The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
ASEE
Paper ID #42769

# Engineering Research in Transition: Assessing Research Behavior while Adapting to Access Changes in Library Resources

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## Abstract

Engineering faculty and graduate students are accustomed to accessing the online full-text of sources through search tools that rely on subscription-based access through their university libraries, open access platforms, as well as through less official access routes. After our library implemented a change in access to content through Elsevier, a publisher that provides access to many engineering scholarly journals, we used this natural experiment to explore this community's information seeking behaviors. We recruited a group of engineering faculty and graduate students to participate in an observational study to see what tools they used to find and access scholarly sources. We also surveyed our participants to learn about their use of library services like interlibrary loan, and how the change in access to sources published by Elsevier had impacted their research workflow. Our findings indicate that these participants primarily rely on freely available search tools that provide highly relevant, current research results, and which include links to the source's full text via the simplest possible route. Participants in our study also valued access provided through professional society memberships that focused their search results on specific research networks and that provided full-text access to sources. Based on our results, we suggest several recommendations to inform collections and access decisions, as well as instruction and outreach planning.


## Introduction

Engineering faculty and graduate students use scholarly literature to inform their research choices and to share their own contributions to the scholarly conversation. Because of the increased availability of instant and seemingly free access to information in both personal and professional spheres, expectations for immediate, online access to the scholarly literature are high. Engineering faculty and graduate students are accustomed to accessing the online full-text of sources through search tools that rely on a range of delivery mechanisms including subscription-based access through their university libraries as well as free platforms like Google Scholar or arXiv. Because the cost for sources accessed via free platforms is often invisible to the searcher, the status quo has been maintained with libraries continuing to pay for search tools and publisher packages without the need for researchers to understand the underlying costs or alter their literature research behaviors while pursuing the easiest and quickest paths to scholarly sources (Olsson et al., 2020).

But what happens when the university library stops subscribing to a large body of engineering literature due to cost and values-driven reasons? Do engineering faculty and graduate students change their research behaviors?

After our library implemented a change in access to content through Elsevier, a publisher that provides access to many engineering scholarly journals, we used this natural experiment to spur our exploration of this population's information seeking behaviors. Would this change in access impact the way this community found, accessed, or ultimately used scholarly literature? Would they even notice? The purpose of this research study was to gain a more nuanced understanding of engineering faculty and graduate students' information seeking behaviors to better understand their current practices and needs.

Exploring these questions has implications for engineering librarians' collection development and instruction choices. It also has implications for the way access points like link resolvers or messages about navigating back to a library's subscription-based resources are designed. Signals about how to access the full text are especially important within non-library controlled tools as searchers continue to move away from initiating their searches on library platforms. In addition, there may be increased roles for librarians to consider related to advocacy in big publisher contract negotiations and facilitating open access scholarship. This paper will describe what we learned from the qualitative portion of a study of engineering faculty and graduate students' scholarly information seeking behaviors, which will better inform our understanding of researcher workflows in this ever-changing access landscape.

**Literature Review**

The information seeking behaviors of engineers have been studied since the 1960s, although the earlier focus tended to be on the information seeking behaviors of professional engineers rather than academics (Leckie et al., 1996). Some of the observations of professional engineers' information seeking behaviors clearly reflects the needs of their particular workplace settings. For example, researchers found a strong preference for professional engineers to work in teams because of the increased facilitation of verbal communication, the ability to develop networks based on trusted information, and the opportunities for richer feedback and contextualization (Fidel & Green, 2004; Freund, 2015). Professional engineers also rely on text-based documents as information sources depending on the task and their knowledge of available sources (Freund, 2015). When asking professional engineers about their information accessibility preferences, a survey conducted 20 years ago still resonates. Researchers found that having information that was quickly accessible, as well as physically close and easy to access were top preferences for these busy professionals (Fidel & Green, 2004).

Relatively few papers have been written about the information seeking behaviors of professional engineers or engineers working in academia in the last few decades. The beginning of the twenty-first century represents an explosion of access to information through the internet. During this time there have also been significant changes in scholarly communication practices, scholarly publishing models, and the ease with which information can be shared both legally and

less legally. One of the key research projects published on engineering academics' information behaviors from this time was a multi-institution study conducted in 2009 surveying engineering faculty members' perceptions of a range of library services. The authors found a high degree of variability in participants' responses across institutions, but the perceived importance of electronic access to current and archived scholarly journals was a consistent theme. Interlibrary loan services and library databases were chosen as the next most important library services, but these services were selected much less frequently than electronic journals (Engel et al., 2011; Robbins et al., 2011). That study evaluated faculty's perception of importance, but did not study the actual use of these collections or services. For example, while 69% of faculty in their study indicated that library databases were important or very important, there was no corresponding assessment of these faculty members' actual use of library databases.

A multi-institution interview study organized by Ithaka S+R of civil and environmental engineering faculty found that researchers preferred to use Google and Google Scholar for a range of information needs including finding datasets, gray literature, and scholarly articles (Cooper et al., 2019). Similarly, in an interview-based study with early career life sciences and engineering faculty at a single institution, researchers found that faculty in their study almost exclusively used Google and Google Scholar for article discovery, although Web of Science was also used because of its well-recognized evaluation process for indexing journals and because of the validation provided by its research metrics. Social media was used by nearly half of the interviewees as a discovery resource. Moreover, faculty found that Google was a helpful tool for displaying gray literature results including grants, videos, presentations, and patents. Faculty in this study shared that they relied on the library for full-text access to content and were satisfied with library services in this area. In addition to their interviews, the researchers also conducted a survey that received over 900 responses. Eighty percent of the early career survey respondents reported using either Google Scholar or a general search engine like Google vs. 13% who used specialized databases. Only 8% reported using the library website or catalog (Brink et al., 2022).

