

DATA LITERACY IN ACADEMIC LIBRARIES

Teaching Critical Thinking with Numbers

EDITED BY JULIA BAUDER

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INTRODUCTION

f, as commentators and theorists have confidently proclaimed, the late twentieth century was the "Information Age," then the twenty-first century is the "Age of Data," or perhaps the "Age of Big Data." As these social observers have noted, millennia-old aspects of human life, from farming to falling in love, are being transformed by zettabytes of newly captured data and the increasingly complex algorithms that process it, and the future belongs to those who know how to capture, manipulate, and make meaning out of that data. Thus, the argument goes, students should be encouraged to become more data literate so that they can be successful in this emerging data-driven world. But what exactly is data literacy, and who specifically should acquire it?

Various definitions of data literacy have been proposed; broadly speaking, they fall into two camps. The first camp attempts to define data literacy by way of the data-related competencies that people need in a particular, limited area of life. Examples include the work done by Carlson and colleagues to define the data literacy skills needed by faculty and advanced students doing research in science, technology, engineering, and mathematics (STEM) fields; Grillenberger and Romeike's development of a data literacy competency model for computer science education; and Mandinach and Gummer's attempts to reach a consensus on a definition of data literacy for teachers and teachers-in-training.¹

The other camp is broader and has more parallels with traditional definitions of information literacy. Just as the Information Age led to the belief that everyone needed to develop "information literacy" to be a fully functional democratic citizen, the Age of Data is leading to similar demands for the broad acquisition of "data literacy" by all students, workers, and voters. A team from Dalhousie University in Nova Scotia, Canada, writing from their own national perspective, provided an apt summary of this view. "Data has become the currency of the new 'Knowledge Economy,' and a critical driver of decision-making in business, government, and social spheres," they wrote. "In this 21st century context, it is crucial to Canada's socioeconomic well-being

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that our citizens have the ability to contribute, interact with, and understand data.... In other words, citizens must be *data literate.*^{"2} As with information literacy, librarians are a primary constituency behind the drive for this variety of data literacy, and for many of the same reasons. Understood this way, data literacy is a cross-cutting skill not limited to a particular disciplinary context, and therefore, many librarians would say, it can best be understood and taught by information experts who approach it from a nondisciplinary position.

There have been many attempts to define data literacy from this perspective, ranging from the simple to the complex. The simplest definition may be that of the Databilities project, which claims that "data literacy is our ability to read, write and comprehend data, just as literacy is our ability to read, write and comprehend our native language."³ Somewhat more detailed is the definition created by the library and information scientists Prado and Marzal, who wrote, "Data literacy can be defined . . . as the component of information literacy that enables individuals to access, interpret, critically assess, manage, handle and ethically use data."⁴ The Dalhousie University team arrived at a similar definition: "Data literacy is the ability to collect, manage, evaluate, and apply data, in a critical manner."⁵ Although these and similar definitions differ in some details, a basic consensus has begun to emerge around the broad skills areas that fall under data literacy.

Consensus has also begun to emerge about some of the specific competencies a person must acquire to be considered data literate, although disagreements persist about whether or not certain competencies are essential. Bonikowska, Sanmartin, and Frenette have done valuable work in this area, comparing five different data literacy–competency frameworks to determine which skills appear most frequently. As they summarize, the frameworks "all include . . . skills necessary to access data, manipulate them, evaluate their quality, conduct analysis, interpret the results, and (in most frameworks) use data ethically."⁶ These competencies clearly parallel the definitions of data literacy noted above, further demonstrating the strength of the emerging consensus on the definition.

However, for all the effort that has been put into defining data literacy and considering what knowledge and skills students need to acquire to be considered data literate, and for all that has been written about how important it is for today's students to acquire data literacy to be functional members of society in this "Age of Data," surprisingly little work has been done on how to teach data literacy at the undergraduate level. This volume attempts to fill that gap.

