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Google vs. the Library (Part II): Student Search Patterns and Behaviors When Using Google and a Federated Search Tool

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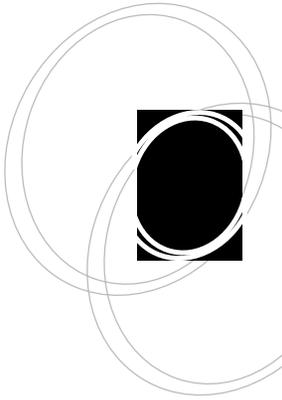
abstract: This study examines the information-seeking behavior of undergraduate students within a research context. Student searches were recorded while the participants used Google and a library (federated) search tool to find sources (one book, two articles, and one other source of their choosing) for a selected topic. The undergraduates in this study believed themselves to be skilled researchers, but their search queries and behaviors did not support this belief. Students did not examine their topics to identify keywords and related terms. They relied heavily on the language presented to them via the list of research topics and performed natural language or simple keyword or phrase queries. They did not reformulate or refine their research questions or search queries, did not move beyond the first page of results, and did not examine metadata to improve searches. When using Google, students frequently visited commercial sites such as Amazon; content farms such as About.com; and subscription databases such as JSTOR. This study concludes by offering suggestions for search interface improvement and pedagogical opportunities on which librarians may wish to focus or refocus. This article is the second in a series that examines student use of Google and a library (federated) search tool.

Introduction

Today's college students believe themselves to be sophisticated searchers of information and frequently use Google to do all of their research.[1] Google's speed, its simple design, its ease-of-use, its ability to handle natural language searches, and its flexibility have altered the information-seeking landscape, making it easy for

students to quickly find information on any research topic. With the advent of Google Scholar and the possibility of leading students to more academic resources, Google has become an even more robust search tool.[2]

The first tenet of Google's company philosophy is "focus on the user and all else will follow."[3] The user is also central to the service philosophy of libraries, yet despite some improvements over the years, library resources remain more complicated than Google for students to use. College students must recognize that the "search" process may work differently in a library tool—be it a discovery search tool, a federated search tool, or a single database—and they must learn to adjust accordingly.

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At Brooklyn College, a large, urban, public university within the City University of New York (CUNY) system, the closest technology to Google-like cross-database searching remained, until recently, federated search. Federated search (also known as meta-search) was once heralded as the library world's one-stop-shopping solution, searching easily and efficiently across the library's subscription resources.[4] In reality, because the technology of federated search is such that multiple databases are searched simultaneously (rather than searching a single index), the generation of results can be slow. Nonetheless, many students preferred it over Google for doing research.[5] Discovery tools now offer a much faster and vastly improved search experience for students, but they require the user to navigate what Peter Coco calls a "host of alien concepts, vocabularies and controversies."[6]

This study examines the information-seeking patterns and behaviors of undergraduates within a research context. How do they search for and find relevant sources online? Do they alter their strategies depending on which search tool they use? Are there features of Google and federated search that they use and do not use, and how might this inform the design of all search tools, including discovery tools? This study is also an examination of where students went to look for relevant sources online. Which Web sites do they visit when using Google to do research? Which other resources might students be led to from within a library search tool? In short, what are students *actually* doing when they sit down at a computer to look for sources, and how can librarians apply this knowledge to improve the research experience of our undergraduates?

Literature Review

Sandra Payette and Oya Rieger pointed out that "library professionals must understand the nature of users' research and information searching behavior in order to be able to provide useful services."[7] Over the last thirty years, many different information-searching models have been identified, confirming that information seeking is a complex and dynamic process.[8] Jia Tina Du and Nina Evans declared, "Information searching on research tasks involves huge mental processing on users' behalf."[9] Gary Marchionini asserted