To supplement evidence that faculty are largely shifting away from using subscription-based search tools to find scholarly sources, researchers have compared the efficacy of top science and engineering databases with Google Scholar. Cole and collaborators (2018) found that Google Scholar outperformed both Compendex and Scopus in terms of citation availability. From a sample pool of citations drawn from engineering dissertations, Google Scholar consistently retrieved approximately 95% of citations, while Scopus retrieved between 40-80% of citations and Compendex 25-55% of citations. These researchers give the rare, but realistic, advice for librarians to move away from purchasing expensive indexing services like Compendex, and to instead focus on purchasing content. This recommendation is based on their findings that tools like Google Scholar demonstrate an enhanced ability to provide access to citations across all aspects of engineering.

Engineering academics are not unique in their move away from relying on subscription-based search tools. A survey of faculty and students in physics found that the search tools they reported using were arXiv and Google Scholar (71%), Web of Science (23%), Scopus (4%), and Inspec (2%) (Gordon et al., 2022, p. 301). Interviews and a large-scale survey with early-career researchers from a range of disciplines revealed that these participants were predominantly using Google, Google Scholar, and social media to find scholarly sources (Nicholas et al., 2020). When looking specifically at responses from engineers and physical scientists, Nicholas and collaborators observed that researchers in these disciplines use Google Scholar more than researchers in social sciences and humanities fields. The authors suggest this use may be because of the type of information they are seeking, such as basic technical information and product information. This study also asked participants to describe how they chose which sources to read. Similar to the professional engineers surveyed decades earlier, early-career researchers prioritized convenience in determining what sources to read. They read what is closest at hand, which in this case typically meant sources that were readily available online.

What scholars are sometimes less willing to admit to is their use of even less traditional search and retrieval tools than Google and Google Scholar. However, in surveys of early-career scholars from seven countries, Nicholas and colleagues (2019) found that a quarter of respondents reported using SciHub. A key reason these early-career researchers gave for using SciHub was the simplicity of the interface. SciHub's search provided clear options for their preferred search workflow, which was to paste in a DOI and then go directly to a PDF of the source without any login or portal pass-through requirements.

As engineering researchers increase their use of non-library database access points and seek out full-text via the quickest and easiest routes at their disposal, academic libraries are grappling with increasingly restrictive, expensive, and opaque contracts from the major publishers of scholarly content. European libraries and institutes were among the first to begin pushing back against publisher contracts and ultimately canceling their subscription agreements with publishers like Elsevier. To determine the impacts of these cancellations, Swedish and German library and research organizations surveyed their researchers (Fraser et al., 2023; Olsson et al., 2020). Swedish researchers found that 81% of the survey respondents had experienced a gap in access at least once. About half of these respondents found the article via another method such as ResearchGate or SciHub; the other half gave up their search for the article. When looking at the number of interlibrary loan requests made after the cancellation, the Swedish libraries found that there was not an increase in requests (Olsson et al., 2020). Attitudes toward the cancellation from researchers across both surveys were mixed, with 61% of German respondents feeling that losing access made their research less efficient (Fraser et al., 2023). Swedish researchers found there was a direct connection between those researchers who had lost access to articles and corresponding negative attitudes toward the cancellation. Researchers from engineering

disciplines tended to have experienced moderate losses in access and therefore had moderate feelings about the negative impact of the cancellation (Olsson et al., 2020).

While conversations about engineering scholars' transition away from using library search tools and subscription resources as an entry point for scholarly searching have been circulating since the introduction of easy-to-use tools like Google Scholar, we saw a gap in rich descriptions of engineering scholars' current methods for finding and using scholarly literature. Similarly, changes in the scholarly publishing landscape have been developing for over a decade, but libraries are just beginning to take more radical steps to change their relationships with publishers. To better understand how these changes impacted our engineering scholars, we conducted a study to closely observe their scholarly research workflows and to learn how and when they used library resources.

## Methods

We conducted a qualitative study including a pre-observation survey, an observation of searching behaviors, and an interview to learn about our participants' scholarly research behaviors. Each of these methods will be described in more detail in the following section.

### *Participants*

This study took place at Oregon State University (OSU). Before the study began, we received Institutional Review Board approval for our study of human subjects behaviors. Because we wanted to learn about the behaviors of engineering academics engaged in regular research using scholarly sources, our participant pool was made up of current tenure-track engineering faculty and graduate students from our institution. As we also wanted to better understand the impact of the suspension of our Elsevier contract, which came into effect on January 1, 2023, we only included graduate students and faculty who had been at our institution for at least a term before the suspension began.

We began our study in mid-October 2023. An email distribution list of faculty and graduate students across the six disciplinary schools within our College of Engineering was compiled. Faculty and graduate student names were randomized, and participants were contacted by email on a rolling basis until we reached saturation in the number of participant observations (Hennink & Kaiser, 2022). We offered $25 gift cards to a selection of nearby regional coffee shops and restaurants as an incentive for participating in the study. Fifteen participants volunteered for and participated in our study out of 923 possible participants who were emailed (see Table 1 for a summary of participant characteristics).

