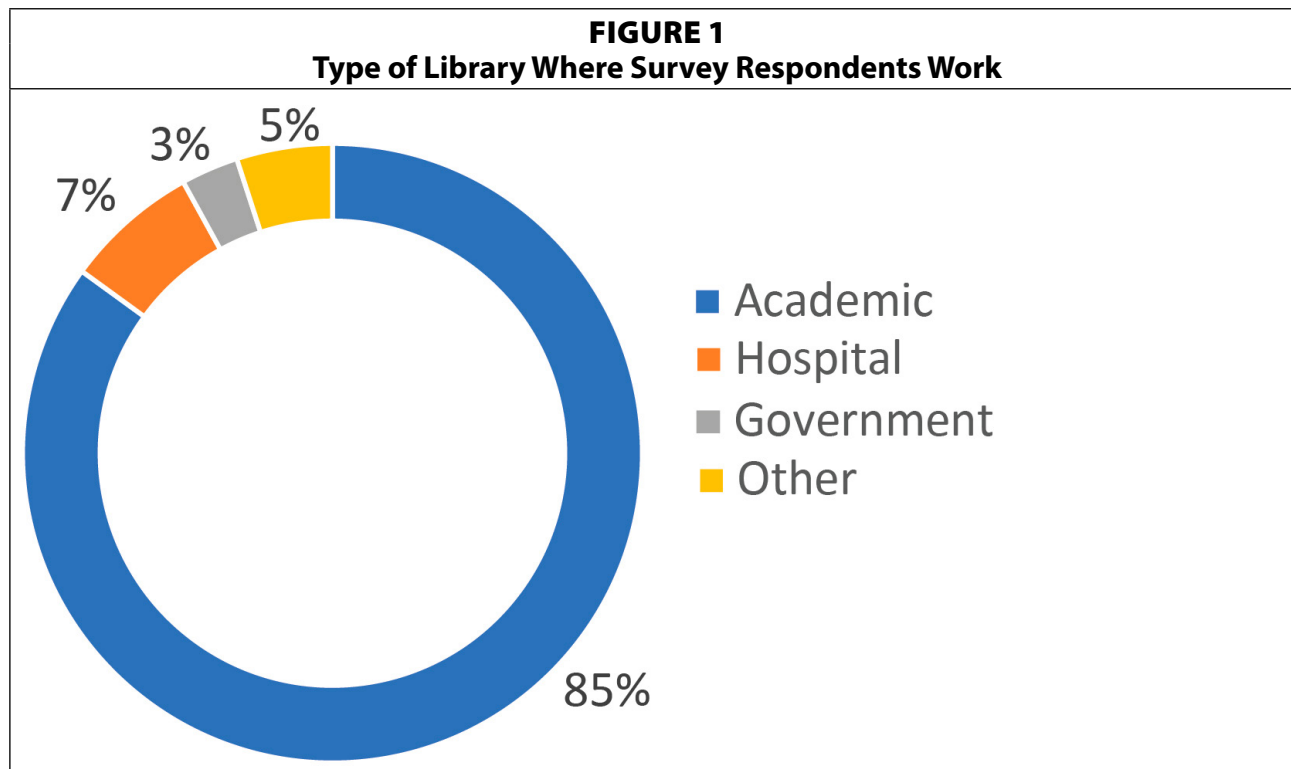
There is a large range of job titles for survey respondents. A sample of the respondent job titles includes: Data Services Librarian, Research/Education Librarian, Research Services Librarian, Software Developer and Librarian, Scholarly Communication Librarian, Data Curation Librarian, Health Sciences Librarian, Engineering Librarian, Research Repository Advisor, Web Librarian, among many others.

In terms of the amount of time an academic librarian spends providing library data services (n = 117), 52 percent spend between 0 and 24 percent of their time providing data services, 9 percent spend between 25 and 49 percent, 18 percent spend between 50 and 74 percent, and 21 percent spend between 75 and 100 percent.

Skill Sets

The survey had respondents rank 25 skill sets organized into four top-level categories: general data services, programming languages and software, library instruction, and soft skills. Each skill set has a corresponding Likert scale, ranging from: no level of competence (0), low level of competence (1), average level of competence (2), moderately high level of confidence (3),

and high level of confidence (4) (coded from 0 to 4 for data analysis). Respondents could also answer "not applicable (n/a)" for any skill set.

Many of the stronger skill sets came from the soft skills and library instruction categories, while many of the weaker skill sets came from the general data services and programming languages and software categories. The full listing of mean scores for individual skill sets is available in appendix B.

TABLE 1 Mean Score of Strongest Skill Sets (n = 120)		
Skill Set	**Category**	**Mean Score (n = 120)**
Written communication	Soft Skills	3.53
One-on-one session	Library Instruction	3.43
Working well with others	Soft Skills	3.4
Interpersonal customer service	Soft Skills	3.37
Library instructional sessions	Library Instruction	3.31
Oral communication	Soft Skills	3.29
In-class instructional sessions	Library Instruction	3.24
Project management	Soft Skills	2.78

As mentioned above, Tenopir et al. divide data services into two groups: technical and informational/consultative services.[39] Throughout the 2010s, more academic libraries were offering informational/consultative services compared to technical.[40] Librarians may have higher skill in informational and consultative services since these services are more frequently offered by academic libraries and these services are more aligned with traditional library services such as library instruction. This survey's library instruction category is second only to the soft skills category in terms of average self-assessed scores (see appendix B).