that information seekers demonstrated distinct yet common patterns and strategies when searching.[10] Reijo Savolainen identified time as a variable in information seeking, along with availability and accessibility of sources.[11] Angela Weiler determined that high on the list of students' information-seeking needs were ease-of-use and currency.[12] Lynn Silipigni Connaway, Timothy Dickey, and Marie Radford cited convenience as a critical factor in information-seeking behavior, where convenience was defined by the information seekers as "complete access to resources, beyond merely discovering and identifying them."[13] Chandra Prabha, Lynn Connaway, Lawrence Olszewski, and Lillie R. Jenkins determined that information seeking led to "satisficing" behavior, in which seekers made choices that were deemed good enough without taking into account all possible options.[14] Claire Warwick, Jon Rimmer, Ann Blandford, Jeremy Gow, and George Buchanan, in coining the term "strategic satisficing," noted that subjects chose both strategies and sources within their information-seeking comfort zone.[15] Carol C. Kuhlthau's longitudinal study of information-seeking behavior found that, as students' cognitive skills developed, so did their information-seeking effectiveness.[16]

Many studies have observed students while they were searching specific information resources. Dianne Cmor and Karen Lippold, observing students' use of the Internet, noted that the participants might spend hours searching or just a few minutes, and that their searching skills varied widely.[17] Jillian Griffiths and Peter Brophy, observing students' use of Google and academic resources, found that students' use of search engines influenced their perception and expectations of other electronic resources, such as library databases.[18] Andrew Asher, Lynda Duke, and Suzanne Wilson underscored this finding with their study of students' use of various discovery tools and Google Scholar. They observed "strong patterns in the way students approached searches no

> *. . . students' use of search engines influenced their perception and expectations of other electronic resources, such as library databases.*

matter which tool they used."[19] Lucy Holman monitored the information-seeking patterns of freshmen when using both search engines and library databases and concluded that first-year students lacked sophisticated mental models of search.[20] In the Ethnographic Research in Illinois Academic Libraries (ERIAL) Project, a cultural anthropology study of freshmen across five Illinois universities, it was discovered that "students exhibited a lack of understanding of search logic, how to build a search to narrow or expand results, how to use subject headings, and how various search engines (including Google) organize and display results."[21] Indeed, even the doctoral candidates that Du and Evans studied were not using library databases to their full potential. The majority of them found Google and Google Scholar easier to use.[22]

The objective of this study, while taking into account some of the established information-seeking patterns, is to further our practical understanding of undergraduates' searching behavior within a research context. This study is unique in that it is the only side-by-side comparison of students' information-searching behaviors while using Google and a library (federated) search tool.

Methods

To ensure that the findings would be as generally applicable as possible, a diverse group of thirty-two Brooklyn College undergraduates across a range of majors, academic years, and ages was recruited (Table 1, Table 2).[23] Participants ranged in age from eighteen to sixty. The average age was twenty-two and a half. The group was almost evenly divided between men and women. The demographics of the study population reflected the undergraduate population of Brooklyn College as a whole, except that a majority of the college's enrollment is female (61 percent).

Students' library experience—both in terms of their use of library resources and how much instruction they had received—also varied widely. These differences were intentional, since the amount of library instruction each undergraduate receives at Brooklyn College varies widely. The instructional program focuses on the freshman year, when students are provided with an online orientation to the library via the first-semester freshman composition class. They also attend an in-person library research session during the second-semester composition class. Beyond the freshman year, instruction is not systematic and depends largely on students' majors and whether their professors request library instruction for specific classes. In addition, transfer students, a significant population at Brooklyn College, may place out of the two freshman composition classes, and thus may not receive any formal library instruction during their undergraduate years.

Two-hour appointments were scheduled with each participant. At the beginning of each session, students were asked to choose a research topic out of a list of six presented to them (Appendix). Participants were asked to consider the topics carefully and choose the one of greatest interest to them, since they were going to be working with the topic throughout the two-hour session. The selection of topics was fairly evenly divided across the disciplines, with the exception of one: American literature (five students), anthropology (five students), business (five students), computer Science (five students), education (one student), and environmental studies (eight students).