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DATA LITERACY IN UNDERGRADUATE EDUCATION Faculty Perspectives and Pedagogical Approaches

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ata is becoming increasingly ingrained in the everyday information landscape of our society. Navigating this reality makes data literacy an essential skill for all educated citizens. Data can take various forms and be presented in a multitude of ways. For example, quantitative data is typically numeric, while qualitative data is often text based. Data-literate students understand the different types of data, how to find reliable data, how to consider the source of the data as well as its purpose, how to determine if the data is appropriate for a given context, and how to use data effectively for research and writing.

Responding to the growing data demands of their research communities, many academic libraries have data specialists who provide a suite of "data services," including data repositories, curation tools, metadata creation, grant writing assistance, and data citation. However, these services focus primarily on the needs of graduate students and faculty and mainly involve aspects of data management. Fewer libraries have created data literacy education and programming specifically targeting undergraduate students.

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As data literacy becomes an essential part of higher education, it *must* be taught to undergraduate students; faculty are already incorporating datadriven assignments into their curriculum and need support. Librarians are practiced in teaching information literacy skills in general education and discipline-specific contexts. The Association of College and Research Library's *Framework for Information Literacy* provides librarians with a set of learning competencies for information literacy instruction.¹ The *Framework* allows librarians to design their instruction in a way that enforces certain key competencies. However, there is little direction on how librarians can support data literacy for undergraduate students and what key competencies these students need to master in order to be data literate. In fact, the definition of data literacy itself is still evolving.

This research study examines this issue further and asks the following central questions:

- 1. What are the main data literacy competencies that faculty expect of undergraduate students?
- 2. What are the issues faculty have in teaching data literacy?
- 3. Considering the above, how can librarians partner with faculty to facilitate the development of data literacy competencies for undergraduate students?

To begin answering these questions, instructors from a variety of disciplines were interviewed and asked about data literacy in the undergraduate classroom setting. Next, a content analysis of interview transcripts was conducted. Significant themes and instructors' direct comments point to some critical findings. Data literacy is linked directly to information literacy, regardless of discipline. There are practical, meaningful ways that librarians, as information literacy experts and teaching partners, can contribute to data literacy development for undergraduate students. Further, many faculty members welcome the opportunity to collaborate with librarians in this arena.

LITERATURE REVIEW

The majority of the professional literature discussing the academic library and the librarian's role with regard to data focus on research data management (RDM) activities and services.² Librarians at small and large institutions have

argued that they have expertise in all stages of the research process including data management activities.³

After an analysis and review of more than fifty needs assessment case studies focusing on RDM services in libraries, Goben and Griffen found that libraries were overwhelmingly prioritizing faculty and their data-related requirements for large scale, grant-driven, or other intensive research projects.⁴ No case study considered the needs of undergraduate students. Further, it was determined that best teaching practices surrounding the "finding, sharing, and reusing of data" and its "organization, documentation, and metadata" represented a major lacuna in library services and research.⁵

Some librarians have been working to address this gap and determine best practices for meeting the data literacy needs of undergraduate students, well before Goben and Griffen's work. For example, Stephenson and Caravello designed and taught instruction sessions that incorporated both information literacy and data literacy concepts to help sociology students develop the essential skills needed for research in the field.⁶ Carlson and colleagues' 2015 work on data information literacy recognized that new graduate students may not be prepared for e-research that requires engagement with digital datasets and the associated responsibilities.⁷ Carlson also affirmed that in addition to RDM-driven work, data-related instruction led by librarians would address an unmet need on college campuses.⁸

Meryl Brodsky made the same argument in the context of liaison librarianship for business disciplines.⁹ Likewise, a 2019 article in *Fortune* made the claim that "librarians have a big role to play in improved data literacy"—specifically, in developing the ability of consumers to understand and analyze data in our now big-data business world.¹⁰ A collaborative white paper titled *Future Themes and Forecasts for Research Libraries and Emerging Technologies* asserts that "a continuum of data analysis skills will be required in every discipline," not only for students but also for instructors and librarians.¹¹ The report goes on to say that research libraries will be central partners to this endeavor and emphasizes that data literacy activities related to analysis and ethics "will move beyond the classroom," helping students prepare for jobs and providing a model for lifelong learning in a changing society.¹²