TABLE 2 Mean Score of Weakest Skill Sets (n = 120)		
Skill Set	**Category**	**Mean Score (n = 120)**
Programming languages (JavaScript, R, Python, C++, etc.)	Programming Languages and Software	0.76
GIS software (e.g. ArcGIS)	Programming Languages and Software	0.77
Data mining	General Data Services Skills	0.94
Statistical software (e.g. SAS, SPSS, RStudio)	Programming Languages and Software	1.02
Text editors (e.g. Jupyter)	Programming Languages and Software	1.05
Data analysis software (e.g. OpenRefine)	Programming Languages and Software	1.15
Web development and maintenance	Programming Languages and Software	1.58
Markup language (e.g. HTML, XML)	Programming Languages and Software	1.78

Percentage of Time Correlates to Technical Data Services Skill

TABLE 3
Mean Score of Four Main Skill Set Categories,
by Time Spent Providing Library Data Services

Time Spent Providing Library Data Services (Percent)	n (total n = 117)	General Data Services Skills	Programming Languages and Software	Library Instruction	Soft Skills
0–24	61	0.89	0.60	2.06	2.44
25–49	11	1.94	1.63	2.11	2.5
50–74	21	1.88	1.08	2.89	3.17
75–100	24	2.22	1.5	2.72	3.44

When respondents (n = 117) are divided into four groups by how much time they spend providing library data services, again there are stronger skills across all groups in library instruction and soft skills compared to the technical categories of general data services skills and programming languages and software. However, there is a substantial increase in the self-assessed score for general data services skills in the group spending the most time providing data services (75–100 percent of time spent providing library data services) compared to the other three groups.

TABLE 4
***P*-Values for Percentage of Time Spent Providing Data Services and Self-Assessed Score of the Four Skill Set Categories**

Skill Set Category	*P*-value	Estimate
General Data Services	0.0000551	0.05617
Programming Languages and Software	0.00000532	0.08182
Library Instruction	0.2578	−0.01598
Soft Skills	0.8439	−0.002174

During data analysis, it was found the variable of percentage of time spent providing data services is statistically significant in regression models for the two technical skill sets: 1) general data services and 2) programming languages and software categories. The more time a librarian spends providing data services, the higher their self-assessed score is likely to be for the two technical skill set categories.

TABLE 5
Mean Score of Four Main Skill Set Categories, by Geographic Region

Geographic Region	n (Total n = 106)	General Data Services Skills	Programming Languages and Software	Library Instruction	Soft Skills
Canada	40	1.73	1.14	2.82	3.02
United States	57	1.81	1.25	2.88	3.18
United Kingdom	6	1.79	0.29	2.58	3.36
Australia	3	2.67	1.21	3.39	3.83

Geographic Regions

When the respondents are divided into the four geographic regions (n = 106), once again there is higher skill in library instruction and soft skills compared to general data services and programming languages and software.

Canadian librarians rank similar to the United States; however, the United States has higher average ratings overall between the two countries (average of 5.42% comparatively across the four categories).

Looking at specific skill sets, the United States has significantly higher scores in data analysis software (1.36) and data visualization (2.04), when compared to Canada (0.83 and 1.59, respectively). Academic librarians from the United States have significantly higher (> 5% higher of total score) skill sets in data mining (1.02), programming languages (0.93), text editors (1.19), and project management (2.79), when compared to Canada (data mining (0.79), programming languages (0.68), text editors (0.88), and project management (2.55).

It is difficult to conclude much from the other two geographic region, the United Kingdom and Australia, due to small sample sizes. After regression analysis of the data, no statistical significance was found between being from any of the four geographic regions and skill levels in any of the categories.

Early-Career Librarians and Experienced Librarians

Comparison between early-career academic librarians (≤ 5 years) and the three other groups of experienced academic librarians (> 5 years) sees early-career librarians with the lowest mean score in library instruction and soft skills, and the second lowest mean score in general data services and programming languages and software.

TABLE 6 Mean Score of Four Main Skill Set Categories, by Years of Experience					
Years of Experience in the Library Field	n (Total n = 120)	General Data Services Skills	Programming Languages and Software	Library Instruction	Soft Skills
0–5	37	1.71	1.15	2.52	2.91
6–10	26	2.25	1.42	3.16	3.39
11–19	28	1.74	3.48	3.5	3.64
20–35	29	1.58	1.06	2.77	3.3

Comparison of specific skill sets found experienced academic librarians have higher averages in every skill set except data curation, programming languages, statistical software, GIS software, data analysis software, and text editors, where early-career librarians have higher average scores. Early-career librarians with higher scores in specific technical skill sets could be attributed to people in other disciplines being hired for academic librarian positions due to demand for technical skill sets in emerging areas. Analysis of participants with advanced degrees (such as MA, MS, PhD) without an MLIS shows early-career academic library workers with a much higher percentage. Six out of 37 (16.22%) of early-career academic library workers who filled out the survey have advanced degrees without a MLIS, compared to seven out of 83 (8.43%) for experienced librarians. This indicates people working at academic libraries from other disciplines, possibly due to new demands for skills.

Data analysis found no statistical significance between the number of years spent in the LIS field and skill level in any category.