Once a topic was selected, each student was presented with a set of research tasks—find one relevant book, two articles (one of them scholarly), and one additional source of their choosing—as if they were actually doing research on that topic. They were then told to begin with one of two search tools, either the Brooklyn College Library's federated search tool or Google.

To avoid bias as much as possible, and to acknowledge the fact that "students want a clean, basic and simple interface," the initial search screen for the federated search tool was designed to mirror the basic single search-box interface of Google (Figure 1).[24] In an attempt to strike a balance between subject comprehensiveness and search speed, and to provide students with access to both books and articles, eleven databases across a range of disciplines were included in the federated search tool: the Brooklyn College Library catalog, ebrary, NetLibrary (now EBSCO eBooks), Academic Search Complete, Business Source Complete, General Science Full Text, Humanities Full Text, JSTOR, LexisNexis, Project Muse, and Social Sciences Full Text. The Brooklyn College Library subscribes to EBSCO's Integrated Search product, so once students moved from the initial single-box search screen to the results screen, they were presented with the standard EBSCO interface (set to the Advanced Search mode, which is the default setting for all of the EBSCO databases at Brooklyn College) (Figure 2).

Table 1.
Academic year of the students

	Freshman	Sophomore	Junior	Senior
Number of students	6	8	9	6
Percent	20.7	27.6	31.0	20.7

Note: Due to the loss of some of the Camtasia files, the video data examined for this portion of the study were for twenty-nine students.

Table 2.
Majors of the students

	Arts and humanities	Social sciences	Math and sciences	Business	Double major (cross-disciplinary)	Undeclared
Number of students	2	7	5	5	5	5
Percent	6.9	24.1	17.2	17.2	17.2	17.2

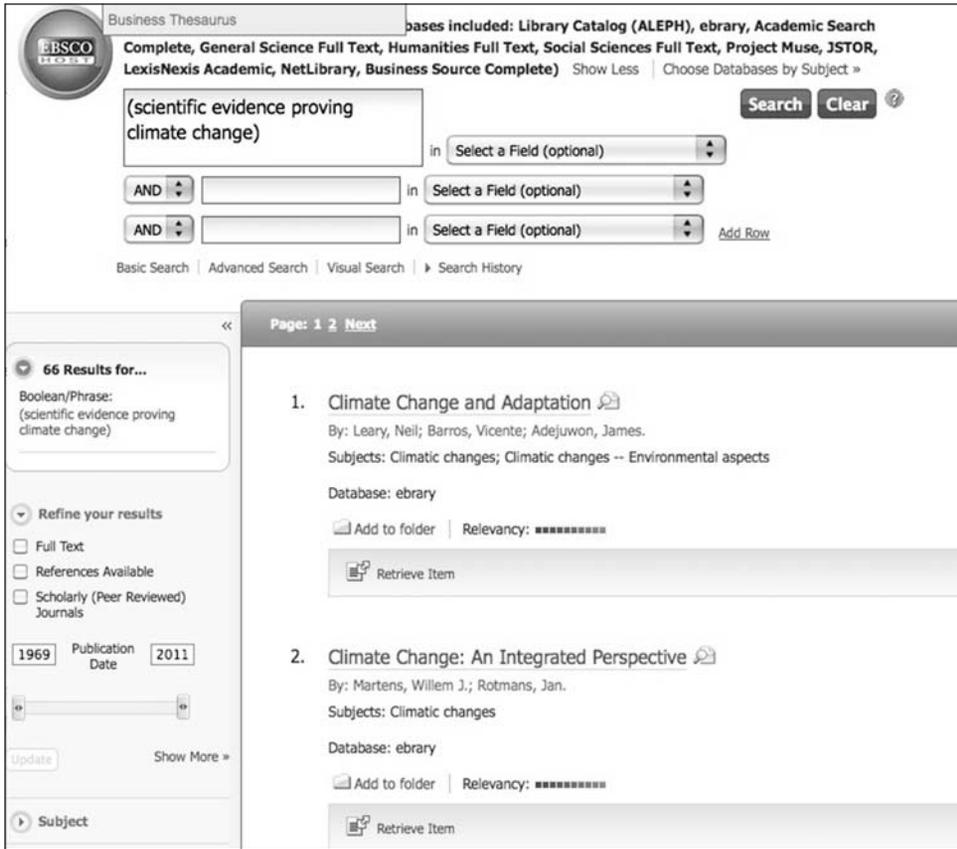Figure 1. Initial search screen of federated search tool