**Table 1**

*Summary of Participant Student or Faculty Status and Representation of Disciplinary Schools from within the Oregon State University's College of Engineering*

| Student or faculty status | |
|---|---|
| Graduate Student | 10 |
| Assistant Professor | 1 |
| Associate Professor | 4 |
| **Disciplinary school in the College of Engineering** | |
| Chemical, Biological, and Environmental Engineering | 3 |
| Civil and Construction Engineering | 1 |
| Electrical Engineering and Computer Science | 7 |
| Mechanical, Industrial, and Manufacturing Engineering | 4 |
| Total participants | 15 |

*Survey*

After participants volunteered to be in the study, a Qualtrics survey was sent to participants prior to their participation in the observational portion of the study. The survey questions focused on five main areas: search tools used, tools used to access the full-text, library services used, potential impacts of the Elsevier contract suspension, and participant demographics. To improve feedback consistency, for the question about search tool use we provided a list of possible search tools to select from including:

- Google Scholar
- OSU library's discovery service (Primo by Ex Libris)
- Engineering Village/Compendex
- ScienceDirect
- IEEE
- ResearchGate
- SciHub
- Google
- Academia.edu
- AI search tools
- an open text box

When asking about full-text access pathways, we included the same list as the search tools, but we also included the following options:

- our library's interlibrary loan service
- emailing the author
- checking the author's website
- connecting with the author via social media
- an open text box

When asking about participants' prior knowledge of and experience with library services, we provided a list of options including:

- interlibrary loan
- Article Galaxy Scholar
- contacting a librarian
- an open text box

Article Galaxy Scholar is a product from Research Solutions, Inc., that our library began subscribing to when we suspended our Elsevier contract. Article Galaxy Scholar gives users the option to request the full-text of single articles and have them delivered within minutes. Our library used this tool to provide access to Elsevier content in part to continue supporting researchers' needs, but also so we could better understand what specific Elsevier content our community was using. We heavily promoted the Article Galaxy Scholar tool when we paused our Elsevier contract, and so we were interested in finding out if participants in our study knew about and were using this service.

If our participants reported using the library's interlibrary loan service, we used skip logic to ask about the frequency with which they used this library service. We asked if participants encountered issues when our library canceled a resource (e.g., Elsevier), and whether those changes in access had impacted the way they access scholarly sources. If they reported being impacted, we asked them to describe the impacts using an open text box.

Finally, we asked several demographic questions, including what disciplinary school within the College of Engineering they belong to, how long they have been a graduate student or a professor, how long they have been at our institution, and what their current research area is. The information about their current research area was used to provide a topic for them to search during the observational portion of the study.

*Observation of Searching Behaviors*

To learn more about participants' scholarly source searching and locating behaviors, we scheduled observational sessions with each of the participants via Zoom. Participants used their own computers from their chosen work space. The participants shared their screen, and their screen movements along with audio were recorded using the Zoom platform. Recordings were

saved to our institution's cloud-based media storage space, which is protected with dual-authentication log-in features.

Participants were given two search tasks. First, participants were asked to conduct a 10-minute search within the ScienceDirect platform, and then we asked participants to search for 10 minutes using a search tool of their choice. We asked participants to search in ScienceDirect because this platform solely provides access to Elsevier content. While some of the content available via the ScienceDirect platform is open access, much of the content requires a subscription to access. Because we no longer have access to the subscription-based Elsevier content, we wanted to learn about participants' searching behaviors when faced with variable access to full-text articles.

To make the search experience more relevant for the participants, they were prompted to conduct a keyword search based on the research area they described in the survey. Participants were prompted to think aloud as they searched to explain choices they were making about selecting sources along with observations they had about the search experience. Participants were encouraged to carry out their search as close to normal as they usually would and to make adjustments to their keywords, skim results lists, click on and open sources, read articles, save sources to a citation manager, or to use any other approaches they would normally engage in during a literature search. At the end of the first 10 minutes, participants were invited to either continue searching on their topic via the ScienceDirect platform or to switch to a search platform they more typically use in their research workflow for the final 10 minutes of the observational portion of the study.

*Follow Up Interview*

Immediately following the observation of searching behaviors, while still on Zoom, the study researchers conducted a 20-minute semi-structured interview with each participant. We used a set of six questions as a jumping off point, but adjusted questions as needed based on the information seeking behaviors observed during the searching portion of the study. Interview questions included a discussion of how their searching behaviors during the observational session deviated from their typical search practices (if at all), specific choices participants made to select sources, and how they dealt with access issues, for example, if they couldn't find the full-text. We also asked questions about their research workflow including questions about their reading and source management behaviors. Finally, we asked how they evaluated if a search was successful.

*Analysis*

In this analysis we focused on participants' reported and observed behaviors related to search tool choice, criteria for selecting relevant sources, and tools and approaches for accessing the full-text of sources. In addition, discussions regarding attitudes to the impact of the Elsevier

contract negotiation were also analyzed for trends. The goal of this research was to provide a rich description of engineering scholars' search behaviors, as a result, as is typical with qualitative data analysis, the findings are not intended to be generalizable, but rather are intended to provide insights into the choices and search behaviors of participants in our study.