TABLE 7 Mean Score of Importance of Professional Development Initiatives (N = 120) (0 = Not Important; 4 = Very Important)	
Professional Development Initiative	**Mean Score**
Learning by doing (trial and error)	3.38
Self-directed learning	3.33
Workshop or bootcamp	3.19
Communities of Practice	3.04
Mentorship with peer (library staff)	3.02
Online courses	2.98
Attending conferences	2.83
Mentorship with researcher or other faculty (non-library staff)	2.69
Webinar	2.60
Courses during LIS graduate school	2.56
Job shadowing	2.11
Fellowship (e.g. early or mid-career fellowship)	2.1

| TABLE 8 Mean Score of Importance of Professional Development Initiatives, by Time Spent Providing Library Data Services			
Time Spent Providing Library Data Services (Percent)	**n (Total n = 117)**	**Most Important (Mean Score in Parentheses)**	**Least Important (Mean Score in Parentheses)**
0–24	61	Mentorship with peer (library staff) (3.33)	Fellowship (e.g. early or mid-career fellowship) (2)
		Mentorship with researcher or other faculty (non-library staff) (3.33)	Courses during LIS graduate school (2)
		Workshop or bootcamp (3.33)	
25–49	11	Self-directed learning (4)	Fellowship (e.g. early or mid-career fellowship) (2)
		Learning by doing (trial and error) (4)	Job shadowing (2)
			Courses during LIS graduate school (2)
50–74	21	Attending conferences (3.67)	Fellowship (e.g. early or mid-career fellowship) (1.67)
		Online courses (3.67)	Job shadowing (1.67)
		Workshop or bootcamp (3.67)	
75–100	24	Workshop or bootcamp (3.67)	Webinar (2.33)
		Learning by doing (trial and error) (3.67)	
		Communities of Practice (3.67)	

Professional Development Initiatives

Respondents ranked 12 professional development initiatives according to how important they felt they were in data services training. Each initiative had a corresponding Likert-scale question ranging from: not important, low importance, average importance, moderate importance, and very important (coded 0 to 4 in data analysis). Respondents could also answer "not applicable (n/a)" for any initiative.

The two highest-rated professional development initiatives are independent: "learning by doing (trial and error)" and "self-directed learning." While there is little cost to both of these independent learning initiatives, there is considerable investment in time and a need for support from supervisors. Indeed, both are noted by respondents as impediments to their professional development. Though researchers suggest one possible solution for bridging the data services skills gap is taking courses during LIS graduate school, it ranks 10th

TABLE 9 Impediments to Professional Development Initiatives (Respondents Could Select Multiple Answers)	
Impediment	**Responses (n = 118)**
Lack of time	91
High cost	76
Lack of support from library administration	42
Lack of support from supervisor	28
Little or no opportunity	24
Little or no desire	7

FIGURE 2
Impediments to Professional Development Initiatives
(n=118, respondents could select multiple answers)
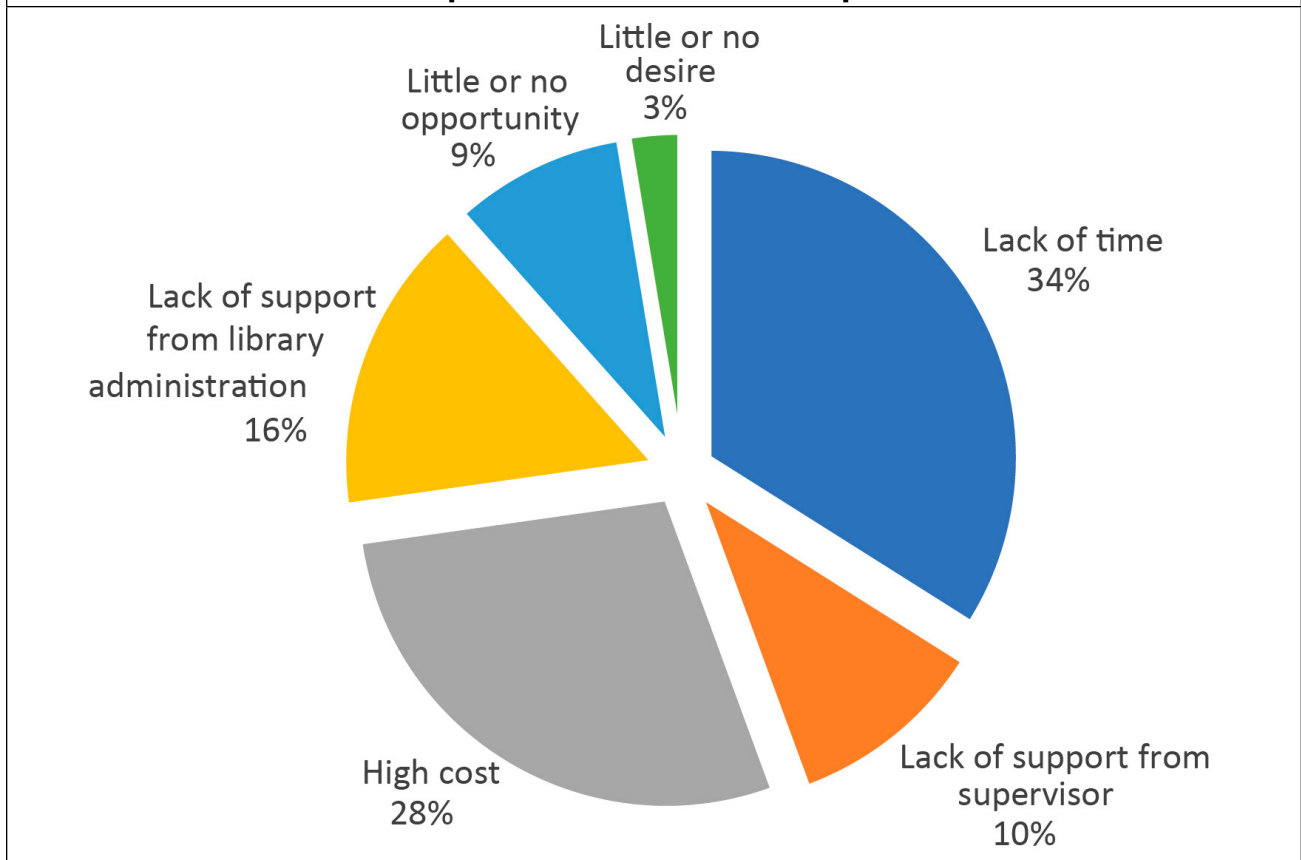
out of the 12 initiatives as being important for respondents. [41] One possible reason for the relative unimportance is due to not taking data services–related courses during the respondent's time in graduate school or not having the opportunity due to these courses not being offered until recently.

