Designing a Science Information Literacy Program for the Digital Age

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Abstract. The rapid growth of scientific information is presenting many challenges to researchers and students, who need to learn to use new tools and approaches for finding and managing scientific literature and research data more efficiently. This paper describes a large-scale information literacy program implemented at the University of Maryland College Park (USA), which has trained more than 5,000 undergraduate and graduate students how to use new digital technologies to find, filter, manage, share, and communicate scientific information.

Keywords: Science Information Literacy, Bibliographic Management, Electronic Laboratory Notebooks (ELNs), eScience

1 Introduction

The new digital technologies are changing the way students learn and scientists perform research, communicate their findings, and collaborate with others. Science is increasingly becoming a global effort, which crosses disciplines and national boundaries. The tremendous growth in scientific information and fierce competition for making an impact present challenges to researchers as they need to keep up with the new technologies and adjust to a fast-moving work environment. New publication models such as open access (Baykoucheva, 2015b), the advent of social media, and new ways to measure academic impact have created new opportunities for researchers to communicate their findings (Baykoucheva, 2015a; Brody, 2013; Brown, 2014; Buschman & Michalek, 2013; Cheung, 2013; Galligan & Dyas-Correia, 2013; Galloway, Pease, & Rauh, 2013).

Many factors such as availability of science resources, familiarity with new digital technologies, as well as skills to find, manage, and communicate scientific information efficiently will affect the quality of research. The rise of "Big data," which Jim Gray of Microsoft called "the fourth paradigm" in scientific research (Tolle, Tansley, & Hey, 2011), is described as the creation and management of large volumes of data. The three first paradigms were the experimental, theoretical, and computational sciences.

The challenges presented by the new technologies are also accompanied by new expectations from higher education. Educating students and researchers about the new technologies and tools will prepare them for successful careers in science. This article

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describes a large-scale information literacy program, which has trained more than 5,000 students at the University of Maryland College Park on using new digital resources and tools to find and manage scientific information and research data.

2 Exposition of the Investigation

2.1 General Design of the Program

The information literacy program described here was integrated in science courses at the University of Maryland College Park. Students were trained for one or two hours in information literacy sessions, tailored toward the discipline, the level of education (graduate or undergraduate), and the course size. A previous article describes the design and the methodology as applied to small and large chemistry courses and provides more details about the content of the information literacy instruction (Baykoucheva, Houck, & White, 2015).

Undergraduate science courses.

The program was designed and implemented in undergraduate chemistry and life sciences courses of two types: (1) small courses (up to 100 students) and (2) large courses (from 400 to 850 students).

Face-to-face instruction was carried out during the course lab times. The author of this article performed face-to-face instruction for the small courses. The large courses were divided into smaller sections of 20 students. Teaching assistants (TAs) were assigned to each sections. They were trained by the author to conduct the face-to-face instruction for their sections. The duration of the classes was one or two hours.

Graduate science courses.

Information literacy instruction was integrated in courses for new graduate students. In addition to the material taught in the undergraduate courses, graduate students were presented with additional information. The size of these courses varied from 15 to 40 students. The face-to-face instruction was performed by the author of this article.

3 Results

3.1 Overview of the Program

The Information literacy program was designed to satisfy specific needs of undergraduate and graduate students and depended on the course level and the discipline. It was based on a blended instruction model, which included both face-to-face instruction and online components such as instructional materials and assignments. A LibGuide, prepared for each individual course, provided access to instructional materials, resources, and online assignments.

Fig. 1. A LibGuide used in information literacy instruction provided access to instructional materials, resources and online assignments.

The LibGuide was a very highly used resource by students. As shown in Figure 2, it was accessed 39,761 times in 2016. The peaks in usage coincided with the periods of information literacy instruction (February and September) and with the peaks in usage of the databases covered during the instruction.

Fig. 2. LibGuide usage statistics. The LibGuide was accessed 39,761 times in 2016.

3.2 Skills Acquired by Students

The topics covered in the program varied from course to course and included skills suitable for the level of education of the students. The modules presented below were used in different courses, depending on the discipline and the level of education of the students.

Basic information literacy skills (covered in all courses).