For the analysis of the survey information, we compiled responses to the survey questions for the fifteen participants to learn about trends in the frequency with which the various search and full-text access tools, as well as library services, were used. For this analysis of the observation and interview recordings, we used the transcription tool Otter.ai (https://otter.ai/). We manually reviewed the transcripts created to verify their accuracy. We then used a spreadsheet to record information seeking behaviors like their searching purpose, the frequencies with which search and full-text access tools were used, trends in the search strategies employed, and trends in preferred troubleshooting approaches. Video captured via Zoom of the observations of participants' research workflows was not analyzed for this part of our research project.

## Results and Discussion

### *Participants and their search purposes*

Participants in our study are all engineering scholars who are actively engaged in literature searching for their own research projects. The fifteen participants in this study represented four out of the six disciplinary schools in our College of Engineering (see Table 1, shown previously). The two disciplinary schools not represented by our participants, Nuclear Science and Engineering and Biological and Ecological Engineering, are the smallest schools in the college.

Our study participants were either graduate students or tenure-track faculty. The ten graduate student participants (Table 1) had multiple reasons for searching the scholarly literature. Some graduate students who were at earlier stages of their studies were looking for project ideas and were learning where there might be gaps in their field that they could pursue. For example, one participant described their searching goals in this way: "Because I'm trying to build like a map of where you know, where all the arrows are pointing in terms of research areas, or like, just techniques maybe, and where I would want to place myself in that web." Other graduate students were looking for methods to use, adapt, or avoid (e.g., if the methods were outdated or different from their advisor's approach) for their thesis or dissertation projects. One additional purpose these graduate students had for searching was to more broadly find literature in their disciplinary field. This was especially the case for graduate students whose labs held journal clubs or meetings where they were expected to regularly share and report out on current literature.

The five faculty participants also had multiple reasons for searching the scholarly literature. Some were actively engaged in writing grant proposals and needed literature to demonstrate the relevance of their proposed projects. Faculty also searched the literature to keep tabs on what

their academic competitors were doing, as well as to look for inspiration from peers in their field. Finally, several faculty participants regularly reviewed current literature in their focus area to make sure their graduate students were accurately and comprehensively describing their research field when writing articles based on thesis and dissertation projects. However, they rarely reported actually reading the articles when scanning the literature for this purpose. One faculty participant described their broad-based exploration approach in this way: “I just go through arXiv, and there are 400 papers this week. So then I just go over the titles, if I find something interesting, I'll send it to my students, and probably not even read them, or save them, I'll just send it to my students.”

*Search Tool Use*

Prior to the search observations, participants reported what tools they used to search for scholarly sources via a survey. Participants could choose as many search tools as were relevant from a provided list of tools, and they had the option to add more tools in an open text box. The pre-populated list of search tools contained a combination of subscription library databases, freely available search tools, and AI search tools. All 15 participants selected Google Scholar, 10 chose Google, and eight chose the library’s discovery tool (Ex Libris’ Primo). No survey respondents reported using one of our library’s main engineering databases, Engineering Village/Compendex (see Table 2).

**Table 2**

*Search Tools Selected or Mentioned by Participants in the Survey and Used During the Information-Seeking Observations*

| Search Tool | Tools Selected from the Survey (Total Count) | Tools Used during Observations (Total Count) |
|---|---|---|
| Google Scholar | 15 | 14 |
| Google | 10 | 5 |
| Library Discovery Service (Ex Libris' Primo) | 8 | 3 |
| IEEE | 5 | 0 |
| *Professional society conference proceedings site* | 0 | 4 |
| ResearchGate | 3 | 0 |
| *Journal website* | 0 | 2 |
| ScienceDirect | 1 | 1 |
| Web of Science | 1 | 1 |
| References from papers on the topic | 1 | 0 |
| ACM | 1 | 0 |
| SciHub | 1 | 0 |
| *arXiv* | 0 | 1 |
| *Google Patents* | 0 | 1 |
| Engineering Village/Compendex | 0 | 0 |
| Academia.edu | 0 | 0 |
| AI search tools | 0 | 0 |

*Note.* Participants could select or use more than one search tool. Selections in italics were not included or mentioned in the survey but were used or mentioned in the observational search.

Because reported searching behaviors are not always the same as actual searching behaviors, we also observed participants conduct a search. In addition, we used the observation sessions to learn if there were other search tools these engineering researchers regularly used that we had not included in our survey. Participants were directed to begin their searching in the ScienceDirect platform. No participants indicated that ScienceDirect was their preferred starting search platform, and only one seemed to have previous experience searching within ScienceDirect.

However, during the portion of the observational study where they were directed to use ScienceDirect, a few participants did find articles they had not previously encountered in their regular literature searching. These participants were surprised to have missed these articles via their normal search approaches and were thankful to have found them.

After searching in the ScienceDirect platform, participants were prompted to search using their preferred search tools for the second half of the observation. Eleven participants immediately chose to switch to Google Scholar and three additional participants used Google Scholar at some point during the second half of the searching observation. One participant used Google for all of their searching; another participant selected Web of Science as their preferred search tool, and one initially chose to stay in ScienceDirect for some of their searching (see Table 2, shown previously). While most participants continued using their first tool of choice for the remainder of the searching observation, several used additional search tools. The most common secondary search tools were Google, professional society conference proceeding sites, followed by the library's discovery service. In the interviews some participants mentioned additional search tools they might occasionally use such as arXiv and Google Patents.