Respondents indicated impediments to their professional development, including lack of time, high cost, and lack of support from library administration and their supervisor.

Qualitative Comments on Professional Development

Respondents also expanded on impediments to their professional development with text-based responses. The responses include challenges such as lack of support from their institution and library administration, lack of direction, and lack of defined roles.

Lack of Support from Institution and Library Administration

Librarians may encounter a lack of support for data initiatives and training from their library administration or their institution. Participants identify needing affirmation and backing from administration to be successful in this newly emerged area:

"Institutional indifference until having an open data policy is linked to some larger strategic initiative like the Research Excellence Framework [available at https://www.ref.ac.uk/]. Then there is a flurry of activity to 'evidence' good practice."

"My library administration is so utterly lacking in vision that I can't implement most of what I take the time to learn. My current manager would be happy if I did what I did 20 years ago (which of course is not what my liaison departments want)."

"Where I still feel lacking is in taking the initiative to lead work at my institution. I lean heavily on leadership in my libraries, which tends to only really turn their attention to support of data services when the topic has caught their attention in other channels that library deans, etc. tend to follow."

Lack of Direction

A major impediment to library data services is a lack of defined direction for librarians. Data services is an emerging area of academic librarianship, and as such, has not had time to mature into fully-defined, standardized library services across all academic libraries. Participants note the difficulties in not only providing data services, but how to upskill effectively:

"It's hard to identify 'training wheels' projects—real world projects where I can *start* to apply new skills I'm developing. The path from novice to expert is basically a big map with 'here be dragons' and no more details."

"For data services, so many librarians and information professionals are participating in disparate but related 'data things' that the typical librarian does not see a 'compass' to point the direction."

Lack of Defined Roles

One theme throughout the literature and among participant responses is a lack of defined roles for providing data services. Here again, since data services is still emerging, participants identify how challenging it is to know which services to provide and which skills to train:
"The challenge is that data librarians are not all doing the same thing and so there is no one key skill set."

Some data services may be offered by nonlibrary departments across campus because of the diverse range of services available and a lack of defined role for data librarians. There are additional challenges when data services are provided by nonlibrarians. This can include a loss of control or autonomy, diverse locations to receive services (such as the Office of Research Services or supercomputing centers), and challenges in creating partnerships and collaborations. As one participant notes:

"It's difficult to know for sure what is the task for us (librarians) versus Data Scientist and even Data [steward]… What is for us to learn (what is for Librarians) and what is to let to others…?"

Overall, the responses show support, clear direction, and defined roles are needed for academic librarians who provide data services. It is clear from the survey data that practitioners rely on financially feasible but time-intensive options like self-directed learning but should also be provided with alternative opportunities like workshops, conferences, and mentorship with library staff.

Discussion
Dedicated Data Librarians
It is encouraging to see academic librarians who are providing data services consistently have higher data services skills. This corresponds to the claim from Tenopir et al. that "growth in current performance of [research data services (RDS)] by librarians can be expected to follow growth in current availability of RDS by libraries."[42] As more data services are offered, and offered at a higher capacity, librarians providing these services become more skilled and adept.

Why are dedicated data librarians skilled in providing technical data services? Two reasons immediately jump out. First, if an academic library has a vacancy for a position where the successful candidate will be spending 75 to 100 percent of their time performing data services, it is likely the successful candidate will have previous technical data services experience. One example would be hiring developers, other IT staff, or otherwise people from other disciplines than librarianship, who already have significant technical skill sets. The survey data trends this way for newly hired librarians, as reported in the results section above. The survey data shows 16.22 percent of early-career respondents have a graduate degree without an MLIS. However, this assumes a higher percentage of data librarians have recently been hired, which is more likely since data services is an emerging area of academic librarianship. Another example could be a data librarian who spent time, whether that was the majority of their time or otherwise, previously providing data services. Librarians with previous data services are more likely to be successful candidates for data librarian vacancies.

Second, dedicated data librarians, due to their specialized role, are more likely to have more opportunities (like financial, time) to spend on training to bridge specific skill gaps. Additionally, data librarians may have more familiarity and confidence with technical data services due to more time spent providing the services, including time devoted to working with data tools common in technical data services. There may also be an expectation to improve your data skills in a dedicated data librarian position.

The more a librarian practices data services, the more skilled and confident they will be. This shows the value for academic libraries to hire dedicated data librarians, when those libraries are currently offering, or planning to offer, data services. These are positions where data librarians perform data services between 75 and 100 percent of their time. Dedicated data

librarians not only provide data-related informational and consultative support; they also actively develop and promote data services initiatives in their library systems, consisting of services supporting all stages of the data lifecycle, from creation to discovery, to preservation and destruction.