Figure 2. Results screen of Brooklyn College Library (EBSCO) federated search tool

After each student completed the first set of research tasks, he or she was instructed to complete the same set of tasks (finding one book, two articles, and one additional source of their choosing) on the same topic, but using the other search tool. While the participants were performing each set of research tasks, Camtasia, a screen-capturing software, was used to record their searches and movements. To further avoid bias, half of the subjects were asked to begin using the federated search tool, and the other half were asked to begin using Google.

Students' search queries and movements were analyzed by examining the Camtasia video data to detect meaningful patterns and habits, and to determine the level of their searching skills. Elements examined included search queries (terminology, syntax), the use of limits and other features offered by both search tools, how students examined or explored results, the types of Web sites or other resources visited and searched, the total number of searches attempted, and the overall length of each research session.

This article is the second in a series. The first article focused on student preferences and perceptions when doing research using both Google and a federated search tool (determined via a written questionnaire), with students expressing a slight preference for using the federated search tool over Google for doing research.[25] The methods presented

here are thus similar to the first article, except for the focus on search behaviors and a different set of data. The last article in this series (not yet published) will analyze the final set of data—the actual sources students found—to determine how effective each search tool was for doing research.

Results

Constructing Search Queries

Types of Queries

Search queries were categorized as follows: natural language queries (for example, effects the Holocaust had on the children of survivors), simple keyword or phrase queries (for example, William Faulkner common themes), and Boolean queries (for example, immigrants + learning English).

When searching via Google, the most common strategy (fifteen students or 51.7 percent) was to use a mix of both natural language and keyword or phrase queries. Overall, natural language queries (twenty students, 69 percent) and simple keyword or phrase queries (twenty-three students, 79.3 percent) dominated. Only one student (3.4 percent) used all three query types when looking for information on his or her topic.

When searching via the federated search tool, the majority of participants (twenty, 51.7 percent) used a combination of different search types, with a mix of natural language and keyword or phrase queries being the most popular (nine students, 31 percent). Again, natural language queries (nineteen students, 65.5 percent) and keyword or phrase queries (twenty-three students, 79.3 percent) dominated (Table 3). Four students (13.8 percent) used all three query types to look for sources.

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Use of Boolean Operators

Via Google, three students (10.3 percent) actively used Boolean operators (in all cases, the + sign) (Table 3). One student (3.4 percent) passively used the Boolean operator AND presented via the Advanced Search page of Google Scholar. All four students' use of Boolean logic was technically correct, but they failed to put quotation marks around phrases.

The same three students who actively used Boolean operators in their search queries via Google also actively used Boolean operators in their search queries via the federated search tool (again, in all cases, the + sign). Two were sophomores, and one was a senior. Their majors were education, accounting and business (double major), and film.

Ten students (34.5 percent) passively used the default Boolean operator AND that appeared between search fields on the results page of the federated search tool (set to EBSCO's Advanced Search mode) (Table 3). Only one student (3.4 percent) changed the default Boolean operator AND to OR. No one used the Boolean operator NOT.

Table 3.
Types of search queries in Google and federated search tool

	Natural language only	Keyword or phrase only	Boolean only	Natural language and keyword or phrase	Natural language and Boolean	Keyword or phrase and Boolean	Natural language and keyword or phrase and Boolean
Google	4	6	2	15	-	1	1
Percent	13.8	20.7	6.9	51.7	-	3.4	3.4
Federated search	3	6	-	9	3	4	4
Percent	10.3	20.7	-	31.0	10.3	13.8	13.8

Overall, more participants used Boolean operators in the federated search tool than in Google. Of the eleven students (37.9 percent) who either actively or passively used Boolean operators (or, in three cases, both) in their queries via the federated search tool, seven used them correctly. This may be a good reason to advocate that all search tools—including discovery tools—provide the option to use Boolean operators from the initial search screen.