Participants noted that their heavy reliance on Google Scholar was driven by their experience of consistently seeing relevant articles within the first few results. The speed with which new sources were added to Google Scholar was another factor that drove their use of this search tool. The importance of speed for staying abreast of rapidly emerging research in the field of engineering was highlighted by this participant who often used Google Scholar to search for specific authors: "I might look them up on Google Scholar to see if they have a new paper because it gets updated faster than the Web of Science. And I'm gonna feel that it's very fast moving. Like, we never give talks on conferences of things that are published, because that's old news."

In comparison to Google Scholar, other search tools required much more scrolling or adaptation of their initial keyword search. However, for many participants, keyword searching was not their normal way of starting a search. As one participant noted, "I usually don't just go explore. I have a pretty specific need." A much more common starting point was to begin with a known paper they had recently read. Participants would enter the title or DOI of this paper and then explore both the references cited in that paper as well as the sources that cited the paper since it was published. This network-based method for searching helped them learn who was in their research community and gave them a sense of the most discussed works. This approach also provided a focused way to learn about new research. Similarly, participants who chose to search directly on a conference proceedings or journal site appreciated the focused set of search results as well as the disciplinary stamp of approval implied by being included in conferences or journals the participants valued.

Our participants' predominant reliance on Google Scholar and Google, as reported via the pre-survey and as observed in the search exercise, matched what other researchers have been discovering. A recent Ithaka S+R faculty survey reported that scientists continue to move away from their use of the library's catalog as an information access point toward general search engines (Blankstein, 2022). A study using interviews with early-career scholars explored this preference for using general search tools in more depth and pointed to the appreciation of Google Scholar's natural fit in researchers' workflows, allowing them to seamlessly open the full-text of sources, as well as to link to sources for easy sharing (Ince et al., 2018). While our participants also liked the easy-to-use features of Google Scholar and Google, even more important to them was the consistent identification of relevant sources and access to the most recently available research.

Our participants' non-use of engineering databases like Engineering Village/Compendex and even multidisciplinary tools like Web of Science, despite our regular promotion of these tools in instruction sessions and subject-area recommendation pages on our library website, underscores participants' entrenched preferences for using a few simple, reliable search tools that quickly provide them with access to current research. Our findings echo Cole and collaborators' (2018) recommendation to strongly consider canceling underused search tools and focus on providing access to content.

*Determining Source Relevance*

As described earlier, each of these participants had goals for searching the literature and wanted to find specific types of sources. One participant described their approach this way, "When I'm looking for papers, there's definitely certain things I'm trying to do. I'm not usually just kind of randomly screening papers." We were interested in learning what indicators of relevance the participants were looking for as they scanned the results list and then skimmed the full text of articles that helped them determine a source's utility.

Participants used several approaches for determining source relevance when reviewing search results lists. The more experienced researchers, not only faculty participants but also graduate students who had spent several years in their program, did not initially focus on the article titles, but instead were looking for authors they knew and respected as well as journals they valued. For example, after seeing an author they recognized in the results list, one participant made this comment, "I know this person's name and so he is a very good person in the civil engineering domain. And we kind of do some interdisciplinary collaborations, so I may want to take a look at that." After verifying that a source was written by respected authors in reliable journals, these searchers would then see if the title indicated the source was reporting on an approach that matched their needs. For example, some researchers were only looking for theoretical approaches, not applied research. Other researchers were looking for applied results, but only wanted results focused on their narrow scope of research interest.

Another approach for determining relevance while looking at the search results was to focus on current research. Almost all of the participants were purposefully looking for new research published within the past year or less. One participant discussed how in their field, cutting edge research could come from many sources. As a result, they appreciated the breadth of results provided by Google, which cut across journals or conferences they already knew about, and frequently showed them new information sources. This researcher also googled authors of interest to view their author websites or Wikipedia pages. Each of these information avenues was of interest, not just traditional scholarly entry points.

Participants who used Google Scholar and Web of Science described the importance of the cited reference information in these tools as a way to determine relevance. Many participants paid as much attention to the citation links as to the actual content in the source itself. The citation number's size was less important than the overall indication that other members of the research community were using these sources. The cited by number signaled a form of community voting or proxy peer review of these articles that made sources with this information more relevant. In addition, the citation trails provided ready access to more sources of potential interest.

Once participants selected a source from the results list as being potentially relevant, another round of decision making was applied to see if the source was worth saving and possibly reading. Understandably, because they were being watched during the search observations, no participants read the full source from start to finish. However, during the interview portion of the study, most participants verified that reading the full source was not typically part of their reading practice. Instead, most participants' first pass review of a source began by reading the abstract. If the source still looked promising after scanning the abstract, many participants would then scroll down to see what figures, models, or other illustrations were provided in the text. However, before jumping down to the figures, several participants did spend some time reviewing the introduction or literature review sections to gain some background context and to pick up any suggestions of additional literature they might pursue. Many of the participants paid particular attention to the references section and were as interested in accumulating more references to search as they were in reviewing the information in the current source itself. These participants indicated that locating relevant papers and their corresponding reference lists was a more fruitful way of finding literature than doing broader keyword searches.