- *Searching for scientific literature* in the following databases: EBSCO databases, Google Scholar, PubMed, SciFinder, Scopus, and Web of Science. Students had to perform searches in literature databases, narrow down the search results by time period, additional key words and other criteria.
- *Finding properties of chemical compounds* using chemical names in ChemSpider, PubChem, Reaxys, and SciFinder.
- *Finding general information* (e.g., from newspapers, magazines, wires) using LexisNexis Academic and government web sites.

Advanced information literacy skills (covered in all courses).

- *Managing citations with bibliographic management programs.* Students had to export selected references obtained through a literature search in a database to a bibliographic management program such as EndNote or Zotero; and create a bibliography with the selected references.
- *Finding properties of chemical compounds* through structure searching in SciFinder and Reaxys. Figure 3 shows an example of structure searching that students had to perform in SciFinder. They had to draw a molecular structure, find the chemical compound that corresponds to this structure, and find specific properties of this compound and how it could be synthesized.

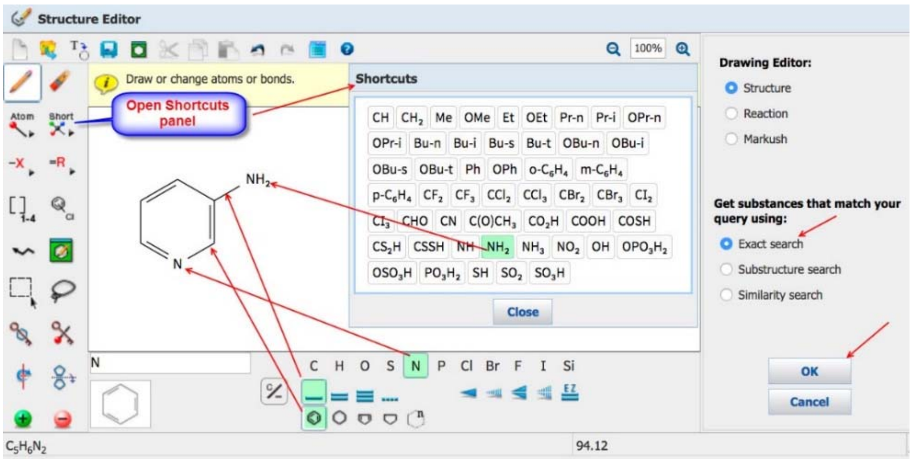

Fig. 3. Structure searching in SciFinder. Students were provided with detailed instructions on how to draw molecular structures and find properties of the chemical compounds that correspond to these structures.

Data literacy: Finding and managing research data (covered in some of the courses).

Data are generated through experiments, statistical procedures, or other ways and include experimental data, computer simulation, textual analysis, and geospatial data. In the social sciences, data are numeric data, and also could be video, audio, and other digital content obtained in the course of social studies or other sources. In some of the courses, students have learned how to manage and find data and use Electronic Laboratory Notebooks (ELNs) (Bird, Willoughby, & Frey, 2013; Bogdan, 2014) to record their lab results (Baykoucheva & Friedman, 2013).

Scientific communication (covered in graduate courses).

- New models and formats of scholarly communication
- Tools and resources for scientific writing
- Visualization of information
- Author identifiers (ORCID, ResearcherID, and Scopus authoring tools)

Academic social networks (covered in graduate courses and higher undergraduate courses).

- Academia.edu
- Blogs
- Facebook
- Google Scholar profiles
- Mendeley
- ResearchGate
- Twitter

Scientific ethics (covered in undergraduate and graduate courses).

Students were made aware of what is considered unethical behavior (e.g., plagiarism, data falsification) and the consequences of engaging in such activity.

Measuring academic impact (covered in graduate courses).

- Journal Impact Factor (IF)
- Web of Science citations
- h-factor
- Google Scholar citations
- Altmetrics

Fig. 4. Screen capture of a ResearcherID profile, which shows how author's articles were cited globally.

3.3 Assessment of Student Learning and Feedback (Implemented in All Courses)

Online assignments were used to assess student learning and to obtain feedback about the instruction. The assignments were designed not only to evaluate the skills acquired during the information literacy instruction but also to allow students to practice, on their own, to use the resources they were shown in face-to-face instruction sessions. Figure 5 shows how students responded to a question about filtering search results.