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Terminology of Queries

The terminology of students' search queries varied remarkably little over the course of the research sessions, both via Google and the federated search tool. In fact, the search terms the undergraduates used almost completely mirrored the language of the research topics presented to them (Appendix).

The participants rarely used synonyms and related terms. The most common synonym used was "global warming" for "climate change." This lack of variety in terminology, however, did not mean that students only performed a handful of searches. Rather, they carried out frequent searches by repeatedly adjusting their queries in minor ways: by adding a preposition or another word (often a word that indicated the format type being sought), by dropping a word or phrase, or by simply inverting the word order. Again, when students used phrases in their search queries, none of them used quotation marks to denote an exact phrase.

Here is a typical example of one student's set of search queries via Google:

> effects of holocaust survivors book
> the impact the holocaust had on the children of holocaust survivors
> effects the holocaust had on children of survivors
> effects the holocaust had on children of survivors interviews
> effects the holocaust had on children of survivors book
> effects the holocaust had on children of survivors film.

Here is a typical example of one student's set of queries via the federated search tool:

> proof for climate change
> climate change scholarly article
> proof for climate change 2010
> evidence of climate change
> climate change proof
> evidence of climate change.

Use of Format Terms

Students' preferred method for meeting the requirement that they find a variety of sources was to include format terms in their search queries ("book," "article," and the like). When using Google, twenty-two students (75.9 percent) included format terms in their search queries (Table 4). When using the federated search tool, seventeen students

(58.6 percent) included format terms within their queries, despite the fact that the federated search tool also offered several options to limit by format (Table 5).

Here is an example of one student's use of format terms when searching via Google:

ethics of intelligence books
good books on ethics of artificial intelligence.

Here is an example of one student's use of format terms when searching via the federated search tool:

books about climate change
climate change journal.

Use of Dates

Via Google, only one student (3.4 percent) used a date or date range in his or her search query (Table 4). In the federated search tool, only two students (6.8 percent) used a date or date range in their queries.

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Use of Limits and Other Features of the Federated Search Tool

Students made frequent use of the various format limits available to them within the federated search tool: Scholarly (Peer-Reviewed) Journals, Full Text, Publication Type, and Document Type (it was unclear whether students understood the difference between the Publication Type and Document Type limits, however). Four students (13.8 percent) used the Language limit, and only two students (6.9 percent) used the Date limit.

The heavy use of format limits is interesting, given that students also frequently used format terms in their search queries (Table 4). There are several possible reasons for this. One is that the format limits only worked within native EBSCO databases (two out of the eleven included). Thus when students tried to limit the search results to articles, for example, the results may still have included citations to books. Another possible reason is that several participants explicitly stated they had trouble using the federated search tool to find books, and no book limit option was available.[26]

The use of dates (as either search terms or limits) may not be essential for most topics, but is very important for time-specific topics, such as the effects of the economic recession on the auto industry. This was a fairly popular topic (five students selected it, three of whom were business majors), but only two students (6.8 percent) used the Date limit presented to them or used a date or date range within their search queries. Furthermore, students—even the thirteen who had selected science-related topics (environmental studies, computer science)—did not use dates (again, as either search terms or limits) as a way to get to the most recent information or scholarship. Five of these

Table 4.
Characteristics of search queries in Google and federated search tool

	Actively used Boolean operators (+)	Passively used Boolean operators (AND)	Used format type in search query	Used date(s) in search query
Google	3	1	22	1
Percent	10.3	3.4	75.9	3.4
Federated search	3	11	17	2
Percent	10.3	37.9	58.6	6.8