Participants' search purposes were closely tied to the kinds of information they looked for to determine the relevance of a particular source. Participants who were developing a proposal or thesis project were more likely to look at the methods section. Those participants who were at the stage of writing an article were looking for findings to back up their approach. Faculty participants in particular were looking at articles to see how the authors constructed their arguments and whether the authors were in philosophical alignment with their own views.

Alternatively, a few faculty participants were looking for methods to critique to provide an argument for why their approach was novel or preferred.

*Tools Used to Access Full-Text Sources*

We distinguished how participants accessed the full-text of sources from how they searched for sources because sometimes different tools or workflows are needed to find a source's full-text. In the survey, we asked participants if they used any different tools than the search tools they had already selected in the previous question (see Table 2, shown previously) to access the full text of sources. Interlibrary loan was the most frequently selected full-text access option with six participants selecting this service. The library's discovery service (Ex Libris' Primo) and using the author's website were also commonly selected approaches, with five participants indicating they used these methods for finding the full-text of sources. Just over a quarter of participants indicated they searched Google Scholar and SciHub to find the full-text of sources (see Table 3). Because the wording of the question asked participants to choose any different tools from what they had already selected, the survey results under describe participants' explicit use of tools like Google Scholar or ResearchGate to access the full-text of sources. However, the responses do indicate that just over half of the participants knew something about the role interlibrary loan played in providing access to the full text of sources.

**Table 3**

*Full-text Access Tools Selected or Mentioned by Participants in the Survey and Used or Discussed during the Information-seeking Observations*

| Access Tools | Tools Selected from the Survey (Total Count) | Tools Used during Observations or Discussed During Interviews (Total Count) |
|---|---|---|
| Oregon State University Libraries interlibrary loan | 6 | 8 |
| Oregon State University Libraries 1Search | 5 | 8 |
| SciHub | 4 | 4 |
| Google Scholar | 4 | 3 |
| *Used society membership access (e.g., IEEE, ICSR)* | 0 | 6 |
| ResearchGate | 2 | 4 |
| Author's website | 5 | 0 |
| *Google* | 0 | 5 |
| *Asked a friend at another university* | 0 | 4 |
| *Email the author* | 0 | 4 |
| *arXiv* | 0 | 3 |
| Message the authors on ResearchGate | 1 | 0 |
| *Web of Science* | 0 | 1 |
| *Article Galaxy Scholar (service provided by the library)* | 0 | 1 |
| *Ask colleagues in their lab* | 0 | 1 |
| Connect with the author via social media | 0 | 0 |
| AI search tools | 0 | 0 |

*Note.* Participants could select or use more than one access tool. Selections in italics were not included or mentioned in the survey but were used or mentioned in the observational search.

Observations of participants' full-text access behaviors and follow-up interview questions revealed a more nuanced and mixed picture of their preferred searching and access patterns as well as how they decided to use library services for full-text access. Many of the participants experienced such consistent full-text access through their preferred search avenues of Google

Scholar or Google that they infrequently needed to use separate access tools. Some participants knew that subscription access to certain journals were provided by the library via tools like Google Scholar or Google, but appreciated only needing to use a single point of access for both search and access.

When participants did run into difficulties accessing the full-text, they could often find a substitute source that met their needs. A participant described the wealth of available sources and how that impacted access roadblocks in this way, “there's so many papers that if there's the paywall, then I probably would just try to find something that's open access first, before I exhaust resources like the library.” Even though a majority of these participants discussed having used interlibrary loan, this sentiment of using the library as a last resort for accessing full-text was mentioned by multiple participants.

During the search observation exercise, when they were unable to immediately find the full-text via a search tool like Google Scholar, several participants tried looking for the source in an alternate tool like arXiv or ResearchGate by pasting the title or the DOI into those tools. While several participants indicated that they used SciHub on the survey, no participants used SciHub during the search observation. However, several participants did discuss their use of SciHub during the interview portion. One participant described how using a SciHub extension for finding the full-text of articles was beneficial for them, because they perceived that any extra clicks or time spent waiting to receive the full-text of sources was unacceptable. Their unvarnished feedback was, “So it's slightly inconvenient to kind of use Interlibrary Loan. I try like hell not to use it honestly.” When discussing their use of SciHub a graduate student participant provided this summary of their use of alternative tools. “The field we are in is moving really fast. And like traditional ways of doing things are no longer viable.”

Our sample size is too small to make generalizations based on differences between engineering disciplines. However, we did observe trends in expectations for full-text access that varied by discipline with participants from some disciplines having become accustomed to a substantial portion of their scholarly literature being available via open access methods, whereas participants from other engineering disciplines knew that a non-trivial amount of the scholarship in their field was available through publishers like Elsevier. One participant who worked in a field that relied much more heavily on subscription-based journal access had adapted to using the Article Galaxy Scholar service since our library’s suspension of access to new Elsevier content, and began to quickly receive articles we no longer subscribed to.

Norms in disciplinary communities impacted both expectations for full-text access as well as methods of troubleshooting access needs. Six participants mentioned their professional society memberships providing a level of access to full-text sources. These participants were accustomed to turning to those society portals for regular access to the full-text of sources. For participants in

disciplines like computer science and electrical engineering where depositing scholarship in repositories like arXiv is more common, access was reliable and plentiful through that modality. For participants who could rely on access tools like arXiv, lack of full-text access to articles they needed was quite rare, often occurring only a few times a year. In these cases, participants expressed that they knew the library was a resource for requesting the full-text of those sources. In the interviews, they noted that they usually made use of the library's interlibrary loan services when necessary, if they perceived they had sufficient time to wait for article delivery.

