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Supporting information for this article (Appendixes A and B) is available following the notes.

What Do Undergraduate Students Know about Scholarly Communication? A Mixed Methods Study

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Abstract

Amid movements that recognize undergraduate students as knowledge creators, transformative work is being done at the intersection of information literacy and scholarly communication. Absent from the literature so far is research related to students' perception and understanding of scholarly communication. This paper reports a mixed methods study at two major research universities in the United States, where undergraduate student researchers were surveyed and interviewed about their scholarly communication practices and perceptions. This work informs development of programming at the intersection of scholarly communication and information literacy in general, and for those involved with undergraduate research experiences in particular.

Introduction

Activity is increasing at the intersection of information literacy and scholarly communication. In a white paper published in 2013, the Association of College and Research Libraries (ACRL) Intersections of Scholarly Communication and Information Literacy Task Force articulated three intersections of information literacy and scholarly communication: publication economics, digital literacies, and librarians' changing roles. The ACRL paper then proposed a set of responses regarding information fluency, transformative pedagogy, and collaboration.¹ *Common Ground at the Nexus of Information Literacy and Scholarly Communication*, a book published the same year, explored how librarians engage students and disciplinary faculty in scholarly communication topics through the lens of information

literacy.² The Intersections website features a growing, dynamic bibliography of more than 50 citations to relevant articles, book chapters, conference presentations, and proceedings papers.³

Meanwhile, key shifts in information literacy and higher education make fertile ground for work at this intersection. First, library-related movements, including ACRL's recent acceptance of the Framework for Information Literacy for Higher Education (often called simply the Framework), are gaining momentum to support undergraduate students as they move beyond their role as knowledge consumers, encouraging them to become skillful knowledge creators. The Framework, including the frames "Scholarship Is Conversation" and "Information Has Value," focuses on larger conceptual understandings in using and creating information.⁴ Across higher education, the Association of American Colleges & Universities (AAC&U) promotes the implementation of high-impact educational practices. The AAC&U identifies 10 such practices, including capstone courses and projects, service-based learning, and undergraduate research, that are especially effective in increasing student engagement and retention, as well as achieving desired learning outcomes.⁵ Such practices require students to interact with faculty and with one another on substantive topics, to commit significant time to the learning activity, and to increase their interactions with a diverse student body. Feedback is a focus of the learning process, and there is direct application of meaningful learning experiences. Consequently, "students better understand themselves in relation to others and the larger world."⁶ This study focuses on students engaged in undergraduate research experiences, which are defined by the Council on Undergraduate Research as "an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline."⁷ The Framework and high-impact educational practices, with their parallel recognition of students as knowledge creators, provide a foundation for libraries to meet students wherever they are in the scholarly communication cycle through a wide variety of information literacy (IL) opportunities.

This study examines undergraduate student researchers' perceptions and understandings on a variety of issues related to scholarly communication. Specifically, what are the students' current scholarly communication practices? Do they value knowledge of scholarly communication topics and issues? How do they learn about these topics and issues, if at all? A desire for answers to these questions, and for a glimpse into the mind and experience of the undergraduate researcher, guided the design of this study. A deeper awareness of student researchers' perceptions and understandings will help librarians in collaborating with disciplinary faculty and other campus partners. Together, we can strategically plan programming and interventions at the intersection of information literacy and scholarly communication.

Literature Review

High-impact educational practices are transforming the traditional structure of higher education. The AAC&U states that high-impact educational practices "increase the odds that any student—educational and social background notwithstanding—will attain his or her educational and personal objectives, acquire the skills and competencies demanded by the

challenges of the twenty-first century, and enjoy the intellectual and monetary gains associated with the completion of the baccalaureate degree.”⁸ Undergraduate research experiences present students with a variety of scholarly communication challenges, including data management and authorship-related issues of research. In turn, these experiences open doors for information literacy instruction previously aimed at graduate-level student learning outcomes.

Several arguments have been made within the library and information science literature for why librarians should introduce undergraduate students to the scholarly communication landscape and support them throughout the entire knowledge creation process. The 2013 ACRL white paper “Intersections of Scholarly Communication and Information Literacy: Creating Strategic Collaborations for a Changing Academic Environment” contended, “Experiential learning takes advantage of the student’s ability to make meaning from direct experiences by actively involving the learner in the experience while presenting opportunities for him or her to reflect on observations and understandings.”⁹ Active, experiential learning, including high-impact educational practices such as undergraduate research experiences, often requires students to interact with information in complex, authentic ways.¹⁰ As Scott Warren and Kim Duckett argue:

It is crucial to expose students to the structural considerations and power dynamics that underlie contemporary academia and the associated industries that aid its massive production and consumption of information. Doing so gives these future citizens and scholars the ability to evaluate such systems from moral and ethical stances of their own choosing.¹¹

Stephanie Davis-Kahl has challenged librarians to think beyond traditional classroom learning. “Developing a holistic approach to educating and developing awareness around scholarly communication issues in the curriculum, in the library, and on campus can help to create a culture of sharing that will impact the scholarly landscape of the future,” she says.¹²

ACRL has made a strong commitment to promoting the instruction of scholarly communication issues with the Framework for Information Literacy for Higher Education. It states, “Students have a greater role and responsibility in creating new knowledge, in understanding the contours and the changing dynamics of the world of information, and in using information, data, and scholarship ethically.”¹³ To further encourage this movement, ACRL has dedicated professional development support for academic librarians interested in exploring pedagogical approaches to the intersection between scholarly communication and information literacy.¹⁴

Other recent literature articulates librarians’ ongoing contributions to student understanding of scholarly communication. Merinda Kaye Hensley, Sarah L. Shreeves, and Stephanie Davis-Kahl performed a benchmark study surveying library support for undergraduate research programs, reporting IL instruction as the most common type of support for these programs.¹⁵ In a follow-up study, Hensley found that librarians continue to teach students traditional information literacy skills such as searching for information, but they

also provide guidance on a wide array of scholarly communication topics, including author's rights and data management. Hensley stated, "Since undergraduate researchers lack the depth of experience and habits of mind of a faculty member (or even a graduate student), it becomes clear why support for fostering IL skills becomes essential for students engaging in research at a level new to them."¹⁶ Catherine Fraser Riehle and Sharon Weiner went a step further by delving into the literature to determine if and how high-impact educational practices include the development of information literacy competencies. Riehle and Weiner found that, while IL competencies are indeed included, they are seldom referred to as "information literacy," in part because of a lack of librarian involvement.¹⁷

Teaching can draw upon many recent studies of pedagogical strategies that combine scholarly communication and information literacy. For example, Warren and Duckett have outlined a series of conversational classroom strategies so that students may better "understand the forces that shape the information they consume."¹⁸ By comparing Google to library databases and engaging students about information economics, Warren and Duckett demonstrate how librarians can uncover the disparities of information access and help students make thoughtful information management decisions:

Search skills must be accompanied by a greater understanding of how scholarly information is created, debated, vetted, stored, and accessed—issues intrinsically tied to scholarly communication and the economic costs that shape not only the scholarship itself but also the tools used to discover and access that content. In the contemporary information landscape, simply teaching students how to distinguish peer-reviewed from non-peer-reviewed research is not sufficient.¹⁹

In a subsequent article, Duckett and Warren challenged librarians to further stretch their conversations "to provide greater context for how to search and how to find by exploring 'Why is it this way?'"²⁰ They offered examples of how they engage students at North Carolina State University in Raleigh to expose the sociocultural and economic frames behind the scholarly communication process, including an instructional video on the peer-review process and a game that asks students to guess the price of academic journals.

Davis-Kahl has also provided several examples of pedagogical strategies for teaching scholarly communication. These include discussion of economic issues related to publishing through students' own temporary access to databases; licensing issues related to creative work to discuss students' ownership of their work; and placing students in the role of reviewer and editor when publishing their own work through undergraduate research journals.²¹ Additional examples include the evaluation of resources within the realm of economics.²²

Not all librarians are on board, have adequate resources, or even have the opportunity to teach undergraduates complex scholarly communication issues. In fact, Edward P. Keane found that a distinct group of librarians expressed ambivalent feelings on teaching undergraduate students about open access.²³ He found that some librarians hesitate to teach complex scholarly communication issues to undergraduates because they prefer to direct their limited resources to the faculty and graduate student populations. Shan C. Sutton has pro-

posed to address this hesitation by inviting librarians to collaborate with faculty, to “consider how instruction in this area may be linked with faculty members’ research in order to cultivate scholarly communication connections between the two.”²⁴

Whether or not librarians actively support students in this area, or partner with other instructors who do, undergraduate students *are* actively participating in the scholarly communication process as content creators. They construct research posters, create digital projects, write articles for undergraduate research and disciplinary journals, and much more.²⁵ This “publication” process as pedagogical strategy provides the teaching librarian with the opportunity to educate students about the scholarly communication cycle.

An increasing number of examples in the literature share case studies of information literacy instruction, paired with publication support. Poster presentations are a low-risk activity where undergraduates can be initiated into the scholarly conversation, as students share their original research while answering questions of poster session attendees. Undergraduate students present posters as part of course assignments and at campus events such as Undergraduate Research Week, and they get their first experience of disciplinary conferences, often under the guidance of faculty mentors. Librarians have become increasingly involved in helping students create research posters, in part because the instruction offers an opportunity to discuss aspects of the research cycle, including author’s rights.²⁶ For example, one of the authors of this study offers workshops for an undergraduate research conference to highlight management of students’ online scholarly presence through the submission of research posters to the institutional repository.²⁷

Denise Hattwig, Nia Lam, and Jill Freidberg worked with undergraduate students and faculty at the University of Washington Bothell to produce a digital collection, the Community Voices project, where students performed research, conducted interviews, and produced oral histories.²⁸ Librarians worked extensively with students on agreement forms. Hattwig, Lam, and Freidberg point out, “By working so closely with the agreement forms and articulating the concepts underlying the forms to their interviewees, students engaged meaningfully with copyright, ownership, licensing, and permissions.”²⁹ The agreement forms gave students the opportunity to see the scholarly communication process from three perspectives. From the interviewee perspective, the forms protected their ability to retain copyright over the interviews; for the students as content creators of the resulting interviews, they retain ownership of the work; and from the perspective of the library, an open access policy allowed the oral histories to be published openly online.