Table 5.
Use of limits specific to federated search tool

	Scholarly (peer-reviewed) limit	Full text limit	Publication type limit	Document type limit	Language limit	Date limit
Number of students	11	7	8	3	4	2
Percent	37.9	24.1	27.6	10.3	13.8	6.9

Table 6.
Use of drop-down fields in federated search tool

	Title field (TI)	Author field (AU)	Subject field (SU)	Abstract field (AB)	All text field (TX)	Source field (SO)
Number of students	4	4	3	2	2	1
Percent	13.8	13.8	10.3	6.9	6.9	3.4

thirteen students were either science majors or intending to become science majors, so one might assume some basic understanding of the importance of accessing the most recent scholarship in their discipline.

Sixteen students changed the drop-down field option from the default—Select a field (Optional)—to the following fields while performing searches within the federated search tool: Title, Author, Subject, Abstract, All Text, and Source (Table 6).

Figure 3. Correct use of drop-down fields in federated search tool

Figure 4. Incorrect use of drop-down fields in federated search tool

Figure 5. Incorrect use of drop-down fields in federated search tool (where student intent seemed reasonable)

Table 7.

Use of linked fields to generate new searches in federated search tool

	Source / journal (SO, JN)	Subject / descriptor (SU, DE)	Author (AU, AR)	Reviews and products (PS)
Number of students	8	4	2	2
Percent	27.6	13.8	6.9	6.9

Eight students used the drop-down fields correctly (Figure 3), and eight used them incorrectly (Figure 4), even though, in some cases, their intent seemed reasonable (Figure 5).

Many of the fields presented within each citation via the federated search tool were linked. As a result, many students clicked on these fields to generate new searches (Table 7).

The most clicked-on field was Journal Name or Source, which generated a list of articles published within that particular journal, but not restricted to the student's topic. Students may have been clicking on the journal title in an attempt to retrieve the full text of the article, which seems reasonable, but is not correct. (Users needed to click on the Find It or Retrieve Item link to see if the full-text version of the article is available via the Brooklyn College Library's collections.)

. . . not a single student went to the Advanced Search page of Google.

Use of Limits and Other Features of Google

Google does not present any limits on its main search page. Google only offers limits via its Advanced Search option (presented in tiny script on the right-hand side of the screen). As a result, not a single student went to the Advanced Search page of Google.

Google Scholar

Ten students (34.5 percent) actively went to Google Scholar during their research sessions, demonstrating that these students had previous knowledge of this tool. Eleven students (37.9 percent) were passively taken to Google Scholar via results presented to them by their search queries in Google. For example, if a student typed in words such as "journal" or "article" in their search, Google suggested results from Google Scholar. Of the eleven students who were first passively taken to Google Scholar, six of them actively went back to it later in the research session. These return visits suggest that the participants either learned of Google Scholar while searching or were reminded of its value as a search tool.

Table 8.

Use of limits and other features within Google Scholar

	Altered articles / patents / legal documents limits	Used cited by feature	Used related articles feature	Used advanced search
Number of students	8	6	2	1
Percent	27.6	20.7	6.9	3.4

Within Google Scholar, eight students (27.6 percent) altered the limits presented to them below the single search box (Table 8). These limits included restricting articles to include patents (automatically selected) or to include legal documents (automatically unselected).

Six students (20.7 percent) used the Cited By feature within Google Scholar, and two students (6.9 percent) used the Related Articles feature. One student (3.4 percent) used the Advanced Scholar Search option available when clicking on the drop-down arrow next to the search box.

Examining Search Results

Within Google, eleven students (37.9 percent) went to the second (or later) page of search results. Within the federated search tool, only two students (6.9 percent) went to the second (or later) page of search results (Table 9).

Five students (17.2 percent) used the references of one source to find another source in Google (Table 9). Two of these students used references from *Wikipedia* articles. Only one student (3.4 percent) used the references of one source to find additional sources in the federated search tool (Table 9).