There is some disagreement about whether librarians are suited to teach data literacy concepts to undergraduates. Shorish argues that data-related learning is best led by faculty subject specialists, while Burress, Mann, and Neville facilitated a recent campus-wide collaboration to begin embedding

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data literacy across disciplines, acknowledging the distinct instruction roles for both teaching faculty and librarians.¹³

Though many librarians do data-related work and many large research institutions employ data services librarians, these librarians are often seen as functional specialists. There is not yet consensus around the question of whether data literacy should be in the instruction portfolios of all liaison and/or instruction librarians. After surveying faculty who taught courses that included numeric or spatial data, Hogenboom, Phillips, and Hensley concluded that it is not enough to simply cultivate strong teaching partnerships with faculty members; libraries need to provide the proper training and support for librarians to take on leadership roles and develop a deeper understanding of how campus stakeholders are using and working with data.¹⁴

Prado and Marzal have defined data literacy as "the component of information literacy that enables individuals to access, interpret, critically assess, manage, handle and ethically use data. From that perspective, information literacy and data literacy form part of a continuum."¹⁵ They used this definition to develop a broad framework for data literacy competencies that can be adapted to any type of library: K-12, public, or academic. More recently, Burress, Mann, and Neville used these competencies as a starting point, working with teaching faculty across disciplines at a midsize university campus to adapt them for a higher education curriculum.¹⁶ The selected competencies were grouped into three categories: general undergraduate education, undergraduate research, and graduate education. The present study aims to test the relevance of these data literacy competencies across the spectrum of undergraduate curricula at two institutions. The authors also explore faculty needs and opportunities for librarians to support data-related instruction and student learning at the undergraduate level.

METHODS

This study takes place at two institutions of higher education in Florida: University of South Florida (USF) St. Petersburg campus and Rollins College. USF St. Petersburg is a branch campus of the University of South Florida, serving approximately 4,500 students, with a focus on undergraduate and some master's programs in three colleges: Arts and Sciences, Business, and Education. Information and data literacy is a core component of the USF Enhanced General Education curriculum.¹⁷ Rollins College is an independently accredited private liberal arts college with an FTE of approximately three thousand.

Rollins comprises three schools: the College of Liberal Arts; the Hamilton Holt School, which offers evening and weekend undergraduate and graduate programs; and the Crummer Graduate School of Business, which includes an MBA program and a small doctoral program. At the time of the data collection for this study in spring 2020, both institutions were independently accredited by the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC), and held the Carnegie Classification of Master's Colleges and Universities: Larger programs.¹⁸

This investigation is informed primarily by interviews with college instructors discussing undergraduate teaching practices specifically relating to data literacy competencies and expectations. A small (n = 22) but diverse sample of teaching faculty were recruited for interviews, eleven from Rollins College and eleven from USF St. Petersburg campus. Disciplines included social sciences, natural sciences, and applied disciplines such as business and education. The authors identified interviewees by contacting individual faculty across subject areas who taught some kind of research methods course or another aspect of data literacy as their disciplinary area of expertise. The goal was to identify faculty in as many different disciplinary areas as possible. The population of faculty interviewees comprised various genders and ranks. Interview subjects were a mix of tenure-track faculty with research requirements and full-time instructors, some of whom teach exclusively and others who teach and conduct research.

Various techniques for collecting relevant data were considered, including individual interviews, focus groups, surveys, and syllabi analysis. Stamatoplos, Neville, and Henry have raised a concern about survey methods limiting discovery in studies "where a topic is relatively new, or thinking and language about it may not be standard."¹⁹ Because data literacy pedagogy and related competencies may be unfamiliar to some faculty members, a qualitative method was chosen in order to build campus conversations around this topic.

The authors' goals for this research were to strengthen liaison librarianfaculty relationships, raise faculty awareness of librarian interest in and knowledge of data literacy, and determine whether faculty see data literacy as within the scope of library instruction. Semistructured interviews and an inductive approach allowed the authors the flexibility to "establish clear links between the research objectives and the summary findings derived from the raw data."²⁰ The institutional review boards at Rollins College and the University of South Florida approved this study, including the interview script, prior to implementation.