Students increasingly participate in the scholarly communication cycle as authors of undergraduate theses and articles in undergraduate research journals. Sharon Weiner and Charles Watkinson have performed an assessment of students who publish in an undergraduate research journal, the *Journal of Purdue Undergraduate Research (JPUR)*. Weiner and Watkinson determined that the publishing process “influence[d] their choices of careers and decisions to write scholarly articles in the future.”³⁰ At Pacific University in Forest Grove, Oregon, Isaac Gilman has developed a credit-bearing course that builds on the goals of the disciplinary curriculum side by side with educating undergraduates about scholarly communication.³¹ Gilman’s semester-long course connected students to an array of scholarly communication issues that “anticipated the potential for the course to serve as a powerful advocacy tool, giving students the opportunity to actively interrogate scholarly

communication issues, such as open access and author rights, within the context of a credit-bearing course, rather than a one-time workshop."³²

Riehle has reported on an undergraduate honors course she developed and taught with Watkinson that engaged students in work related to scholarly communication topics and issues. The course culminated with the publication of a print and online open access book of student-written essays.³³ Char Miller and Char Booth made the case for open access as pedagogy by sharing their experience as undergraduates, stating that publishing as an undergraduate "challenges traditional hierarchical dynamics in academia and publishing and gives student authors space to assert their intellectual agency."³⁴

Despite this growing body of scholarship, little is known about undergraduate students' understanding of scholarly communications topics. While several articles explored undergraduates' understanding of copyright, the authors found no studies that systemically gauge understanding of other ethical, legal, and social dimensions of scholarly communication.³⁵ Reports from the Center for Studies in Higher Education at the University of California, Berkeley and from Ithaka S+R focused on understanding the scholarly communication needs and practices of faculty, but there is no recent research related to students' awareness and understanding of these topics.³⁶

The Setting

This research study was conducted over three terms beginning in summer 2014 at Purdue University and the University of Illinois at Urbana-Champaign. Both are public land-grant institutions, founded in 1869 and 1867, respectively.

Purdue University

The study was conducted at the main campus in West Lafayette, Indiana, about 67 miles northwest of Indianapolis. In 2015, enrollment at the West Lafayette campus encompassed 29,500 undergraduate and 8,900 graduate students, including more than 9,200 international students.³⁷ About 30 percent of Purdue's undergraduate students participate in at least one formal research experience during their time at Purdue.³⁸ Purdue students may pursue participation in departmental honors programs, Purdue's Honors College, or both. The Honors College was founded in fall 2012 and currently enrolls over 500 first-year students. Participation in many of these programs, including the Honors College, requires students to complete a capstone thesis or scholarly project. Most students do so through individual arrangements with faculty. A major annual event is the Undergraduate Research and Poster Symposium, which takes place in April. The Purdue Libraries sponsor a "best abstract" contest for which librarians review abstracts, disciplinary faculty judge students' posters, and cash awards are given in a variety of categories. Other opportunities to present original research include those for formal programs such as the Discovery Park Undergraduate Research Internship Program, the Cancer Prevention Internship Program, the Summer Undergraduate Research Fellowship (SURF), the Margo Katherine Wilke Undergraduate Research Internship, and the Clarence E. Dammon Dean's Scholars Program in the College of Liberal Arts. Many of these programs culminate with presentation of stu-

dent work in the form of symposia, poster presentations, or both. Undergraduate researchers at Purdue have several student publications on campus in which to publish their work, including the *Purdue Journal of Service-Learning*, the *Purdue Historian*, and the *Journal of Purdue Undergraduate Research (JPUR)*, all of which are published online in Purdue ePubs, Purdue's open access institutional repository. SURF research abstracts are also featured in a unique series within Purdue ePubs.

Catherine Fraser Riehle, an instructional resources design librarian and one of the authors of this study, serves on *JPUR*'s faculty advisory board; offers learning opportunities, including workshops, for *JPUR* authors and potential authors; and leads a required abstract-writing workshop annually for SURF participants. She also regularly reviews abstracts submitted for the annual Undergraduate Research and Poster Symposium, most frequently selecting winning abstracts in the humanities and social sciences category.

The University of Illinois

The University of Illinois at Urbana-Champaign (Illinois) is in east-central Illinois, about 140 miles south of Chicago. The university features 16 colleges and instructional units and over 150 programs of study, and is the academic home to 32,000 undergraduate students, 11,000 graduate students, and more than 10,000 international students.³⁹ Illinois offers students a wide variety of opportunities to participate in formal undergraduate research experiences and honors programs, mostly within the school's academic departments. In addition, approximately 125 students are admitted annually to an interdisciplinary Campus Honors Program, and students across disciplines can also participate in college and departmental honors programs.

The Office of Undergraduate Research was established in August 2012 to disseminate best practices and models to campus stakeholders. A spring 2015 campus-wide survey found that most students at Illinois gain undergraduate research experience as part of a course, and that their motivations for doing so focus on enhancing their resumes and career prospects.⁴⁰ The Office of Undergraduate Research now offers an undergraduate research certificate program that recognizes student achievement in undergraduate research, with 41 certificates awarded in 2015. Certification requires two research presentations; relevant coursework, research experiences, or both; and attendance at professional workshops, research, or library presentations. Like other research institutions, Illinois holds an annual Undergraduate Research Week in April, featuring almost 600 oral and poster presentations at the 2015 symposium. The Summer Undergraduate Research Fellowship (SURF), which provides funds for undergraduate students to engage in faculty-mentored research during the summer, presented 14 awards in 2015. The University Library collaborates with five campus departments and programs to publish online undergraduate research journals, using Open Journal Systems, a journal management and publishing system, and the institutional repository, IDEALS (Illinois Digital Environment for Access to Learning and Scholarship), for archiving. The five journals are (1) *i-ACES (inquiry-ACES)*; (2) *Peer Review: The Undergraduate Research Journal of the Ethnography of the University Initiative*; (3) *Re:Search: The Undergraduate Literary Criticism Journal*; (4) *TRiO: McNair Scholars Undergraduate Research Journal*; and the (5) *Illini Journal of International Security*.⁴¹

As the library's undergraduate research liaison, Merinda Kaye Hensley, the other author of this study, serves on the faculty advisory board for the Office of Undergraduate Research, is an Executive Committee member of the Ethnography of the University Initiative, manages the campus suite of online undergraduate research journals, and organizes the library's Image of Research competition for undergraduates. In collaboration with Illinois Library faculty and staff, she also offers a wide variety of "Savvy Researcher" workshops on data services, information management, and other scholarly communication topics.

Study Aims

This study aims to fill gaps in the literature related to undergraduate students' knowledge and perceptions of scholarly communication topics, including the peer-review process, author and publisher rights, publication and access models, processes for determining the impact of scholarly research publications, and data management. Data were gathered in alignment from Purdue University and the University of Illinois at Urbana-Champaign to compare and contrast students at similar institutions. This contribution to a growing body of scholarship on the intersection of information literacy and scholarly communication informs the development of campus-wide and curricular collaborations, library programming, and other instructional interventions. The following research questions guided the researchers' work:

- What do undergraduate students from a variety of disciplines report to know about scholarly communication?
- Do they value knowledge of a variety of topics and issues related to scholarly communication?
- When and how do they expect to gain knowledge about these topics and issues, if at all?

Methods

Survey Participants

The researchers used purposive sampling for this exploratory study, deliberately selecting their sample from undergraduate students who were currently participating in or who had recently completed formal undergraduate research experiences with faculty mentors.⁴² The researchers referred to these students as "immediate stakeholders" because they had recently participated or were currently participating in the scholarly communication process. As such, participants were students involved in formal undergraduate research experiences, published authors and editorial board members of undergraduate research journals, and honors students expected to complete a major capstone project—an honors thesis or other culminating scholarly project.

A Mixed Methods Approach

The Institutional Review Board offices of both campuses approved the study. It used a mixed methods approach: major data sources included student survey responses, followed by semi-structured interviews with a select number of respondents. The sequential explanatory design consisted of two primary data collection phases: quantitative followed by qualitative. Combining and integrating quantitative and qualitative methods can “[provide] a stronger understanding of the problem or question than either by itself.”⁴³

First, researchers collected and analyzed quantitative data from two online surveys, one for each campus. An initial analysis of survey responses informed the development of the interview protocol, also performed separately on each campus. Next, the researchers collected and analyzed qualitative data from semi-structured interviews to elaborate on and further inform the survey data and research questions. After coding interview transcripts and identifying themes from the qualitative data, connections and anomalies were explored among and between both data sources.

Part One: Survey

Respondents from Purdue were invited to participate in the survey via e-mails sent from research or honors program coordinators with whom Riehle had been in contact, through liaison support for undergraduate research publication, information literacy instruction efforts, or both. Respondents from Illinois were invited by e-mails sent from Hensley as identified through the undergraduate research activities on campus, including journal publishing efforts (Purdue N = 221; Illinois N = 345). All participants who completed the survey were entered into a random drawing to receive a \$50 Amazon gift card, with one awarded on each campus. Surveys ran separately for each campus and remained open for three weeks. Respondents were reminded about the opportunity approximately one week before the survey closed.

Respondents completed a 12-item online survey consisting of demographic questions and questions designed to gauge students’ perceptions and understanding of scholarly communication topics, including the peer-review process, author and publisher rights, publication and access models, determining the impact of scholarly research publications, and data management. Respondents were asked to rank, on a Likert scale, their perceived levels of knowledge as well as how much they value knowledge about these topics. They were also asked to identify the context in which they expect to learn about these topics, if at all. Participants were invited to participate in a 15- to 20-minute follow-up interview, for which they would be compensated for their time with a \$20 Amazon gift card. The Purdue and Illinois surveys were identical, apart from institution-specific categories (for example, names of academic programs). Purdue’s survey was administrated using Qualtrics survey software, while Illinois used institution-specific survey software. Data were normed and merged later to enable aggregation and comparison.

The Purdue survey (n = 77 of 221; 34.8 percent response rate) was distributed during the summer of 2014 to students participating in formal summer undergraduate research experiences. Participants in Purdue’s Honors College and departmental honors programs were not invited separately to participate, because Riehle prioritized participants in Summer

Undergraduate Research Fellowships (SURF), one of the largest formal undergraduate research programs on campus. In addition, Purdue's Honors College had been established less than two years prior, so an overwhelming majority of Honors College students were in their first or second semester and had not yet begun work toward a thesis or culminating scholarly project. Respondents could indicate on the survey, however, if they were members of the Honors College or a college or departmental honors program.