There are numerous benefits to having a dedicated data librarian. Dedicated data librarians have higher technical skills, whether due to having a variety of technical experience or taking additional training. Academic libraries will increase their capacity to provide a higher level of data services to their users. Dedicated data librarians have the time to devote to concentrating solely on data services, to provide users with current services and for planning and coordinating new service offerings. This is important since, as Tenopir et al. found, academic libraries are looking to increase their data services capacity beyond informational and consultative data services.[43] Dedicated data librarians can increase current services to develop increased services for the future, depending on user need and demand, library and institutional priorities, financial considerations, among other considerations.

Academic libraries have capacity to provide data services, including technical services. Since dedicated data librarians have higher data services skill sets, academic libraries are encouraged to create and retain these positions. Dedicated data librarians can focus on developing data services initiatives and programs, and they have a higher capacity to do so when compared to librarians who have other duties and support other roles.

Data Services Training Initiatives

Overall, academic librarians have average to moderate self-assessed scores across technical data services skill sets, and moderately high to high scores across library instruction and soft skills. While hiring dedicated data librarians can help, it is clear academic librarians need training opportunities in data services, especially technical skill sets, to bridge skill gaps. Responses to the question of whether respondents felt proficient before they started in their current role resulted in answers such as "I never feel fully proficient, there's always more to learn and you never know what's going to be thrown at you," and, even more bluntly, "I do not feel proficient in data librarianship."

The importance of professional development should not be understated. While there are high average scores for traditional academic librarian skills such as library instruction (2.86) and soft skills (3.18), technical skills in general data services (1.83) and programming languages and software (1.18) are low. Since technical skills are low, librarians need training to bridge this skill gap. It should be noted that, depending on the specific data services offered, librarians may not need these skills. Individuals, library administration, and their institution will need to decide which skills their library staff need training in, based on current and future data services offered by their academic library.

Data services skills are overall similar across different geographic regions, which for this study includes Canada, the United States, the United Kingdom, and Australia. This indicates that, where there is a need for more training, similar initiatives can be provided in these regions. Based on the survey data, independent learning, such as self-directed learning, should be emphasized, followed by workshops and bootcamps, communities of practice, and mentorship by other library staff. One issue with workshops and bootcamps is the short length of time provided to learn complex topics. Ideally, workshops and bootcamps should be combined with additional training. For example, Brown, Wolski, and Richardson describe

a successful multipronged approach with training a new data librarian using formal skills training (background reading and an eight-week long online course), having a mentor and coach, and a supportive network of experts to draw upon when needed.[44]

While there is an emphasis in the literature on increasing data services training in LIS graduate school curriculums, during data analysis, there was no statistical significance found between years of experience and data services skills. The demographic most likely to have taken data-related grad school courses, early-career librarians, had lower average scores in every skill set except several specific technical skills: data curation, programming languages, statistical/GIS/data analysis software, and text editors. This could indicate lack of experience since they are still early in their career, or not receiving any or enough training, and/or relevant training, throughout their graduate program. There was also little recognition by respondents of the value of taking data-related courses during grad school. This indicates the relative insignificance of these courses by respondents.

This does not mean graduate programs should scrap all current and future data-related courses. However, graduate programs training future information professionals should assess their data-related course offerings. This could mean offering more data-related courses or shifting course content to different types of library data services. As well, different educational formats should be considered. For example, if an LIS program already offers data-related courses, they could offer work placements with data librarians. This could provide a different mode of training compared to for-credit courses, and students may find they also receive one of the most highly rated types of training: mentorship by other library staff.

Academic libraries should provide their staff with the specific skills they need to offer data services at a consistent level. For some academic libraries, this will be informational and consultative services, or technical, and for others, a mixture of both. Training initiatives should be provided that give staff the skills to be confident in providing data services.

Range of Data Services

It is clear not all data librarians do the same thing. Expanding on one quotation from above:

> "[t]he challenge is that data librarians are not all doing the same thing and so there is no one key skill set. I've always thought of data librarians fitting into three different categories: (1) Acquisition librarians who focus on procuring, ingesting, and support access to data collections; (2) Analytical data librarians—the unicorns who do have program and analysis skills often gained from other jobs. They seem to focus on teaching and training basic skills to meet short term needs of researchers; and (3) Curation librarians who focus on end products like research output data, sharing, preservation etc. I don't think one person can effectively do all three at a high level."

One only needs to view the survey respondent job titles to see the large range of different data services roles: Data Librarian, Research Services Librarian, Software Developer and Librarian, Data Curation Librarian, Research Data Management Analyst, STEM and Research Data Outreach Librarian, and so on. This is also seen in the differing scores of the various skill sets for data librarians. The survey data shows librarians are involved in different areas—and provide different levels—of data services. Federer aptly notes data librarians provide an array

of diverse services, including data management, curation, preservation, visualization, and more. "[D]ata librarianship," Federer writes, "may not be a single role but rather one that allows professionals to focus on areas related to their own interests or their users' needs."[45]

Data librarians should focus their training on those data services an academic library currently provides, and will provide in the future, to increase and diversify their skill set in those areas. While one librarian who supports faculty and researcher data preservation may need training using preservation software, another librarian may need training in consultative data services, such as hosting library information sessions using institutional and data repositories.