Participants were also sometimes willing to draw on community connections by sending out email queries for the full-text of sources. For graduate students, these contacts were usually friends in graduate programs at other institutions. A graduate student participant described their use of email for accessing sources in this way, "I know students don't really care about publishers, and they'll be like, whatever, you can have it. Professors might ignore your emails, but students usually are happy to share." One graduate student participant in the survey and in the observational stage mentioned emailing the author through ResearchGate. While a few faculty members noted they would sometimes email authors they knew to request the article, they described that mode of access as a rare route for finding the full-text.

Three participants mentioned using books for their research, and as a result they had used interlibrary loan services to access content our library did not own. Unfortunately, they had also experienced difficulties and confusion with interlibrary loan. For example, they had expected to receive more notifications about where their loan request was in the workflow similar to what they might have experienced from an online shopping site. A participant described an interlibrary loan request they had recently placed and their resulting lack of clarity in this way, "I've done this a few times yesterday, I haven't received any confirmation that my, my order was placed, or there was a way for me to follow up on my request. So I'm not really sure." Another participant described their confusion when the library was unable to complete their interlibrary loan request, "probably the next day, I got an email that my request was denied. I don't know why. And there is no mention of the reason why the request was denied."

Overall, participants in our study tended to be quite well-informed about library tools they could use to access the full-text of sources. It is possible that participants who volunteered to be part of our study might be more likely to know about library services. It is also possible that our library's consistent messaging about alternative access options in preparation for the suspension of access to Elsevier content may have played a role in their awareness. The Swedish library and research organizations who canceled their Elsevier contracts highlighted the problems libraries face when their users no longer recognize who is bearing the costs of access to the full-text of scholarship (Olsson et al., 2020). Our participants' knowledge of the library as at least one access point for finding the full-text of sources provides a promising illustration that a community of

researchers can increase their awareness of some of the infrastructure behind providing access to scholarship.

However, our participants' awareness of and even occasional use of library services like interlibrary loan did not mean this was their preferred access method. Similar to Brink and collaborators' (2022) findings that an increase in access to openly available articles led to a decrease in the reliance on the library for providing specialized content, participants in our study who were accustomed to near universal access to freely available articles experienced the occasional need to use the library's services for finding sources as a significant interruption in their workflow. As one participant noted, "That's when I do that [search via the library's discovery tool] when I'm usually truly desperate to find a paper." Our observations of participants' attempts to find alternate routes for full-text access sometimes contradicted their professed desire for prioritizing faster and more efficient access. While our interlibrary loan department has made significant gains in timely delivery with electronic articles typically being sent to users on average 13 hours after their request is made, and our acquisition of the Article Galaxy Scholar service has meant that Elsevier articles can be emailed within 1-2 minutes, some participants still preferred to email friends or article authors and wait an unknown amount of time to receive those articles, or to search on multiple alternative article access websites hoping to find the full-text.

*Attitudes Toward the Elsevier Cancellations*

The interview portion of the study gave us the opportunity to hear participants' views on the library's decision to suspend our Elsevier contract and to learn about any impacts on their research workflows. On the whole, faculty participants tended to agree with our library's decision to suspend our Elsevier contract. Several faculty described pre-existing negative attitudes toward big publishers in general and Elsevier specifically because of the amount they charge and because they are making money off of publicly funded research. One faculty participant observed that the Elsevier contract suspension had changed their research workflow, but because the library began using Article Galaxy Scholar to provide quick access to the specific Elsevier articles they needed, they were in support of the library's decision. Even the faculty participant who was an editor for an Elsevier journal generally supported the library's approach and was more frustrated with Elsevier for not recognizing the labor they provided as an editor by automatically providing them with access to the final published version of that journal.

Graduate student participants at this stage of our study had less to say about the Elsevier contract suspension, but they were more likely to feel inconvenienced by lack of access to sources. However, because of the large amount of open access content in their fields, several participants were buffered from the impact of the Elsevier changes, and a few were unaware of the contract suspension.

While our study was not intended to measure researchers' use of Elsevier content, German library and research organizations who studied research behaviors after they canceled Elsevier contracts found that German authors published in Elsevier journals somewhat less after the cancellations. They also observed increases in publishing in open access journals, likely due to strong incentives for open access publishing and agreements made for granting gold and hybrid access with publishers like Springer Nature. However, researchers did not change their habits around depositing articles in green open access repositories or in citing articles published by Elsevier journals (Fraser et al., 2023). Fraser and collaborators note that this lack of change in citation behaviors may indicate that access through conventional library channels matters less than anticipated. This observation matches our own initial findings, based on input from this pool of participants, that our library's suspension of access to Elsevier content does not pose notable interruptions to our participants' ability to find content that meets their research needs.

*Limitations*

Because this is a qualitative study intended to gain in-depth insights on engineering researchers' information seeking behaviors based on a small group of volunteer participants, the results are not meant to be generalizable to all engineering researchers. In addition, the results presented in this paper are based on an analysis of a portion of the results, with a focus on participants' search and full-text access tool use, as well as their perceptions of the impact of the suspension of access to Elsevier content. More analysis of these results, coupled with quantitative results based on trends in engineering researchers' use of our subscription content both before and after the Elsevier contract suspension will help provide a richer picture of engineering researchers' evolving information seeking needs and behaviors.