Students often identified a potential source via one of their searches and then immediately performed a search for that source (Table 9). None of the students used quotation marks to look for what were largely exact titles. It is possible that students were looking for more information about that item, to determine whether it was indeed a relevant source, or, more likely, they were looking for the full text. The frequency with which students did this was surprising, especially because the federated search tool included a Find It or Retrieve Item link within each citation (which less than half the students used [Table 9]). This, along with the high use of the linked Journal or Source field, suggests that the language that will lead users to the full-text version needs to be more meaningful for

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undergraduates. Going even further, search tools need to offer multiple ways to access the full text. These findings also imply that students do not fully understand how the tool they are searching, be it Google or a library database, fits within a larger information architecture. In other words, they do not know where else they need to go to determine whether the full-text version of an article or book is available.

One of the most heavily used features of the federated search tool was the Cite feature, in which a citation could automatically be formatted in a particular style. Fifteen students (51.7 percent) used this feature, many of them repeatedly (Table 9). Although Google itself does not offer a Cite feature (nor, at the time of this study, did Google Scholar), Google led four students (13.8 percent) to resources that did—Questia, Mendeley, JSTOR, and Cambridge Journals Online (Table 9).

One of the disadvantages of such a feature, of course, is that students may not necessarily have to understand what kind of resource they are looking at (such as a book or article), even though it is clear that they need help doing so. Rather, students want the search tool to do it for them—they do not want to decipher citations for themselves.[27]

Via Google (and Google Scholar), six students (20.7 percent) used some sort of Find It or Find Full Text option, either within the Google or Google Scholar interface, or within a resource or site (for example, *Wikipedia*) that the student visited (Table 9). Within the federated search tool, thirteen students (44.8 percent) used a Find It or Retrieve Item option (Table 9).

Within the federated search tool, five students (17.2 percent) altered the selection of databases on the right-hand side of the screen. Only one student (3.4 percent) changed the sort order of results (from Relevance to Source).

Sites Visited and Searched via Google

Eighteen students (62.1 percent) visited commercial sites such as Amazon during their research sessions in Google. Of the eighteen students who went to such sites, four of them performed searches, thereby using the site as a way to look for additional sources. This suggests that undergraduates are willing to use commercial sites even for serious research. Looked at another way, it is notable how few students

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actually searched these commercial sites, thus relying heavily on Google-suggested sources, rather than digging deeper.

Nineteen students (65.5 percent) visited informational sites—sites that purport to provide information, sources, or answers of some kind—such as Questia. Three students (10.3 percent) performed searches via these sites.

Commercial Sites Visited via Google

The most popular commercial site visited via Google was Amazon (fourteen students). The remaining commercial sites consulted were eBay, Google Shopping, World of Books, and ebookbrowse.com (one student each). Of the four students who performed searches

Table 9.

Examining results in Google and federated search tool

	Went to 2nd page (or later) of results	Used result to search for that result	Used references of one source to find another	Used cite feature	Used find it button / retrieve item link
Google	11	16	5	4	6
Percent	37.9	55.1	17.2	13.8	20.7
Federated search	2	9	1	15	13
Percent	6.9	31.0	3.4	51.7	44.8

via these commercial sites, three carried out searches on their topics in Amazon, and one student searched for his or her topic in eBay.

Informational Sites Visited via Google

The most popular informational sites visited via Google were About.com (eight students), Questia (six students), *Wikipedia* (six students), Yahoo! Answers (two students), and HighBeam.com (two students). One student each went to the following sites: Find-Articles.com, PubArticles.com, Novelguide.com, Spark Notes, and William Faulkner Books.com. Two participants performed searches in Questia (one of whom used the Advanced Search features), and one student did a search in About.com. Five students (17.2 percent) visited multiple informational sites during their research sessions.

The relatively low number of visits to *Wikipedia,* despite its popularity and the fact that it is often the first Google search result that appears, suggests that undergraduates understand that a *Wikipedia* article itself is not a reliable source for research papers (although only two students used the references of a *Wikipedia* article to find additional sources). It may be that, given *Wikipedia*'s reputation with faculty, students were reluctant to use it while doing research in the presence of a librarian.