The Illinois survey (n = 64 of 345; 18.6 percent) was distributed in the fall semester of 2014 to a combined list of students who had participated in the spring 2014 campus-wide undergraduate research symposium as well as student editors of undergraduate research journals. This method provided a broad cross-section of respondents across disciplines who identified as recently active in a formal undergraduate research process.

Most respondents were juniors or seniors, which was not unexpected because undergraduate research opportunities target students within their declared major. Respondents were asked to identify their departments or colleges by selecting from a list. The Purdue and Illinois lists varied because of different institutional programs and major offerings. A majority of respondents identified with STEM (science, technology, and mathematics) disciplines (Purdue n = 68, 94.4 percent; Illinois n = 38, 61.3 percent). There were also respondents from both institutions who identified with disciplines in the social sciences and humanities (Purdue n = 15, 20.8 percent; Illinois n = 19, 30.7 percent). A group of Illinois students were classified as "other" (n = 15; 24.2 percent). Eleven respondents from Purdue and 10 from Illinois identified with more than one discipline (n = 83 Purdue; n = 72 Illinois), therefore percentages add up to more than 100 percent.

The Purdue University disciplines were engineering (n = 32, 44.4 percent); science (n = 14, 19.4 percent); liberal arts (n = 12, 16.7 percent); agriculture (n = 11, 15.3 percent); health and human sciences (n = 9, 12.5 percent); Honors College (n = 3, 4.2 percent); and technology (n = 2, 2.8 percent), total N = 72. The disciplines at the University of Illinois at Urbana-Champaign were "other" (n = 15, 24.2 percent—mostly fine and applied arts and English); biology (n = 10, 16.1 percent); engineering (n = 7, 11.3 percent); psychology (n = 7, 11.3 percent); political science (n = 6, 9.7 percent); agriculture, consumer, and environmental sciences (n = 5, 8.1 percent); computer science (n = 4, 6.5 percent); mathematics (n = 4, 6.5 percent); applied health and sciences (n = 3, 4.8 percent); education (n = 3, 4.8 percent); human development and family studies (n = 2, 3.2 percent); physics (n = 2, 3.2 percent); and African American studies, astronomy, neuroscience, and veterinary medicine (n = 1 each, 1.6 percent). Two participants skipped this question (total N = 62).

Respondents selected the undergraduate research experience or experiences in which they had participated. Institution-specific options were provided in each survey and included honors programs, summer undergraduate research programs, internship programs, and undergraduate research journals. Several respondents had participated in more than one experience. The final demographic question focused on respondents' international status, since both institutions have a significant international student population. Overall, respondents' demographics were similar across both institutions.

The following definition for scholarly communication was provided at the beginning of the survey:

Scholarly communication is the system through which research and other scholarly writings are created, evaluated for quality, disseminated to the scholarly community, and preserved for future use. The system includes both formal means of communication, such as publication in peer-reviewed journals, and informal channels, such as electronic listservs. (Association of College and Research Libraries, 2003).

The researchers analyzed three Likert scale questions and created diverging stacked bar charts using RStudio, software for statistical analysis and graphics, to enable comparison between the various scholarly communication topics presented in each question. Each Likert question is represented by two charts: the first chart for each question represents aggregated data from both Purdue and Illinois, and the second compares the institutions.

Because Purdue and Illinois are similar institutions with a comparable range of undergraduate research experiences available to students across disciplines, the data were combined to aggregate overall respondent perception of understanding on a variety of scholarly communication topics. In each chart, the bars represent the combined respondent data for both institutions for each topic related to scholarly communication.

The survey began by asking respondents about their current level of knowledge on five scholarly communication topics (peer-review process, author and publisher rights, publication and access models, determining the impact of scholarly research publications, and data management). The data indicate that respondents were more confident about their understanding of the peer-review process and data management and slightly less confident about author and publisher rights, publication and access models, and determining the impact of scholarly research publication. In the middle columns, which represent the percentage of respondents who selected “moderately knowledgeable” for each topic, the highest percentage of respondents indicated they felt “moderately knowledgeable” about the peer-review process (40 percent), and the lowest percentage felt “moderately knowledgeable” about publication and access models (21 percent). See Figure 1.

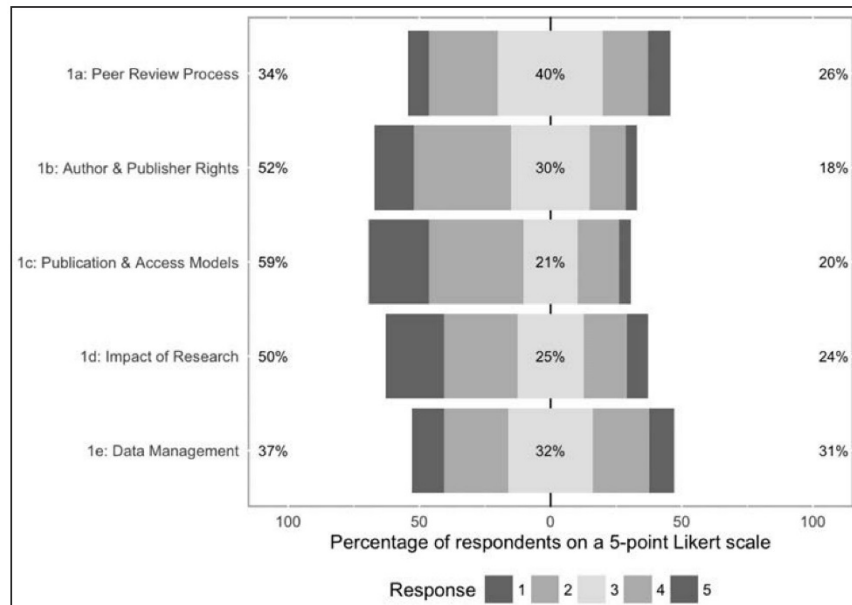


Figure 1. Respondents’ responses to the question “How would you rate your current level of knowledge about the following topics related to scholarly communication?” scored on a Likert scale: (1) not at all knowledgeable, (2) slightly knowledgeable, (3) moderately knowledgeable, (4) very knowledgeable, (5) extremely knowledgeable (aggregated data from Purdue University and the University of Illinois at Urbana-Champaign).

The second chart represents the same data broken down by institution (see Figure 2). While Purdue and Illinois students often responded similarly, there are fine differences between the two institutions. For example, Purdue respondents were twice as likely to say they were “moderately knowledgeable” about their data management skills and about author and publisher rights than were Illinois students. They were also nearly three times more likely to select “moderately knowledgeable” when ranking their ability to determine the impact of scholarly research publications. Overall, Purdue respondents reported higher levels of perceived knowledge for every scholarly communication topic.

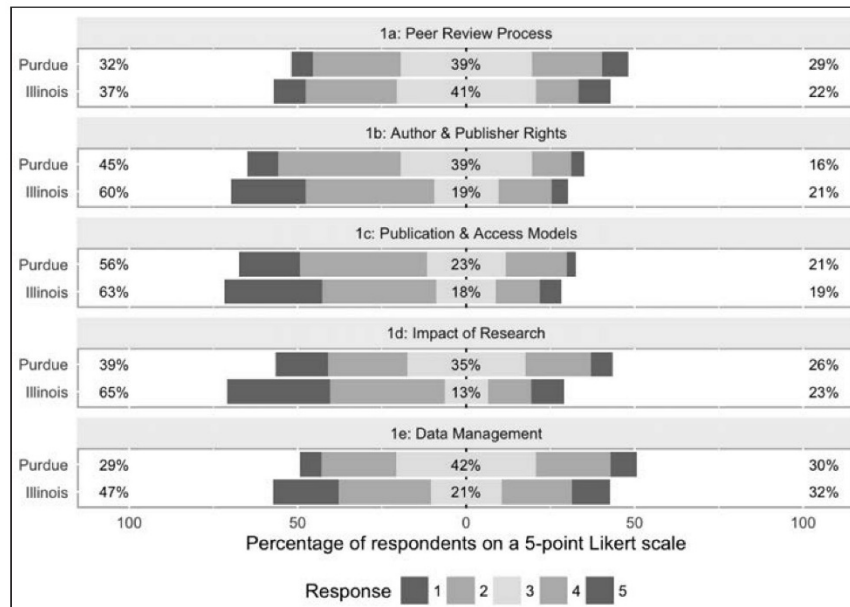


Figure 2. Comparison between Purdue University and the University of Illinois of respondents' perceived levels of understanding on scholarly communication topics.

Later in the survey, respondents were asked to gauge their confidence in engaging with a variety of scholarly communication activities. The activities were selected to mirror the topics listed earlier in the survey, to determine whether there would be differences in respondents' reported confidence in their topical knowledge versus participation in related activities. Respondents' confidence level was highest with data management, which reflects the survey population of respondents working in STEM fields. Respondents reported less confidence with advising a peer on author's rights, defining open access, and describing the scholarly communication cycle. Respondents reported higher perceived levels of understanding than they did confidence in engaging in related activities (see Figures 3 and 4). For example, respondents reported considerably higher levels of understanding related to the peer-review process than they did confidence in their ability to participate in that process. Respondents also reported to be least confident of all in their ability to advise a peer on author's rights. See Figure 3 for combined data from both institutions and Figure 4 for institutional comparison.