## Conclusions

Our library's suspension of access to journal article content provided by Elsevier prompted us to explore how engineering researchers at our institution seek and use information. We wanted to learn what specific impacts the Elsevier decision may have had. But we were also interested in gaining a richer understanding of this community of researchers' current information seeking practices to inform how our library might adapt services to meet engineering researchers' current information workflow realities. The combined use of a pre-survey, search observations, and a follow-up interview provided a unique window into our participants' information seeking practices. Based on our findings, we suggest several recommendations for librarians to consider that can inform collections and access decisions, as well as instruction and outreach planning.

*Collections and Access Recommendations*

Our study findings, combined with the work of other library researchers (Brink et al., 2022; Cole et al., 2018), indicates that engineering scholars are not relying on databases provided by the library for their main access to research results. They prefer to use freely available search tools

that provide highly relevant, current research findings, and which include links to the source's full text via the simplest possible route. Participants in our study also valued access provided through professional society memberships that focused their search results on specific research networks and that provided full-text access to sources. We recommend that libraries take a close look at usage of their subscription engineering databases, and if the usage has significantly declined, consider suspending those subscriptions. When possible, we recommend that libraries instead focus on purchasing access to content rather than search tools, with an emphasis on access to content from the professional societies that most closely match the research interests of their engineering constituency. One additional collections recommendation would be to provide tiered access based on the stage the researcher is at in their career. Participants in our study who were graduate students and assistant professors were much more likely to engage in in-depth and regular literature searching and reading, while associate professors engaged in more skimming and scanning behaviors. We recognize a tiered access model would require new ways of negotiating access to society memberships or other types of subscription content, but we believe new approaches are needed. Providing higher levels of full-text access to early career researchers would benefit those who need to read literature the most.

Our observations of how participants accessed the full text of sources showed us the workflow barriers that our users encounter. While some of these barriers are based on institutional constraints not shared by all universities, perceived drawbacks like the need to sign in via dual-authentication systems in order to access subscription content provided by the library, or the sometimes confusing way link resolvers display on a publisher's website are likely common issues for many institutions. We recommend that other libraries conduct some form of usability testing to see how their users are accessing the full text of sources and what their perceived difficulties might be. Not all of the access barriers may be realistic for libraries to change or remove (e.g., dual-authentication systems are here to stay on our campus due to broader campus IT security decisions), but we may be able to advocate with our vendors for improvements in link resolver styling and placement on publisher websites or other access points.

Interlibrary loan remains a key solution for full-text access to sources. For our library the addition of the Article Galaxy Scholar service was beneficial for providing a choice between two different speeds of delivery of Elsevier-published journal articles to meet individual researcher's needs. Resource sharing units are often well aware of their researchers' needs, but continued examinations of ways to simplify processes like interlibrary loan request forms, or considering new ways of messaging users about the status of their requests, will help remove participants' perceived barriers to using these services. Our participants demonstrated that library access tools must be very simple, convenient, and clearly integrated into their workflows in order for them to use these services. Additionally, the documents delivered must include all elements of the requested source such as supplemental information, which is often crucial information for engineers seeking to better understand the types of data other researchers have collected.

*Instruction and Outreach Recommendations*

Members of our instruction team and liaisons to our engineering departments have demonstrated the use of subscription-based search tools like Engineering Village/Compendex in instruction sessions for many years with no resulting increase in the use of these tools. Based on our observations and findings in this study, we recommend that engineering instruction and liaison librarians develop their expertise in the search tools their constituents are using, such as Google Scholar, arXiv, and conference proceeding sites, and then teach users how to use those tools efficiently and effectively.

Engineering instruction and liaison librarians can also guide newer engineering researchers to methods of searching and scanning search results that are valued in their field. Less experienced researchers tended to scan for their key words in article titles, which is a logical starting point. Learning about key authors in their field and then searching for those authors was one highly used approach by more experienced participants in our study. Librarians could also discuss methods for learning which journals or conferences are most valued in their field so newer researchers could learn to scan for those journal titles and conference proceedings. Librarians should also continue emphasizing the search workflow of using one good source to find another by using citation networks and reference lists. This classic advice could have additional heft if instruction librarians note that experienced engineering researchers are known to rely on this method to find relevant sources.

Continued outreach is crucial for introducing engineering researchers to new library services like Article Galaxy Scholar. Outreach is also needed to highlight the value of long-standing services like interlibrary loan as an approach for navigating changes in the scholarly publishing landscape. Many participants in our study indicated they knew about tools and services like our discovery tool and interlibrary loan. However, their use of these tools did not always match their knowledge. We must be willing to listen to feedback about needed improvements and gaps in perceived service as we promote these tools so that we can make changes to reflect current expectations around ease and timeliness of access.

Libraries should also continue engaging in outreach to their campus communities about open access publishing options and seek ways to create large scale open access agreements. On our campus, our negotiations with Elsevier provided opportunities for outreach around scholarly publishing and open access, frank conversations about the costs of providing access to scholarship, and the methods the library currently uses to provide that access. Future research will help us learn how to develop sustainable approaches for providing targeted full-text access to the content our engineering researchers need most.

**Institutional Review Board Information**

The IRB project approval number for this exempt study is HE-2023-430.

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