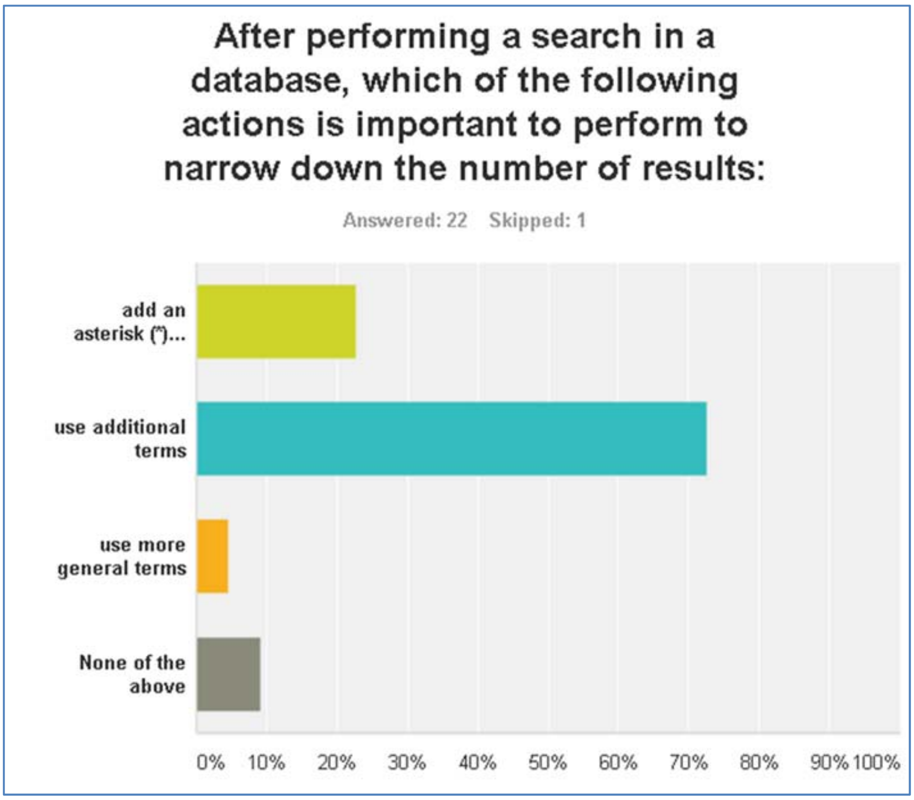

Fig. 5. Responses from students to a question on an online assignment.

By obtaining feedback from students (See Figure 6), it was possible to compare their familiarity with the resources before and after the instruction.