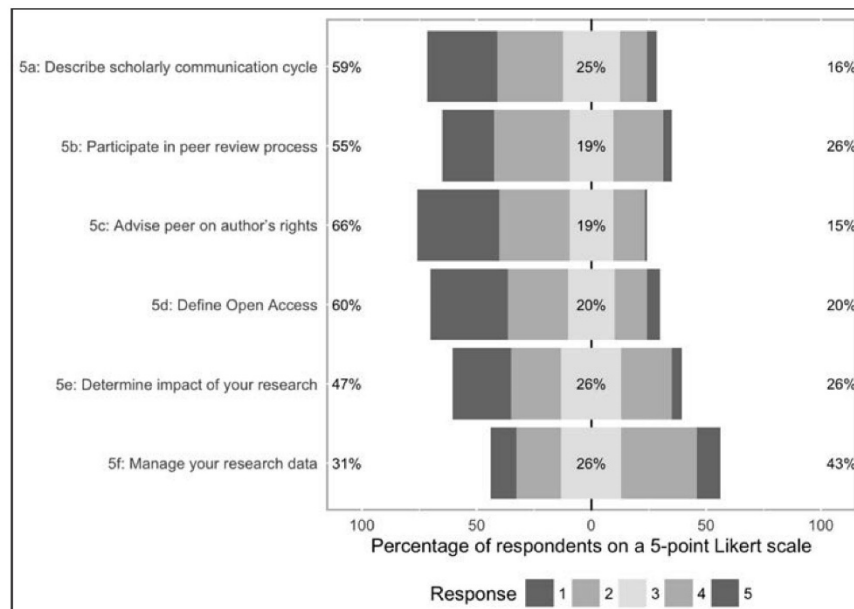


Figure 3. Respondents' answers to the question "How confident are you in your current ability to do the following?" for a list of activities related to scholarly communication, on a Likert scale: (1) not at all confident, (2) slightly confident, (3) neutral, (4) very confident, (5) extremely confident (aggregated data from Purdue University and the University of Illinois).

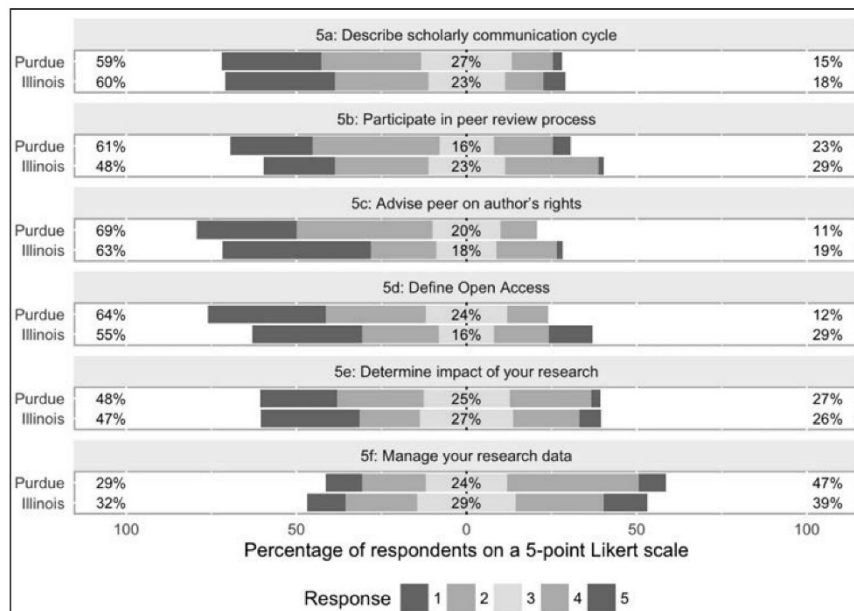


Figure 4. Comparison between Purdue University and the University of Illinois of respondents' perceived confidence in activities related to scholarly communication.

Respondents were asked to rank the value of knowledge about scholarly communication topics. They were decidedly firm about the importance they place on understanding these concepts. For example, Figure 5 shows that most respondents felt it is “very important” or “extremely important” to learn about all included topics, with added perceived value of knowledge about how to determine the impact of scholarly research publications and manage data.

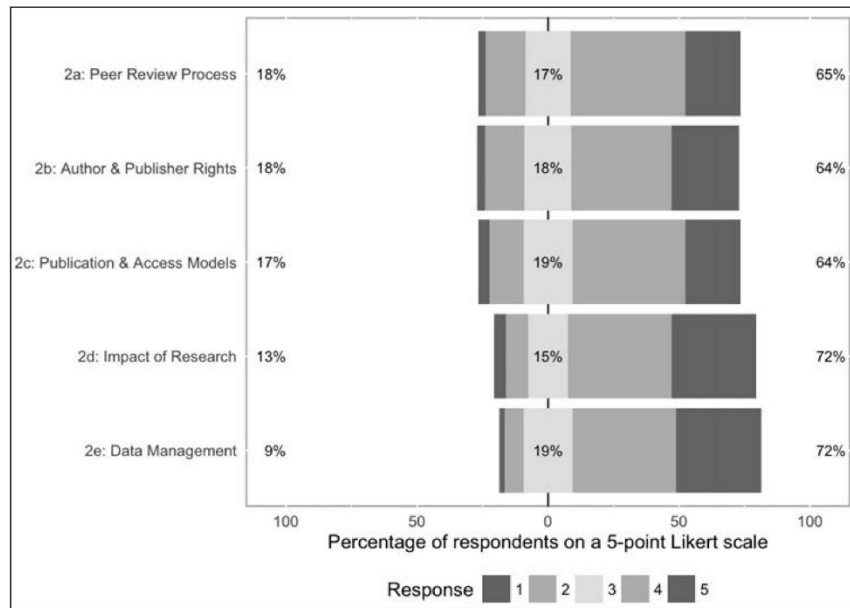


Figure 5. Respondents’ answers to the question “As an undergraduate student, how important is it for you to have knowledge of the following topics?” scored on a Likert scale: (1) not at all important, (2) slightly important, (3) neutral, (4) very important, (5) extremely important (aggregated data from Purdue University and the University of Illinois).

Figure 6 illustrates there are only slight differences between the two institutions for all five topics. There are two exceptions: (1) More respondents at Purdue (22 percent) believed learning about the peer-review process was “not at all important” or “slightly important” than at Illinois (13 percent); and (2) Illinois respondents placed less emphasis on the importance of data management (13 percent rated knowledge of data management as “not at all important” or “slightly important” compared to 6 percent of Purdue respondents).

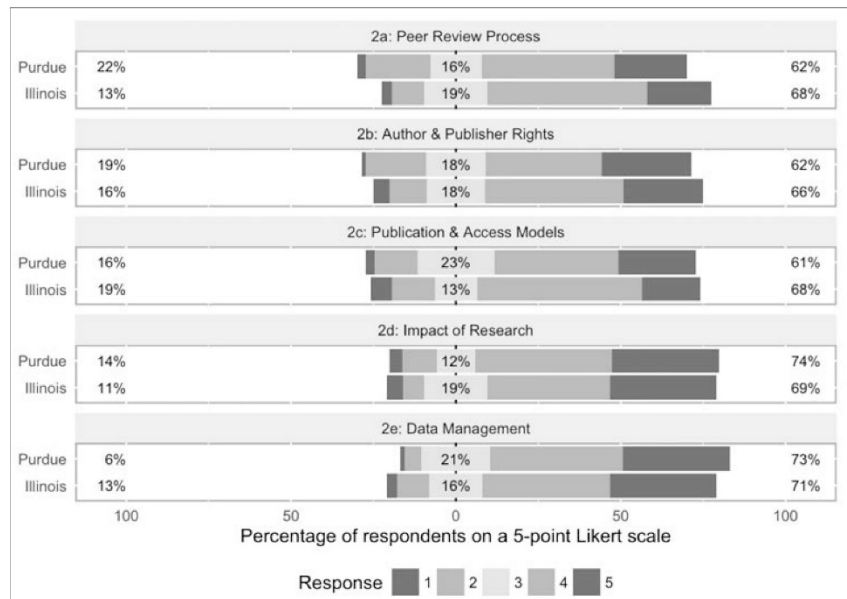


Figure 6. Comparison between Purdue University and the University of Illinois of respondents' reported value of knowledge of scholarly communication topics.

Respondents at both Purdue and the University of Illinois expect to learn about a variety of scholarly communication topics as part of their undergraduate research experience, especially the peer-review process, how to determine the impact of scholarly research publications, and data management. Purdue respondents consistently reported higher expectations for learning about these topics than did Illinois respondents. Figure 7 illustrates respondents who answered “Yes” to the question “Do you expect to learn about the following topics during your undergraduate academic experience?”

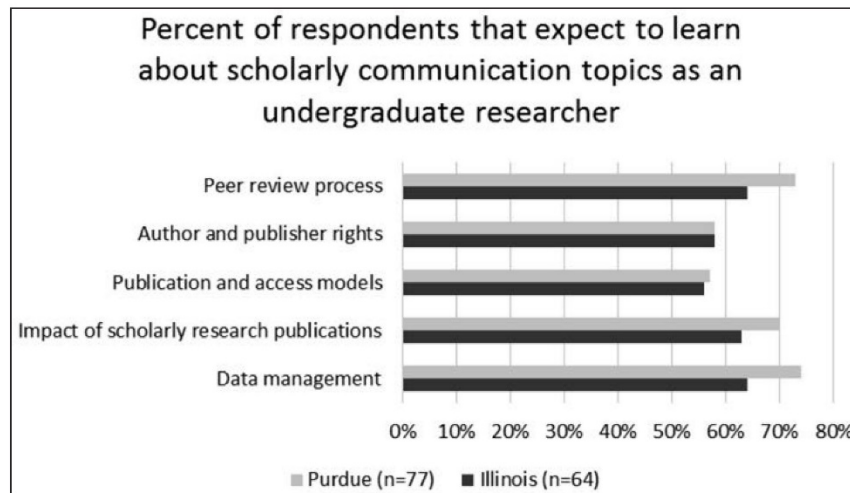


Figure 7. Percentage of respondents who expect to learn about scholarly communication topics.

As a follow-up question, respondents were asked to select the context or contexts in which they expect to learn about each identified scholarly communication topic. Respondents from both institutions expect to learn about most scholarly communication topics in their courses, from their extracurricular or research experience, or from their faculty mentors; these were the three most selected contexts for every scholarly communication topic. Extracurricular or research experience was the most selected choice for every topic. For learning about author and publisher rights, respondents turn most frequently to their faculty mentors. With one exception, where Illinois respondents rely on a variety of avenues to learn about peer review, both institutions' respondents closely align. Although some respondents report expectation of using online tutorials or library workshops to learn about scholarly communication, most reported they would not expect to turn to the library or online tutorials to learn about these concepts.