Academic librarians looking for positions providing data services should be mindful of what skills a particular data librarian position requires. As well, bear in mind academic libraries may hire outside the profession. Based on the survey data and summarized above, there is a higher percentage of early-career librarians without an MLIS compared to librarians with six or more years of experience. While this could be explained by getting a MLIS while working as an academic librarian, it remains that academic libraries are filling at least some data-related positions outside the profession. Why is this the case? Academic librarians may not have the required skills for such a position. Academic librarians should keep this in mind when looking at their long-term career goals and what training they take in data-related skill sets.

Conclusion

Data librarianship is an emerging field in academic librarianship, one that comprises a wide range of services and different levels of expertise among practitioners. This study determined areas of strength and weakness of academic librarians providing data services. As well, the study demonstrated the importance of different training opportunities for academic librarians.

Statistically significant data shows that academic librarians providing data services have higher scores in technical skill sets. Evidence is provided of the benefit for dedicated data librarians in academic libraries currently offering, or planning to offer, technical data services. It is this author's recommendation that academic libraries hire dedicated data librarians.

Academic librarians providing data services should be given the opportunity to take a mixture of learning opportunities and training initiatives, depending on their specific areas of expertise and what is available to them. As data services is an increasingly common academic library service, training needs to be provided to those academic librarians who are providing this service. Data librarians are diverse; there is no one-size-fits-all model for the role data librarians play. The same is true for data services training initiatives; academic librarians should explore what data services their institution is currently offering or planning to offer and participate in training appropriate to their expertise.

Academic librarians have shown the value they provide to faculty, researchers, and students with data services. Data services is emerging as a significant area for academic libraries. We must ensure that our library data services practitioners are receiving appropriate training to bridge any skill gaps to continue to provide high-level library services to our users.

Limitations

Limitations to this research include small sample sizes of two geographic regions in this study (United Kingdom, Australia), and the small number of regions surveyed overall (4). The survey was self-selecting, so there may be self-selecting bias. Also, survey participants were only

presented with predefined skills to measure their competency in data services, as well as an English-language-only survey. The potential pool of survey participants was limited to the reach of listserv invitations and social media posts.

Future Research
Future research could include a follow-up survey to update the skill set baseline of academic librarians, providing data services now or in the future. Future researchers could also track skill set assessment after training opportunities are provided to library staff. Future studies could also expand the scope of geographic regions, including those with small sample sizes in this study (United Kingdom, Australia) and increase the sample size for the survey overall. Thought should be given to updating the measured skill sets that consider future data services. Adjusting the skill set categories based upon current uptake of library data services could provide more accurate data.

One aspect not addressed in this study is the development and provision of data services. This study focuses on training in data services currently offered and those offered in the future in participants' libraries. However, drivers such as the unique data needs of a library's users could be explored to assess how libraries and librarians develop their suite of data services and how librarians respond in terms of upskilling to provide these services.

APPENDIX A. Survey

Survey available here: https://libguides.lib.umanitoba.ca/ld.php?content_id=35814630

Developing Skills for Data Services in Academic Libraries

This consent form, a copy of which will be available for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

You are being asked to participate in a research study. Please take your time to review this consent form and discuss any questions you may have. Please ask the study staff to explain any words or information that you do not clearly understand.

The study's goal is to collect and analyze data related to professional development initiatives to train current and future data services librarians. The purpose of this study is to evaluate whether additional skills training is needed to provide data services in Canadian academic libraries. Further, this study will evaluate which professional development initiatives are preferred by academic library practitioners.The first part of the questionnaire situates the participant in their library's context. The second part of the questionnaire analyzes what skills are needed to perform data services in libraries. The third part of the questionnaire analyzes what professional development initiatives would best train data services librarians.

Your feedback will be collected through an online questionnaire which will ask you a series of questions and should take about 10-20 minutes to complete. Your participating is important to us and will help to produce evidence to inform implementation of new library services in academic libraries.

Your participation in this online questionnaire is completely voluntary. Risks are no greater than everyday life. You are not required to provide any personal information such as your name, address or telephone number, and you don't have to answer any questions you don't want to. Survey responses are anonymous. The survey system will not record your e-mail address or IP address. The information you share will be kept confidential and will be securely stored on a secure hard drive and shared only with the investigator. Data will be retained for one year after the completion of the study, at which point it will be destroyed, approximately December 2021.

If you wish to be entered into a draw for a $50 (CAD) Amazon gift certificate at the conclusion of the questionnaire, you will be directed to an external, separate online form to enter your name and email. Your personal information will not be in any way connected to your questionnaire responses as this information is stored separately from survey responses. Your email address will be securely stored on a secure hard drive and after the draw for the gift certificate, email address data will be destroyed no later than July 2020.

Survey results will be available no later than December 2020 at the following https://libguides.lib.umanitoba.ca/fuhr/surveyresults. Anonymized results of this research, which could include summary statistics and direct quotations, may be shared at conferences or in journal publications. Direct quotations will be attributed as a "study participant."

Clicking "Begin" indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Joint Faculty Research Ethics Board. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator at 204-474-7122 or humanethics@umanitoba.ca. A copy of this consent form which you can download or print for your reference is available at:
https://bit.ly/DataServicesConsentForm

Notice Regarding Collection, Use, and Disclosure of Personal Information by the University
Your personal information is being collected under the authority of The University of Manitoba Act. The information you provide will be used by the University for the purpose of this study, as outlined above. If you choose to participate in the draw, your email address will be used to determine your eligibility for the draw, and for communication in the event that you win one of the prizes. Your personal information will not be used or disclosed for other purposes, unless permitted by The Freedom of Information and Protection of Privacy Act (FIPPA). If you have any questions about the collection of your personal information, contact the Access & Privacy Office (tel. 204-474-9462), 233 Elizabeth Dafoe Library, University of Manitoba, Winnipeg, MB, R3T 2N2.