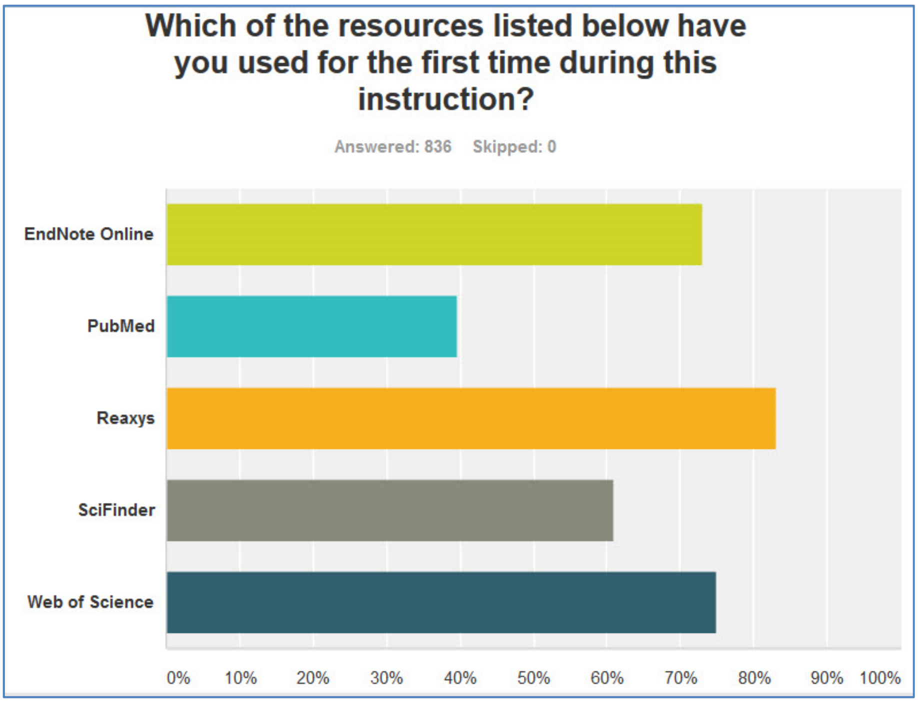

Fig. 6. Feedback from students about their familiarity with the resources before the instruction.

4 Discussion

The described large-scale science information literacy program was very successful. The logistics of implementing the program in large courses was very complicated, but the use of many instructional materials and online assignments made it very manageable. The collaboration between a librarian (the author of this article) and instructors of the science courses was of major importance for its success. Students acquired many new sophisticated skills and learned how to find and manage scientific information in a more efficient way. As shown in Figure 7, the feedback from students about the instruction and the assignments were very positive.

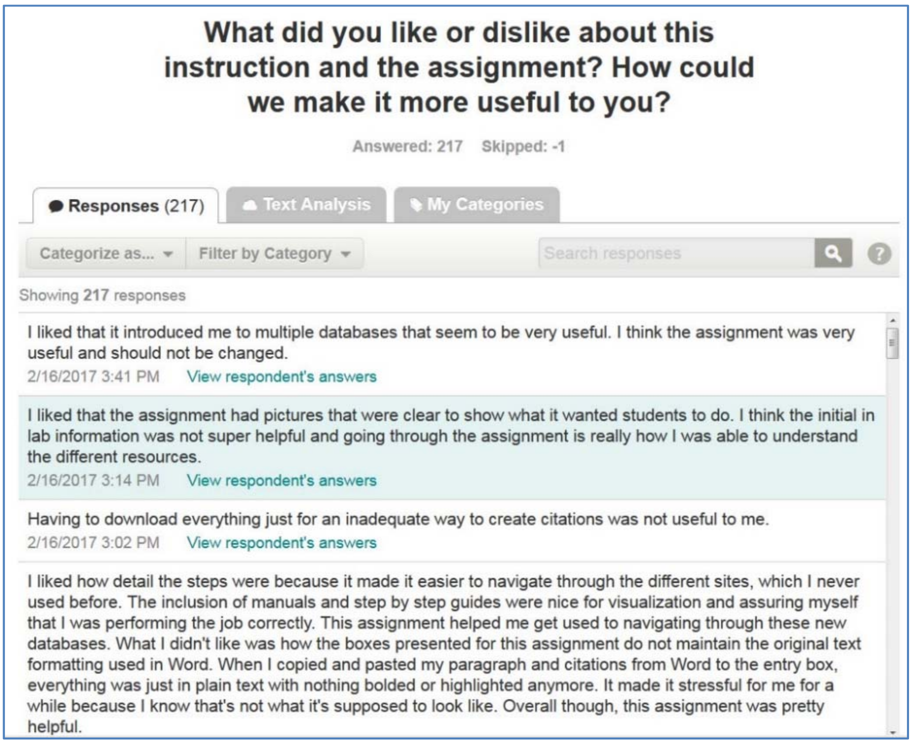

Fig. 7. Positive feedback from 217 students in a chemistry course about the benefits they obtained from the instruction.

Information literacy programs today have to adjust to the new technologies, as the needs of students and researchers and the way they learn and conduct research are changing. Finding scientific information and communicating are closely connected processes that are integrated in researchers' actual scientific activity. Practical information about tools and resources that can make scientific research and communication and collaboration more efficient will benefit researchers and students.

It is important to look at science information literacy instruction from a broader perspective. It is not enough to teach students how to find literature and property information. It is important to teach them also about communicating in science, scientific writing, new models of publishing, and emphasize research ethical standards. They need to learn how to manage their results and find data sets, how to use the academic social networks to make their research visible and cited by others.

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