Respondents were asked an open-ended question to describe an example of a time when they had to apply knowledge of one or more topics related to scholarly communication. Most respondents referred to a publication or presentation opportunity when they had to manage data or prepare a paper or poster for review. One student from the humanities replied, "While serving as a research assistant for my Theatre professor . . . I had to apply my previous knowledge of managing my research data and adapt it to assist my professor and his methodology in writing his essay for a conference." Another respondent said, "As a science journalist, I have had to evaluate the impact factor and prestigiousness of research papers before writing about them." Respondents described gaining experience through their roles as undergraduate research journal editors, assisting their faculty mentors in the lab environment, and independently.

Key survey findings include:

1. Respondents reported moderate levels of confidence in their knowledge of scholarly communication topics, with slightly lower levels of confidence in their knowledge about publication and access models, author and publisher rights, and determining the impact of research, and slightly higher levels of confidence about their knowledge of the peer-review process and data management.
2. Although respondents at both institutions responded similarly, Purdue respondents were generally more confident (especially in data management and research impact categories) and had higher expectations of learning opportunities in these areas. Researchers believe the difference may result from the proportionately higher percentage of STEM respondents, especially engineering students.
3. Respondents perceive learning about scholarly information topics to be important, and they expect to learn about these topics in courses, as part of extracurricular or research activities, or from faculty mentors. They rarely report learning about these topics independently, from online tutorials, or from library workshops.

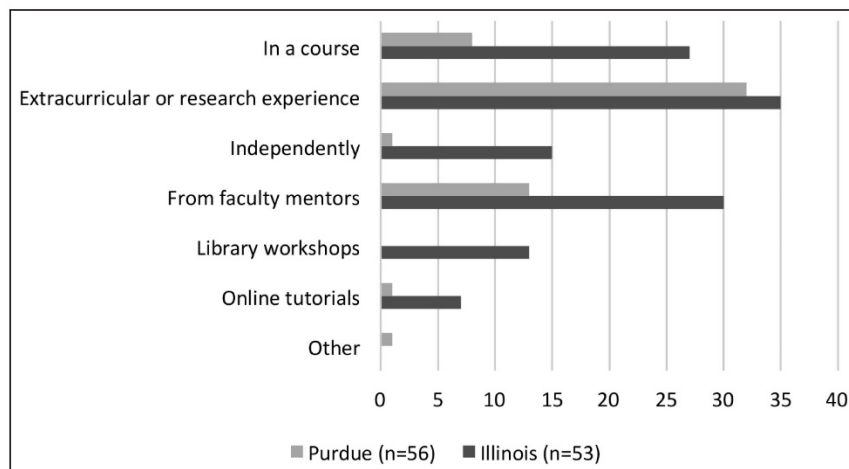


Figure 8. Contexts in which respondents expect to learn about peer review.

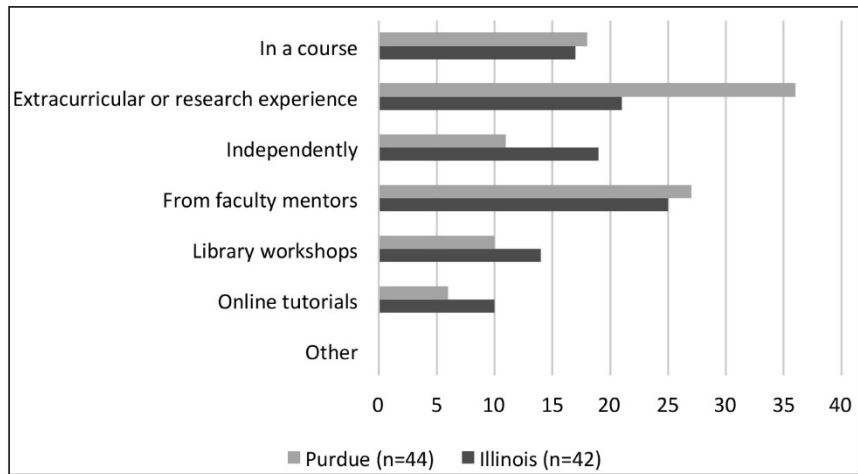


Figure 9. Contexts in which respondents expect to learn about publication and access models.

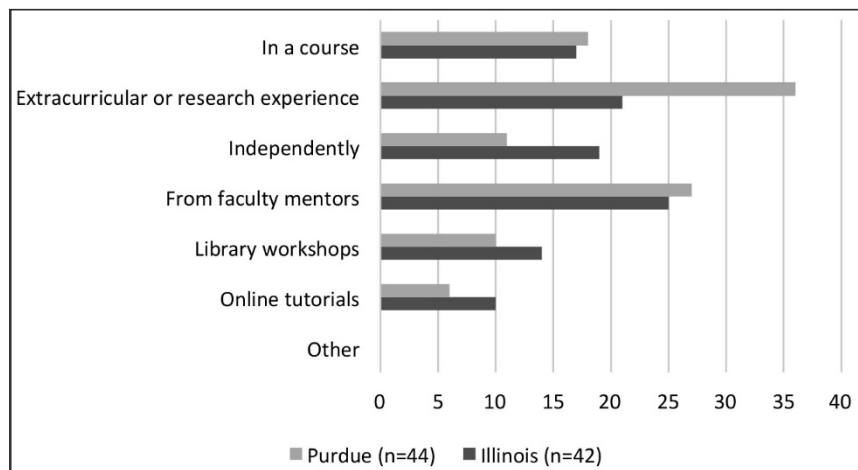


Figure 10. Contexts in which respondents expect to learn about publication and access models.

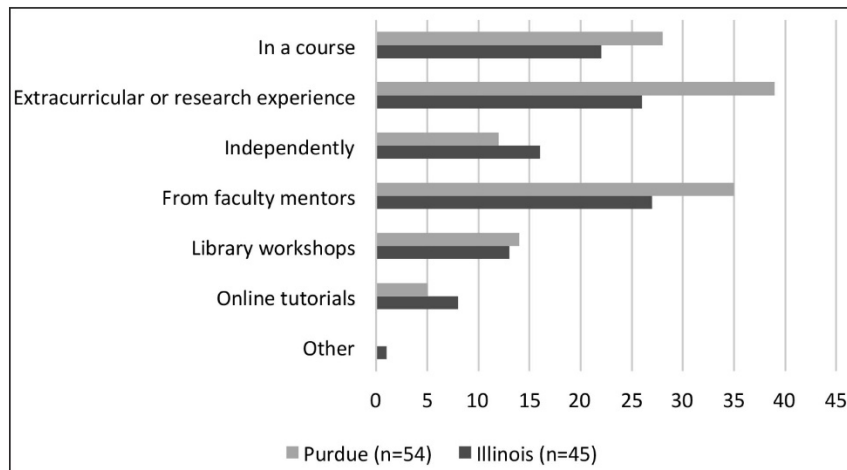


Figure 11. Contexts in which respondents expect to learn about the impact of scholarly research.

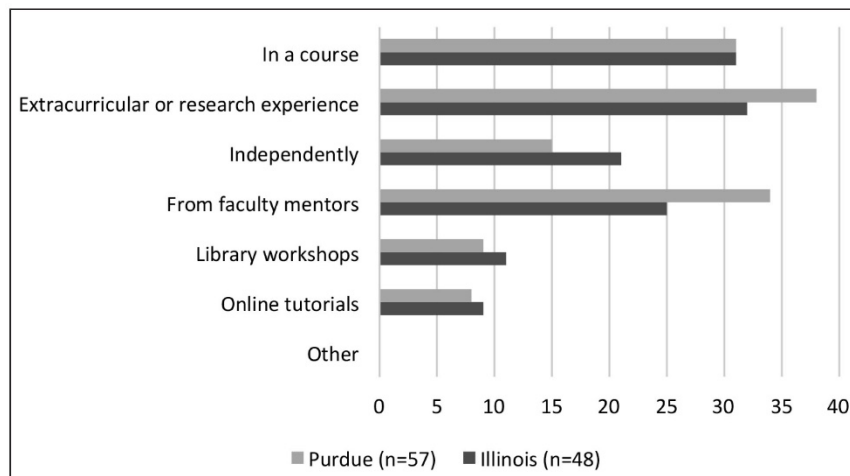


Figure 12. Contexts in which respondents expect to learn about data management.

Part Two: Interviews

The researchers developed a semi-structured interview protocol that included four open-ended questions and a list of examples for possible follow-up questions. Each interview began with a question that asked students to consider and describe what came to mind when they heard the phrase “scholarly communication.” They were also asked to articulate the scholarly communication cycle in their own words. The researchers asked follow-up questions related to interviewees’ individual experiences (in research or honors programs, for example) and their particular survey responses. Most interviews culminated with some discussion of students’ post-college plans and whether or not they envisioned applying

knowledge of scholarly communication in those contexts. The researchers interviewed students from their respective institutions who indicated in the survey that they were willing to participate in interviews for the study: 5 students from Purdue and 12 from Illinois were interviewed.

After reading transcripts individually and noting emerging themes while immersed in the data, the researchers collaboratively developed a qualitative codebook, which featured hierarchical topical anchors for organizing the data and included definitions and examples from the interviews for each. The researchers used NVivo software for analysis. When the researchers began the coding process, each independently coded four interviews. The coding was merged in NVivo, and the software's coding comparison tool was used to calculate coder agreement. The researchers' average percentage agreement was 86 percent (kappa coefficient = 0.65) and 97.8 percent (kappa coefficient = 0.616), respectively, for each pair of interviews. Kappa coefficients of 0.40 to 0.75 indicate "fair to good agreement."⁴⁴ After discussing areas of discrepancy, the researchers divided and independently coded the remaining 13 interviews.

After all interviews were coded, the researchers met in person to thematically analyze the interview data. First, they discussed thematic codes as included in the codebook, noting particular patterns, themes, and anomalies that emerged in the transcripts. Next, each researcher shared key themes and takeaways that had occurred to her while conducting interviews and reading transcripts. Then, the researchers ran coding queries in NVivo for each of the six primary thematic nodes or categories: (1) scholarly communication (general), (2) peer-review process, (3) author and publisher rights, (4) publication and access models, (5) determining the impact of research, and (6) data management. Together, the researchers carefully read coded sections of interview transcripts for each node. At this time, the researchers also collected representative quotations. Finally, key findings from close review of the coded interview segments were compared to the initially brainstormed thematic findings, which were amended and clarified as necessary.

Interview Analysis: Key Themes

The researchers focused on four main questions during the qualitative data analysis phase:

- What are students' current scholarly communication practices?
- What do they know about these topics and issues?
- How do they learn (and expect to learn) about these topics and issues, if at all?
- Do they value knowledge in these areas?