Last updated February 10, 2020

Begin

Developing Skills for Data Services in Academic Libraries

Part 1: Background Information

1. What type of library do you work for?

○ Academic

○ Hospital

○ Law

○ Public

○ Other (please specify)

2. Is your library affiliated with a post-secondary institution?

○ Yes

○ No

3. In which province/territory is your library located? If outside Canada, please indicate by selecting "Other".

Make a selection	▾

4. What is your current job title?

5. In your position, what percentage of your time is spent doing data-related work?

min 0 max 100

6. How long have you been employed in your current role? (in years, round to nearest number)

min 0

7. How long have you been employed in the information studies field? (in years, round to nearest number)

min 0

8. What degrees do you possess?

☐ MLIS/MLS/other ALA-accredited Master's degree

☐ M.A./M.Sc. in other subject

☐ Ph.D.

☐ Other (please specify)

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Developing Skills for Data Services in Academic Libraries

Part 2: Self-Assessment of Data Services Skill Sets

Please rank each data services skill from "no level of competence" to "high level of competence" according to your current level of expertise.

Feel free to leave any answer blank or select "n/a" for any skills that do not apply to your position.

---

9. General Data Services Skills

	No level of competence	Low level of competence	Average level of competence	Moderately high level of competence	High level of competence	n/a
Data mining	☐	☐	☐	☐	☐	☐
Data use and analysis	☐	☐	☐	☐	☐	☐
Data curation and preservation	☐	☐	☐	☐	☐	☐
Data visualization and/or informatics	☐	☐	☐	☐	☐	☐
Data depositing and/or work with repositories	☐	☐	☐	☐	☐	☐
Policy and advisory skills (e.g. interpreting the upcoming Tri-Agency Research Data Management Policy For Consultation)	☐	☐	☐	☐	☐	☐

10. Programming Languages and Software

	No level of competence	Low level of competence	Average level of competence	Moderately high level of competence	High level of competence	n/a
Programming languages (JavaScript, R, Python, C++, etc.)	☐	☐	☐	☐	☐	☐
Markup languages (HTML, XML)	☐	☐	☐	☐	☐	☐
Web development and maintenance	☐	☐	☐	☐	☐	☐
Statistical software (e.g. SAS, SPSS, RStudio)	☐	☐	☐	☐	☐	☐
GIS software (e.g. ArcGIS)	☐	☐	☐	☐	☐	☐
Data visualization software (e.g. Tableau)	☐	☐	☐	☐	☐	☐
Data analysis software (e.g. OpenRefine)	☐	☐	☐	☐	☐	☐
Text editors (e.g. Jupyter)	☐	☐	☐	☐	☐	☐

11. **Library Instruction**

	No level of competence	Low level of competence	Average level of competence	Moderately high level of competence	High level of competence	n/a
Library instructional sessions	☐	☐	☐	☐	☐	☐
In-class instructional sessions	☐	☐	☐	☐	☐	☐
One-on-one sessions	☐	☐	☐	☐	☐	☐
Development of online instruction tutorials or modules	☐	☐	☐	☐	☐	☐
Knowledge of blended and online learning theory	☐	☐	☐	☐	☐	☐
Experience with learning management systems	☐	☐	☐	☐	☐	☐

12. **Soft Skills**

	No level of competence	Low level of competence	Average level of competence	Moderately high level of competence	High level of competence	n/a
Oral communication	☐	☐	☐	☐	☐	☐
Written communication	☐	☐	☐	☐	☐	☐
Management and leadership	☐	☐	☐	☐	☐	☐
Interpersonal customer service	☐	☐	☐	☐	☐	☐
Working well with others	☐	☐	☐	☐	☐	☐
Project management	☐	☐	☐	☐	☐	☐

13. Taken as a whole, do you feel proficient in the skills you need to adequately perform your assigned responsibilities in your current role? Why or why not?

Some skills and personal attributes adapted from:
Federer, L. (2019). Defining data librarianship: A survey of competencies, skills, and training. *Journal of the Medical Library Association, 106*(3), 294-303. doi: 10.5195/jmla.2018.306

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Developing Skills for Data Services in Academic Libraries

Part 3: Professional Development Initiatives

The following section lists various professional development initiatives intended to provide training in data services. Please rank each initiative between "1" (Not important) to "5" (Very Important) according to how you feel of each initiative's importance to educate librarians in offering data services.

Feel free to leave answers blank or select "n/a" for any initiatives you feel do not apply to your work in data services.

14. Professional Development Initiatives **(1 = not important; 5 = very important)**

	1	2	3	4	5	n/a
Self-directed learning	☐	☐	☐	☐	☐	☐
Mentorship with peer (library staff)	☐	☐	☐	☐	☐	☐
Mentorship with researcher or other faculty (non-library staff)	☐	☐	☐	☐	☐	☐
Fellowship (e.g. early or mid-career fellowship)	☐	☐	☐	☐	☐	☐
Job shadowing	☐	☐	☐	☐	☐	☐
Webinar	☐	☐	☐	☐	☐	☐
Attending conferences	☐	☐	☐	☐	☐	☐
Online courses	☐	☐	☐	☐	☐	☐
Workshop or bootcamp	☐	☐	☐	☐	☐	☐
Courses during LIS graduate school	☐	☐	☐	☐	☐	☐
Learning by doing (trial and error)	☐	☐	☐	☐	☐	☐
Communities of Practice	☐	☐	☐	☐	☐	☐

15. Did you feel proficient at your current position before starting? If not, what professional development initiatives did you complete, if any?