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The final interview script and protocol were modeled after the work by Stamatoplos, Neville, and Henry in 2016 and the earlier work of Carlson and Johnston in 2015.²¹ The interview script (see the appendix at the end of the chapter) began with a discussion of current and past courses taught by each faculty member, followed by a series of questions about their understanding of data literacy and whether or how they integrate data literacy into their teaching. The interviewees were also provided a list of data literacy competencies previously developed for USF St. Petersburg campus and asked about the applicability and importance of each competency in the context of their courses.²²

Semistructured virtual interviews took place in April, May, and June 2020. A standard protocol was followed for each interview. Each author met virtually with a single participant, and all sessions were recorded and transcribed (with one exception made at a faculty member's request). Webex and Microsoft Teams were used for recording each interview, and then the interviews were transcribed using Microsoft Stream transcription. Each interview lasted approximately 30 to 40 minutes, and all interview transcripts were anonymized by assigning a sequential ID number.

The interview transcripts, video recordings, and associated written notes make up the dataset. Each researcher examined the transcripts of the interviews they conducted, and, based on initial analysis, the research team collaboratively identified attributes of interest. These attributes were developed into a set of six thematic codes and compiled into a common codebook using First Cycle Descriptive Codes as described by Johnny Saldaña.²³ These themes are defined in the results according to the respective pedagogical discourses of instruction librarians and teaching faculty.

The next stage of the data analysis included systematic coding, again as outlined in Saldaña with a process to ensure the validity of assigning the codes.²⁴ As stressed by Connaway and Radford, "It is important to remember that it is inadequate to have only one coder."²⁵ The interrater reliability check (ICR) contributed to the agreement of assigned codes and gave reviewers the opportunity to discuss codes, obtain feedback, and build confidence in the coding process. Researchers completed independent close readings of at least eleven interviews they did not conduct. The researchers then compared and combined codes from each transcript in norming meetings to create consensus and reliability around the final coding choices.

Finally, the researchers drew conclusions and developed recommendations based on the significant themes that emerged from the descriptive codes. These

conclusions, explained herein, are supplemented by basic descriptive statistics relating to interviewee responses to qualitative interview questions as well as by research participant quotes, which have been lightly edited for readability.

RESULTS

Conversations with twenty-two faculty from various disciplines and teaching backgrounds revealed acute interest and enthusiasm for the topic of data literacy, with high levels of agreement about the value of this skill set for undergraduate students. Data literacy was also seen as critical for students' postgraduate entry into today's competitive job market and success in adult life.

The researchers presented faculty with a list of competencies without scaffolding and asked them to select the competencies most applicable to their undergraduate courses (see figure 1.1 and the appendix at the end of the chapter). While data analysis is a crucial component of data literacy, there are entire courses devoted to this subject. This list of data literacy competencies focuses on the data-related skills that complement data analysis and therefore may be embedded throughout the curriculum.

FIGURE 1.1

Faculty agreement on data literacy competencies

Select data literacy competencies with the percentage of interviewed faculty who agree these are relevant for undergraduate education.



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Figure 1.1 reflects interviewees' agreement that many data literacy competencies are applicable to undergraduate education across disciplines. Almost unanimously (95 percent) faculty found the following three competencies relevant for undergraduate learners: recognizing how data is integrated into daily life; interpreting and critically evaluating data and their sources; and communicating data effectively to different audiences in part by using visualizations. Close readings of the interview transcripts affirm this agreement, and indicate that faculty from a range of disciplines consider many of these competencies to be not only applicable to but essential for undergraduate student education. For example, one faculty member explained the importance of recognizing how data is integrated into daily life, saying, "I think that once [students] become comfortable with data meaning more than just numbers, they can better see data in all its forms in their life." Regarding interpreting and critically evaluating data and their sources, a faculty member stated, "[Students] need to be critical of things we know from data; they need to assess data rather than just take it as something that we know . . . some monolithic body of knowledge." Another interviewee spoke about the importance of communicating data as follows: "Being able to write and communicate the data to other people is as important as doing the experiment itself in lab. That's the first real objective."