Three primary themes clearly emerged through the interview process with students from both campuses.

Theme 1

Interviewees could not accurately address copyright and author's rights as applied to their scholarship. While many interviewees indicated they authored or coauthored publications,

they were overwhelmingly unclear about who owns the copyright of their work, which confirms survey findings related to authors' rights. One interviewee, an editor of a journal, described an experience in which he had to track down authors for permission to publish their content in a new online platform. Most participants, however, had not considered their current or future rights as authors. Interviewees reported they received little or no guidance related to their rights as authors and other legal implications for sharing their research.

Several interviewees reported that their peers were eager to publish their work as undergraduates but did not consider the legal issues associated with publication. They saw lack of knowledge in this area as a problem:

I think a lot of students don't look at it from a legal perspective, and they have no idea what rights they have after publication, and where those things go. I just think that it is really important for them as we move more and more to the digital world . . . I mean it is flattering to get published and you also don't think of the ramifications. (Purdue, liberal arts/health and human sciences, senior)

Two interviewees shared reservations about the potential long-term ramifications of publishing student work online, for example, in undergraduate research journals. One interviewee expressed concern that undergraduate student work, especially work done earlier in the college experience, would be easily accessible via Google Scholar anytime someone searches his name for years to come. He explained that the work he had completed as a junior was published online and was "now permanent"; he had "more reservations about it than enthusiasm."

Though unsure, many interviewees assume the university owns copyright of their scholarly work. For example, from two separate interviews:

Interviewer: So you wrote your own thesis paper. Who owns the copyright to that paper?

Interviewee 1: Gosh, well, I wish I could confidently say me, but it is probably like the university or something. (Illinois, economics, senior)

Interviewer: Who owns the copyright [of your scholarly output]?

Interviewee 2: I think probably the University of Illinois because I applied to present it at an undergrad research symposium here and, um, they accepted it and they were the ones who published the abstract and everything, so I am guessing them. I am not sure though. (Illinois, molecular cellular biology, senior)

While some interviewees expressed concern about the "permanence" of publishing their work online, others had positive things to say about sharing their work. According to one interviewee, "I feel like research, the point of research is, you know, to tell everyone about it and to share the knowledge I guess. So in a sense, I can't say that this knowledge is mine, you know. So I guess it doesn't really bother me" (Illinois, nutritional science, senior). Since the University of Illinois had published the student's research abstract, she assumed the

university held the copyright, which she said was acceptable to her, because the publication process enabled her to share her knowledge. Sharing new knowledge, she expressed, was the primary goal of original research, and she was willing to relinquish rights to her work if it was achieving that goal.

The interviews seemed to confirm the survey findings. Survey respondents had reported relatively low levels of confidence in their knowledge of author and publisher rights. Fifty-two percent of respondents reported themselves “not at all” or “slightly knowledgeable” in this area. In practice, 55 percent reported they would be “not at all” or “slightly confident” in advising a peer on author’s rights. While the majority (60 percent) of survey respondents reported they expect to learn about author and publisher rights as an undergraduate student, they also overwhelmingly reported that they expect to learn about this topic in extracurricular or research experiences and with guidance from faculty mentors.

Theme 2

Interviewees rarely receive specific guidance but instead tend to follow faculty and graduate student mentors’ leads on (often problematic) data management practices. When asked about their experience with and knowledge of data management practices, most interviewees referred to their roles and experience in labs. Few had any formal data management training; most learned what to do in practice or by trial and error with varying levels of support and guidance from faculty and graduate student mentors. Undergraduate and graduate student researchers typically have a close working relationship in the labs; many interviewees claimed they interacted with and sought guidance from graduate students more than faculty mentors. One interviewee reported learning about file-naming conventions from graduate mentors, but most could not describe receiving specific guidance in this area. For example,

I wish the guy I worked for would have been at least, “Yeah, you are doing it fine.” Or anything. That kind of feedback. But he kind of just, like, let me go, and was like, “If you have any questions, ask.” And I didn’t want to ask him and be, like, “How do I store this data?” After about the fourth or fifth time of trying to organize . . . I finally got a good method down. (Purdue, engineering, senior)

None of the interviewees could articulate a long-term plan for the data they collected or worked with for their projects. They said the data were “filed away,” “for three or four years maybe,” and interviewees were not aware of any plans for long-term management or access. One STEM interviewee noted that it was only his summary, not the primary data, that was really important, claiming, “Nobody is going to search through that [transcriptions] because that is too much information. Whereas the summary that I have already includes all of the important data that people might need or might refer to” (Illinois, chemical engineering, senior).

Several interviewees reported leaving their lab notebooks, filled with data, on shelves in labs or offices after completing their research experiences, possibly to be used by other students in future semesters. One interviewee said, “I was keeping track of it [the data] in my notebook basically. And the person in the lab that took over after me, um, she took that

notebook, so I think she is writing a thesis on it now actually" (Illinois, molecular cellular biology, senior).

While reading through transcript sections that referenced data management practices, it became clear to the researchers that many of the interviewees were clearly involved in just *one* aspect—usually data collection—of a larger research project. Thus, they were rarely exposed to the entire research process. This may account for feelings of disconnection from the project as a whole, including aspects related to long-term data management and scholarly communication. According to one interviewee, "I came in to a point where it is only collection. It is not like they are trying to exclude us. But the disconnect feeling is there." She elaborates,

You do a lot of data collection, but then at the end of the year you do a research poster at the Undergraduate Research Symposium and what you do is you get assigned to a researcher . . . that will help you run the SPSS [a software package used for statistical analysis] and things like that . . . they are really compassionate, forgiving, and, like, us not knowing how to do it, but they also don't push you to learn how to do it. So it's helpful because as a student we are so busy, but at the same time it is not helpful because we aren't learning those skills. (Illinois, agricultural and consumer economics, senior)

Survey respondents rated data management as one of the most important scholarly communication topics, and 72 percent of respondents rated it "very" or "extremely important." Interestingly, respondents also reported relatively high levels of knowledge related to data management, with 32 percent reporting themselves as "moderately knowledgeable," and another 32 percent as "very" or "extremely knowledgeable." Respondents were relatively confident in their abilities to manage their research data; 26 percent reported they were "moderately confident," and 43 percent "very" or "extremely confident." Despite their confidence, anecdotes shared during interviews seem to beg the question "Do they really know what is data management?" Many student researchers seem to know enough about data management to access and use their data throughout the duration of their research experience, but without training and emphasis on long-term data management principles and best practices, their confidence may vastly outshine their skills (or practices) in this area.

Theme 3

Interviewees struggle to articulate how they determine the impact of research. Interviewees struggled to distinguish between the impact of a particular project and the impact of the scholarship or communication of the project. Several interviewees referred to the importance of citation counts and journal reputation, and others mentioned metrics such as impact factor with at least some basic understanding: "I think there's a general impact factor like the more cited it is or the fact that it has like the journals that people have cited on, for example *Nature*, and so that's one factor that I'm very familiar with" (Illinois, biochemistry, senior). Another participant said:

Um, I think from what I understand, the biggest impact is how many times it is cited, or how much it is used in other subsequent papers that people are publishing in related research . . . I met up with my professor actually a couple of weeks ago, and she is like, “Oh your paper is getting cited, that is really good.” And like the more citations it means it is really valid and, like, I guess impactful. (Illinois, nutritional science, senior)

Another interviewee equated “impact factor” with accessibility in addition to citations, stating, “Yeah, because I want to make work that will have a higher impact factor. So I guess I would try to make it more accessible to more people so that it would be more cited, I guess” (Illinois, biochemistry, senior).

Others interpreted this question to be specifically about the value of the research itself—its novelty, relevance to individuals, or influence on daily life. A student journal editor stressed uniqueness in particular: “You know, you don’t want to write something that has been written before, something that . . . has been studied, how it has been written to advance a topic or something new . . . from an editor’s perspective . . . I don’t want three bland articles that all issues have been addressed” (Purdue, liberal arts/health and human sciences, senior).

One interviewee claimed he considered research to be high-impact if it addressed a problem “we face as a whole globe,” referring in particular to the National Academy of Engineering’s 14 Grand Challenges, the organization’s list of critical problems that it says must be solved to maintain national security, quality of life, and a sustainable future. In his field, impactful research would relate to one of the challenges and address “a problem that needs to be solved or a gap in the knowledge” (Purdue, engineering, junior).

Other interviewees equated impact with personal relevance. One stated, “I feel like it really depends on your interest level and if it is something that you’re personally researching, then it is probably very important . . . If it is something that is vaguely in your field but not really related to your research, then you probably won’t consider it quite as important” (Illinois, molecular cellular biology, senior).

Finally, an interviewee expanded impact criteria to include both relevance and efficiency: “When I am searching for information I don’t necessarily search for what kind of impact it has, more like is it congruent with what I was looking for.” She continued by asserting that her “generation” “takes a lot of things at face value,” explaining that if articles looked “professional” and “complete” and created “those conclusions that we were searching for to prove our points, that’s what we want . . . because it’s easy and fast.” When doing research papers in college, she explained, students do not consider impact, because they “just want to get it out” and “done” (Illinois, agricultural and consumer economics, senior).

The researchers suspect the varied responses to this question could arise from a number of factors, including

1. Language: the word “impact” is used in a variety of contexts as it applies to research.
2. Formal training and mentoring: some interviewees had clearly learned about metrics such as journal impact factors from research mentors or in formal learning settings.
3. The research experience itself: students often contribute to and report on only a part of a bigger project. While they may share their work in university symposia, they may not experience the full scholarly communication process that would involve publication in a peer-reviewed journal, for instance, and have not been asked or required to consider questions regarding potential impact of their publication source.

Variation in responses also may come from disciplinary differences that correspond to different types of research questions, methods for information and data collection, and accepted ways of sharing research products.

While the same challenges apply to survey questions about this topic, the interviews seem to echo the survey findings. Survey respondents reported relatively low levels of confidence in determining the impact of research. In this area, 32 percent reported themselves as “moderately confident,” and 37 percent as “not at all” or “slightly confident.” Survey respondents ranked value of knowledge in this area as relatively high; 72 percent of survey respondents ranked determining the impact of research as “very” or “extremely important,” perhaps because of some of the reasons articulated during interviews, chiefly when deciding on what topic to conduct research and publish.