16. Please list any other professional development initiatives you feel apply to your work in data services.

[ ]

17. **Please select** any of the following impediments that would inhibit you from pursuing professional development initiatives.

☐ Lack of support from supervisor

☐ Lack of support from library administration

☐ Lack of time

☐ Little or no desire

☐ High cost

☐ Little or no opportunity

☐ Other (please specify)

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18. Any final comments?

[ ]

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Developing Skills for Data Services in Academic Libraries

Thank you for participating. If you wish to be entered into a draw for a $50 (CAD) Amazon gift certificate, please click here and you will be taken to an external site where you can enter your name and email.

Your personal information will not be linked to your survey responses.

APPENDIX B. Mean Scores for All Categories

Data mining	0.94
Data use and analysis	1.95
Data curation and preservation	1.98
Data visualization and/or informatics	1.86
Data depositing and/or work with repositories	2.07
Policy and advisory skills (such as interpreting the upcoming Tri-Agency Research Data Management Policy for Consultation)	2.12
MEAN FOR GENERAL DATA SERVICES SKILLS	**1.83**
Programming languages (JavaScript, R, Python, C++, and others)	0.76
Markup languages (HTML XML)	1.78
Web development and maintenance	1.58
Statistical software (such as SAS, SPSS, RStudio)	1.02
GIS software (such as ArcGIS)	0.77
Data visualization software (such as Tableau)	1.25
Data analysis software (such as OpenRefine)	1.15
Text editors (such as Jupyter)	1.05
MEAN FOR PROGRAMMING LANGUAGES AND SOFTWARE	**1.18**
Library instructional sessions	3.31
In-class instructional sessions	3.24
One-on-one sessions	3.43
Development of online instruction tutorials or modules	2.62
Knowledge of blended and online learning theory	2.24
Experience with learning management systems	2.29
MEAN FOR LIBRARY INSTRUCTION	**2.86**
Oral communication	3.29
Written communication	3.53
Management and leadership	2.67
Interpersonal customer service	3.37
Working well with others	3.40
Project management	2.78
MEAN FOR SOFT SKILLS	**3.18**

Notes

1. Carol Tenopir et al., "Academic Librarians and Research Data Services: Preparation and Attitudes," *IFLA Journal* 39, no. 1 (2013): 70, doi10.1177/0340035212473089.

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2009), www.jisc.ac.uk/media/documents/publications/research/2009/open-science-report-6nov09-final-sentojisc.pdf.

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5. Mark P. Newton, C.C. Miller, and Marianne Stowell Bracke, "Librarian Roles in Institutional Repository Data Set Collecting: Outcomes of a Research Library Task Force," *Collection Management* 36, no. 1 (2011): 53–67, https://doi.org/10.1080/01462679.2011.530546; Sheila Corrall, Mary Anne Keenan, and Waseem Afzal, "Bibliometrics and Research Data Management Services: Emerging Trends in Library Support for Research," *Library Trends* 61, no. 3 (2013): 636–74, https://doi.org/10.1353/lib.2013.0005; Sheila Corrall, "Roles and Responsibilities: Libraries, Librarians and Data," in *Managing Research Data*, ed. Graham Pryor (London, UK: Facet, 2012), 105–33; Liz Lyon, "The Informatics Transform: Re-Engineering Libraries for the Data Decade," *International Journal of Digital Curation* 7, no. 1 (March 11, 2012): 126–38, https://doi.org/10.2218/ijdc.v7i1.220; Lisa Federer, "Research Data Management in the Age of Big Data: Roles and Opportunities for Librarians," *Information Services & Use* 36, no. 1/2 (2016), 35–43, https://doi.org/10.3233/ISU-160797.

6. Carol Tenopir, Ben Birch, and Suzie Allard, "Academic Libraries and Research Data Services: Current Practices and Plans for the Future," Association of College & Research Libraries (2012): 1–55, www.ala.org/acrl/sites/ala.org.acrl/files/content/publications/whitepapers/Tenopir_Birch_Allard.pdf.

7. Tenopir et al., "Academic Librarians and Research Data Services: Preparation and Attitudes."

8. Corrall, Kennan, and Afzal, "Bibliometrics and Research Data Management Services"; Andrew M. Cox and Stephen Pinfield, "Research Data Management and Libraries: Current Activities and Future Priorities," *Journal of Librarianship and Information Science* 46, no. 4 (December 2014): 299–316, https://doi.org/10.1177/0961000613492542.

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10. Tenopir et al., "Research Data Services in Academic Libraries: Where Are We Today?"; Andrew M. Cox et al., "Developments in Research Data Management in Academic Libraries: Towards an Understanding of Research Data Service Maturity," *Journal of the Association for Information Science and Technology* 68, no. 9 (September 2017): 2182–2200, https://doi.org/10.1002/asi.23781; Alexandra Cooper et al., "Institutional Research Data Management Services Capacity Survey: Executive Summary," Portage Network, Research Intelligence Expert Group (January 2020), https://portagenetwork.ca/wp-content/uploads/2020/02/RIEGSurvey_execsummary_2020_02_12_EN.pdf.

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