Further, a large majority of faculty found eight of the ten competencies appropriate for the undergraduate curriculum. Eighty percent or more of faculty interviewees confirmed that competencies originally designated as undergraduate-level skills aligned with the capacities they were trying to instill in their students, whether in general education courses or upper-level, major coursework. Data management and preservation as well as publication metadata activities were, for the most part, seen as better suited to graduate study. However, one competency originally marked as useful for graduate students—data processing and wrangling—was deemed as useful for undergraduates by 73 percent of faculty. It is important to note that there was also variation in how faculty described the scaffolding between general education and upper-level or capstone experiences for undergraduate students. (This will be discussed further later in the chapter.)

The authors identified six main concepts and used these to code all transcripts. The concepts are defined below:

1. *Value of Data Literacy:* The participant shares their perception of the overarching value of data literacy to students.

- 2. *Data Ethics:* The participant shares their concerns relating to ethical use, collection, and citation of data or datasets.
- 3. *Information Literacy and Research Process:* The participant uses language that also describes major/typical tenets or components of information literacy.
- 4. *Datasets:* The participant discusses their strategies for how they provide students opportunities to utilize datasets in their course (create new data versus find/compile data versus use "approved" datasets).
- 5. *Math Anxiety:* The participant discusses obstacles to student readiness for learning data-related competencies with regard to numerical or math literacy.
- 6. *Pedagogy:* The participant discusses different techniques/methods used to teach students data literacy concepts.

During the coding process, the authors quickly realized that Pedagogy was infused in almost every aspect of our conversations, and thus, while a critical point of analysis, was difficult to code effectively. Information Literacy and Research Process, the Value of Data Literacy, and Datasets were well represented in the interview transcripts; Data Ethics was represented in the transcripts to a lesser extent. Initially, the authors thought Math Anxiety was thought to be a major theme; however, the coding process revealed that it was mentioned less frequently.

The authors examined the most significant themes to better understand their relevance in data literacy instruction. The expectation was to learn ways librarians could engage with faculty colleagues to enhance student learning.

DISCUSSION

Faculty interview responses about data literacy emphasized students' ability to make informed decisions or conclusions based on data, both inside and outside of academic pursuits. The majority of interviewees, regardless of discipline, saw data literacy as the foundational understanding that data is part of our everyday lives (see the top-rated competency listed in figure 1.1 and table 1.1). As one faculty member commented, "The entire world is data. How could we not make sure that students are a part of that?" This also speaks to the larger value proposition of data literacy as a critical life skill.

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Based on the results of the coding and analysis of faculty interviews, these authors propose a shift in the scaffolding previously outlined by Burress, Mann, and Neville.²⁶ The updated scaffolding proposed in table 1.1 reflects a number of insights that arose from analysis of the transcripts and accompanying metadata.

The data reflected in figure 1.1 indicate that nearly three quarters of faculty considered data processing and wrangling to be a relevant undergraduate competency. A number of faculty asked for clarification of the term *data wrangling*, borrowed from data science, because they were unfamiliar with it. Therefore, these authors suggest that this language be adapted and customized for different disciplinary contexts to better reflect the activities of students,

TABLE 1.1

Revised data literacy competencies

Data literacy competency	Undergraduate scaffolding	
Recognize how data is integrated into daily life	Introductory level* All disciplines	
Interpret and critically evaluate data and their sources Analyze data Communicate data effectively to different audiences, in part by using visualizations	All levels, with increasing complexity All disciplines	
Read/understand data types and formats Clean / process / convert data Find, select, access, or create datasets in order to test a hypothesis or answer a research question	Introductory level* Natural sciences	Upper-level** or undergraduate research Social sciences
Ethically collect / use / cite data Integrate and synthesize data into different contexts with other sources and prior knowledge	Upper-level** or undergraduate Research Natural sciences	All levels, increasing complexity Social sciences

* "Introductory level" refers to first-/second-year undergraduates.

** "Upper-level" refers to third-/fourth-year undergraduates.

Revised data literacy competencies with flexible scaffolding for the undergraduate curriculum, acknowledging potential disciplinary differences in approaches to data. (Note: Disciplinary groups are organized alphabetically from left to right, not by value.)

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