Secondary Themes

One secondary theme gleaned from the interviews relates to interviewees’ levels of knowledge and experience related to the peer-review process. Overwhelmingly, interviewees seemed more familiar with this scholarly communication topic than with others. Several had experience with formal and informal peer review in courses, and others had experience with peer review because of involvement in undergraduate research journals as authors or editorial board members, or as coauthors on articles for disciplinary journals. One interviewee noted coverage of peer review “is very common in any English course” though “maybe not necessarily scientific peer review” (Purdue, engineering, senior). Another interviewee described the process as a “hurdle that you have to get through in order to end up being published,” also noting that in his discipline, “It’s supposed to be blind, but I mean you know who it is” (Illinois, economics, senior). This corroborates with survey findings that indicate students perceive their understanding of the peer-review process as relatively high; 66 percent of respondents reported themselves “moderately” to “extremely knowledgeable” in this area. They reported relatively lower levels of confidence in participating in the peer-review process, however, with only 41 percent of respondents reporting “mod-

erate" to "extreme" levels of confidence. This discrepancy may be because students recognize that peer review in courses (of assignments, for example) is, in many ways, a different process than peer review in formal scholarly communication. They also likely recognize they are not yet experts in their disciplines.

Another secondary theme relates to interviewees' expectations for learning about scholarly communication topics and issues. Interviewees articulated the value of learning about scholarly communication in the context of "real-life" research experiences, echoing survey findings. Many interviewees cited particular examples (peer review of journal articles, creating posters, writing abstracts, doing formal literature reviews for a project, and working with research data, for example) as scenarios that provided learning opportunities related to scholarly communication. In research experiences, they reported "learn[ing] as you go" or "sort of by trial and error." One interviewee said, "There is a pro and a con to having someone teach you how to do something then just figuring out how to do it . . . I suppose to learn it on your own . . . sticks with you a little more" (Purdue, engineering, senior). Apart from the topic of peer review, which interviewees more often related to coursework, they enthusiastically reported learning about scholarly communication topics from faculty and graduate student mentors and in seminars offered in affiliation with formal research programs, if they were fortunate enough to have such opportunities. Some interviewees mentioned learning about these topics in introductory English courses, a sociology research methods course, and a nursing course focusing on evidence-based practice, for example, but they were not especially enthusiastic about these learning opportunities. Their comments supported what instruction librarians already know about the importance of effective integration and point-of-need instruction. Some even claimed that only students doing research "need to know" about these topics, even claiming "I really don't think the majority of undergrads would ever take a course [about scholarly communication topics] like that" (Purdue, health and human sciences, junior). A few interviewees mentioned librarians and library workshops, citing only interactions during which they learned about searching and finding information. A few interviewees indicated they may seek out librarians with questions related to scholarly communication (perhaps with hopes of pleasing the researchers), though none reported having sought out librarians in the past.

Interviewee anecdotes mirrored survey findings about learning contexts, in that respondents most often selected "extracurricular or research experiences" as expected learning contexts for every scholarly communication topic. "Library workshops" was routinely one of the three least selected learning contexts (with "online tutorials" and "independently").

Limitations

This initial exploratory study features a relatively small sample size of students from similar institutions: two large institutions designated as "Doctoral Universities—Highest Research Activity (R1)" in the Midwest, according to the Carnegie Classification of Institutions of Higher Education.⁴⁵ While the researchers feel their data and conclusions will likely resonate with undergraduate student researchers at a variety of institutions, the amount and variety of formal research opportunities on each campus and the corresponding library support will vary.

Another limitation of the study lies in its reliance on mostly physical and applied science undergraduate students. Would findings have been different if a higher percentage of humanities and social science students were included in this study? Perhaps, though the researchers' experiences speaking with at least a few humanities and social sciences students involved in undergraduate research reveal some similarities in background knowledge, practice, and perspectives to those of students in physical and applied sciences, even if their research questions and data types vary significantly. It should be noted that fewer humanities and social science students have the opportunity to participate in formal research experiences, though this seems to be changing.

In addition, the researchers were keenly aware that translating their description of research practice for students may have led to some use of unfamiliar library and information science jargon. For instance, the researchers were intentional in using the phrase "scholarly communication" and tried to use it as an opportunity to educate students on a common definition. While many of the interviewees may not have previously heard that phrase, they were often able to articulate the cycle or the overall process from their own research experience. The researchers borrowed language from ACRL's definition of scholarly communication and used qualifiers to help prevent "translation" issues, though they recognize the language may have been challenging for some participants.

Discussion

There is clearly opportunity for librarians to support student-researchers in learning about topics and issues related to scholarly communication. Study participants overwhelmingly reported they perceive knowledge about these topics as important, though they are moderately confident in their knowledge and related abilities. This confidence is problematic, as evidenced by interviewees' inability to explain their rights as authors and knowledge producers and their anecdotes related to haphazard data management practices. Just as librarians advocate for faculty and graduate student awareness of data management practices and rights issues associated with scholarly communication processes, we should do so for undergraduate students who collect data and publish their own work, or (as is the case with student journal editorial members) the work of others.

As more institutions implement high-impact educational practices as part of the undergraduate experience, will administrators and program coordinators understand the importance of supporting students' information use and scholarly communication-related issues relevant to their roles as knowledge creators? Publishing student work in open access institutional repositories, for example, can be an excellent opportunity for students, but dialogue about the process and implications is important. Interviewees who expressed reservation about their work being indexed in heavily used databases and search engines, such as Google Scholar, seem astute. In an age when accessing student-produced work is as simple as searching an author's name, they should be aware of the implications about the quality of their work and the ownership of scholarly contributions, especially since undergraduate research experiences are often relatively small contributions to larger faculty and graduate student-run projects.

Many undergraduate researchers in general, and participants in this study in particular, will attend graduate school and continue to participate in the scholarly communication process. Their lack of understanding about these key topics leads one to ask: If they do not learn about these topics and issues as undergraduate students, when will they do so? And how can librarians increase future researchers' awareness of their rights as authors and knowledge-producers? One interviewee even claimed, "I think my graduate mentor kind of is confused on how exactly this whole [publishing, sharing research, scholarly communication] thing works, too" (Purdue, engineering, junior). Faculty misperceptions and assumptions about undergraduate (and perhaps even graduate) students' knowledge and abilities about these topics and issues puts students at a disadvantage, making it difficult for them to make informed decisions. Librarians could collaborate with disciplinary faculty on curriculum design addressing the scholarly communication elements most pertinent to their undergraduate research experience to provide the most impactful experience for undergraduate students.

Participants reported they expect to learn about scholarly communication topics as part of formal undergraduate research experiences, in courses, and from faculty mentors. They also reported that they rarely, if ever, seek out librarians or library resources and programming for support in these areas. While the data indicate that students' value of scholarly communication topics does not align with their understanding, it is not necessarily surprising that most students do not perceive the library as a place to learn about these topics. Therefore, these findings may encourage librarians to partner with those leading and mentoring undergraduate research experiences. The benefit of such partnership is that undergraduate researchers can immediately use what they learn about scholarly communication. Participants reported learning about topics such as data management by trial and error as they progressed through the experience, and interviewees acknowledged both the usefulness and frustration of this method. Could librarians partner with undergraduate research program directors and faculty and graduate student mentors so students are supported in these areas, even at point-of-need, when the coaching would be most relevant and helpful? Partnering with program directors and faculty and graduate student mentors, perhaps via train-the-trainer programs and tailored offerings in established research and publication programs, has the added benefit of promoting better practices to those populations as well.

There are opportunities for future research in this area. First, this exploratory study's participant pool did not provide enough diversity to compare and contrast trends among various disciplines. The researchers suspect there may be relevant, interesting differences in perspective and experience between student researchers in the liberal arts, social sciences, and STEM disciplines, but could not draw conclusions. It would be interesting to gauge faculty perspectives regarding the value they place on students' understanding related to their expectations. Second, would findings differ if participants were not "immediate stakeholders," as defined in this study—that is, participants in formal undergraduate research or publication experiences? According to one interviewee:

I feel like many undergraduates could go through the entirety of their college career and I don't think it would positively or negatively affect them if they had more knowledge on the other [scholarly communication] topics as opposed to

being able to search the information they need . . . If you have it [knowledge of scholarly communication topics], good for you. If you don't have it, I don't feel like you are missing out on too much. (Purdue, health and human sciences, junior)

Furthermore, is the undergraduate research experience—including the growing landscape of high-impact educational practices and corresponding publication experience—the key to buy-in for undergraduate student learning about scholarly communication topics? Librarians argue that knowledge about the scholarly communication process, and the host of complicated issues and factors that influence it, are important for any undergraduate student. If librarians assert that such understanding provides valuable context for the information environment in which we all navigate, what are the next steps for addressing this? What topics and student learning outcomes are essential, and will the Framework provide inspiration? How can we more effectively collaborate with faculty mentors to complement student lab and classroom research experiences? The results of this study continue to point librarians toward information literacy instruction that ties together a wide variety of scholarly communication issues.

Conclusion

To support undergraduate student researchers' learning about scholarly communication topics and issues, librarians should strive to form strategic campus partnerships with undergraduate research program coordinators and graduate student and faculty mentors. Doing so would better support the integration of scholarly communication skills into undergraduate research experiences and other relevant active, authentic learning opportunities. Advocacy for work in this area is critical, and the researchers hope that the findings presented in this study could provide helpful talking points when discussing students' perceptions and knowledge gaps.

Several voices in librarianship advocate for greater interactions with undergraduate students around the entire scholarly communication process. In "Time to Step on the Gas in Approaching the *Intersections of Scholarly Communication and Information Literacy*," Shan C. Sutton argues that a "holistic approach [that] could help to ensure the incorporation of information literacy can leverage, rather than detract from, scholarly communication efforts that relate primarily to faculty research."⁴⁶ This approach, he claims, could demonstrate the value of academic libraries while aligning the goals of libraries, institutions, and higher education as a whole. In a follow-up to the "Intersections" white paper, Joyce Ogburn and Merinda Kaye Hensley challenge librarians to "imagine the power of our collective knowledge about information literacy and learning with our advocacy for scholarly communication."⁴⁷ These voices, along with strategic changes in higher education, will drive the incorporation of scholarly communication topics into undergraduate information literacy efforts.

Although student researchers lack a broad understanding of the scholarly communication topics that are relevant to their undergraduate research experiences, the data from this

study start to uncover the value students' place on learning about a wide variety of scholarly communication topics. As more undergraduates engage in the creation of scholarly research, there is important work to be done at the intersection of information literacy and scholarly communication. In the context of experiential, active learning, including high-impact educational practices such as undergraduate research experiences, librarians' strategies for supporting students as knowledge creators should include advocacy, collaboration, and pedagogy, with a particular focus on teaching data literacy, copyright and authors' rights, and determining the impact of research.

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Notes

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Appendix A

Survey Questions (Purdue University)

You have been asked to complete this survey as part of a research project, “Undergraduate Students’ Knowledge and Perceptions of Scholarly Communication Topics and Issues,” conducted by Catherine Fraser Riehle, associate professor of library science at Purdue University, and Merinda Kaye Hensley, assistant professor, University Library at the University of Illinois at Urbana-Champaign. You’ve been invited to take this survey because of your participation in a coordinated undergraduate research experience.

Your participation is entirely voluntary, and you may skip questions you do not want to answer. The survey should take no more than 10 minutes to complete. It is designed to be anonymous, meaning that there should be no way to connect your responses to you. You may choose to provide contact information at the end of the survey to indicate your interest in participating in an interview, but it will not be attached to your answers. To enter the gift card drawing, watch for a link at the end of the survey where you can provide an email address.

By completing and submitting the survey, you affirm that you are at least 18 years old and that you give your consent for Professors Riehle and Hensley to use your anonymous responses in their research. If you have any questions about this research before or after you complete the survey, please contact Professor Riehle at cfriehle@purdue.edu.

Scholarly communication (a definition): Scholarly communication is the system through which research and other scholarly writings are created, evaluated for quality, disseminated to the scholarly community, and preserved for future use. The system includes both formal means of communication, such as publication in peer-reviewed journals, and informal channels, such as electronic listservs (Association of College and Research Libraries, 2003).

Q1: How would you rate your current level of knowledge about the following topics related to scholarly communication? Please refer to the definition above, if helpful.

[5-point Likert scale: not at all knowledgeable; slightly knowledgeable; moderately knowledgeable; very knowledgeable; extremely knowledgeable]

- a. The peer-review process (as it applies to review of scholarly works before publication)
- b. Author and publisher rights (as this applies to intellectual property, copyright law, and author/publisher agreements)
- c. Publication and access models (as it applies to costs associated with accessing research, free/open access vs. pay/subscription-based access)
- d. How to determine the impact of scholarly research publications (citation analysis, impact factor and altmetrics, for example)
- e. Data management (as it applies to managing, storing, preserving, and providing access to research data)

Q2: As an undergraduate student, how important is it for you to have knowledge of the following topics?

[5-point Likert scale: not at all important; slightly important; neutral; very important; extremely important]

- a. The peer-review process (as it applies to review of scholarly works before publication)
- b. Author and publisher rights (as this applies to intellectual property, copyright law, and author/publisher agreements)
- c. Publication and access models (as it applies to costs associated with accessing research, free/open access vs. pay/subscription-based access)
- d. How to determine the impact of scholarly research publications (citation analysis, impact factor and altmetrics, for example)
- e. Data management (as it applies to managing, storing, preserving, and providing access to research data)

Q3: Do you expect to learn about the following topics during your undergraduate academic experience?

[Yes; No; I don't know.]

- a. The peer-review process (as it applies to review of scholarly works before publication)
- b. Author and publisher rights (as this applies to intellectual property, copyright law, and author/publisher agreements)
- c. Publication and access models (as it applies to costs associated with accessing research, free/open access vs. pay/subscription-based access)
- d. How to determine the impact of scholarly research publications (citation analysis, impact factor and altmetrics, for example)
- e. Data management (as it applies to managing, storing, preserving, and providing access to research data)

Q4: In what context(s) do you expect to learn about [the peer-review process, author and publisher rights, publication and access models, how to determine the impact of scholarly research publications, and data management]?

For each topic, choose one or more option from below:

- In a course (or courses)
- While participating in extracurricular activities or experiences, including undergraduate research experiences
- Independently
- From your faculty mentor
- Library workshops
- Online tutorials
- Other? Please explain. _____

Q5: How confident are you in your current ability to do the following?

[5-point Likert scale: not at all confident; slightly confident; neutral; very confident; extremely confident]

- a. Describe the scholarly communication cycle.
- b. Participate in the peer-review process as it applies to review of scholarly works before publication.
- c. Advise a fellow student-author on authors' rights, as it applies to intellectual property and copyright.
- d. Define "open access" as it applies to publication and access models.
- e. Determine the impact of your research publications.
- f. Manage your research data.

Q6: If willing, please describe an example of a time you've had to apply knowledge of one or more of these topics related to scholarly communication. If not, please continue to the next question. [Open-ended response]

You're almost done! Just a few questions about you now, please.

Q7: What is your year in school?

- Freshman
- Sophomore
- Junior
- Senior

Q8: Within which college/school is your current major/program of study? if you are affiliated with multiple colleges/schools, please select all that apply.

- Agriculture
- Education
- Engineering
- Exploratory Studies
- Health and Human Sciences
- Honors College
- Liberal Arts
- Management
- Pharmacy
- Science
- Technology
- Veterinary Medicine
- I don't know
- Other (Please specify) _____

Q9: Have you previously participated in or are you currently participating in any of the following programs? Please select all that apply.

- Purdue Honors College
- College, school, or departmental honors program
- Summer Undergraduate Research Fellowship (SURF)
- Discovery Park Undergraduate Research Internship (DURI)
- The Journal of Purdue Undergraduate Research (JPUR)
- Cancer Prevention Internship Program (CPIP)
- Wilke Undergraduate Research Internship
- Other research or honors programs (Please list below.) _____

Q10: Are you an international student? [Yes; No]

Q11: Are you interested in participating in a 15- to 20-minute follow-up interview as part of this research project? Each interviewee will receive a \$20 Amazon gift card for participating. [Yes; No]

Q12: If yes, the participant will be prompted: Thank you for your interest and participation. Please provide your first and last name, as well as a preferred method of contacting you (email address and/or phone number), and you will be contacted within a few weeks to schedule an interview.

Appendix B. Codebook for the Analysis of Interview Transcripts

Code	Definition	Example from text
Confusion/misunderstanding	Student either explicitly expresses confusion or lack of knowledge related to a scholarly communication topic, or makes a statement that indicates confusion or misunderstanding.	"So, um, I think determining, er, determining the impact of research to me, I would interpret that is, is the, the application is important and then um, if you don't like the application you're not going to be excited about the research no matter, um, how much you like it" [describes articulation of project relevance when prompted to discuss determining research impact].
Competence/understanding	Student demonstrates competence or understanding related to a scholarly communication topic.	"I feel like it's, from a research aspect of it, when you conduct your research and you talk to other people, and you write an article . . . we usually have a couple people in our department peer review it and submit it to a journal and they have their own peer reviewers and they give you feedback and then you edit it and then get it submitted and published" [describing the scholarly communication cycle].
Faculty as teacher/mentor	Student describes the contribution of a faculty member to his/her knowledge related to a scholarly communication topic.	"Yeah, I have had great mentors, I think . . . the professor I work for now is phenomenal, and he would send me, say okay, 'We are not finding what we need with this, so try these keywords,' and then I could take those and go from there."
Graduate student as teacher/mentor	Student describes the contribution of a graduate student to his/her knowledge related to a scholarly communication topic.	"We are all really close and I mean, they definitely, the grad students definitely help out the undergrads."
Learning in class	Student describes learning about a scholarly communication topic in a class (actual or theoretical).	"Yeah, I would love to have a class about this. Especially in the honor program."
Peer-review process	Comment or discussion related to the peer-review process.	"I feel like in my English class I took freshman year we learned about peer review and I feel like that is very common in any English course, maybe not necessarily scientific peer review, but I mean peer review is kind of peer review."

Author and publisher rights	Comment or discussion related to author and publisher rights.	"I think a lot of students don't look at it from a legal perspective and they have no idea what rights they have after publication, and where those things go."
Publication and access models	Comment or discussion related to publication and access models.	"Through Purdue we have a bunch of subscribed journals, so I mean, if you use a Purdue computer, I've learned that this summer, 'cause if I try to do research at home there were tons of articles that I didn't have access to or that I had to pay for, but if you're on campus you can use them."
Determining the impact of research	Comment or discussion related to determining the impact of research.	". . . learning how to do literature reviews. When you do research . . . you can check how many people have cited the research . . . how many articles followed it . . . things like that."
Data management	Comment or discussion related to data management.	"Because since I was doing computer modeling, I had a ton, I used MCNP [Monte Carlo N-Particle Transport Code, software for simulating nuclear processes] . . . they have massive output files that you have to sift through a lot to get the information you want out of it."
Independent learning	Student describes learning about a scholarly communication topic independently.	"And that I kind of had to figure out the data management things sort of by trial and error."
Online tutorials	Student describes learning about a scholarly communication topic via online tutorials.	
Libraries/librarians	Student describes learning about a scholarly communication topic via libraries or librarians.	"For the Modern History program at Purdue, you are required to go to two library workshops to learn about research and the publication process."
Importance/value	Student articulates valuing knowledge of a scholarly communication topic.	"I can see a benefit of it. Yeah because I am doing science and I have to keep up scholarly communication, I have to [give] presentation something like that I think is important to me and is more likely for me to take a class like that."

Experiential learning	Student describes learning about a scholarly communication topic via an experiential learning experience (as part of an undergraduate research experience, for example).	"I'd expect that learning about the, how the peer-review process really works, and how publishing a paper, writing, all of those things work is kind of a learn as you go thing."
Scholarly communication (general)	Comment or discussion related to scholarly communication or the scholarly communication cycle in general.	"Okay, so are we talking about the overall cycle, how you publish and it goes in a circle, or like, we kind of covered that, we never really officially talked about it, but like someone does research, then they give it to people to review before it goes into a journal then other people read it and they either try to build on the work or replicate it and then it kind of goes in a circle because if it, if the people can't do it you get the feedback going back the other way. Um, that's pretty much all I am going to have to say about that."