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Subscription Databases and Google Scholar

Fifteen students (51.7 percent) were taken to subscription databases during their research sessions in Google. In every case, students ended up in a subscription database via their use of Google Scholar. Because the research sessions were conducted on campus and students were not required to authenticate, they were seamlessly led from an article citation in a Google Scholar results list to the corresponding full-text source within the database.

The most frequently visited subscription databases were JSTOR (seven students), SpringerLink (five students), ScienceDirect (three students), Wiley (two students), and Cambridge Journals Online (two students). The remaining subscription databases that students consulted were Academic Search Complete and PsycArticles (one student each). Three students performed searches in these subscription databases once they were led there: two students searched JSTOR, and one searched ScienceDirect.

Other Sites Visited via Google

Google, not surprisingly, led students to numerous Google sites. Google Books was the most frequently visited, with more than a third of participants (37.9 percent) being led there and a few searching that site for books on their research topic. Four students (13.8 percent) went to Google News, and one student each (3.4 percent) visited Google Shopping and Google Videos.

Nine students (31.0 percent) visited the *New York Times* site, and one student searched that site for information about his or her topic. Three students each (10.3 percent) consulted Wikibooks and *Science* magazine, and two students each (6.9 percent) visited *Scientific American,* the Public Broadcasting Service (PBS), the National Aeronautics and Space Administration (NASA), the ACM (Association for Computing Machinery), Mendeley, and YouTube. One student searched the YouTube site for videos about his or her topic.

In addition to the *New York Times,* other news sites visited by students more than once included *USA Today* (two students) and Fox News (two students). One student who went to the *Jewish Press* site performed a search while there. Four students (13.8 percent) visited library sites (including a visit to the Brooklyn College Library catalog), and one student (3.4 percent) consulted the Purdue Owl.

Sites Visited and Searched via the Federated Search Tool

Because the federated search tool is entirely comprised of citations from subscription databases, the number of visits to such databases (browsing of results, no actions performed) was not tracked. Five students (17.2 percent) did, however, carry out searches in the subscription databases they were led to from the federated search tool. The databases students searched were Project Muse (three students), ebrary (two students), and JSTOR (one student). One of the students searched both ebrary and Project Muse. One participant, while searching Project Muse, used the Advanced Search feature and tried out various limits presented there.

Only one participant (3.4 percent) actively left the federated search interface. The student searched Google briefly to look for a particular magazine but did not actually visit any Web sites. Two other students (6.9 percent) were taken to government (.gov) sites when they attempted to retrieve the full-text version of sources presented to them. No one was led to or actively visited either commercial or informational sites from the federated search tool.

Number of Searches Performed

The average number of searches performed in the search tool students used first (8.2) was about the same as the average number of searches performed (8.5) in the search tool they used second (Table 10). Taking into account only content searches (searches that were actually querying for content rather than searches to get to a particular site), the average number of searches performed in the search tool students used first (8.0) was also about the same as the average number of searches performed in the search tool they used second (8.2).

When using Google, the average number of content searches performed was 8.8. When using the federated search tool, the average number of content searches was 7.4.

The lowest and highest number of content searches performed by a student in Google were one and twenty-two, respectively. The lowest and highest number of content searches performed by a student in the federated search tool were one and eighteen, respectively.

Table 10.

Number of searches performed and length of research sessions

	Search tool #1	Search tool #2	Google	Federated search
Average number of total searches	8.2	8.5	9.2	7.4
Average number of content searches	8.0	8.2	8.8	7.4
Lowest number of content searches	-	-	1	1
Highest number of content searches	-	-	22	18
Average length of research session	40:53	29:54	33:52	36:41

Length of Research Sessions

Twenty-five of the twenty-nine students (86.2 percent) spent more time using the first search tool to look for sources, regardless of whether they started with Google or with the federated search tool (Table 10). On average, participants spent over ten minutes more using the first search tool than they did using the second search tool.

The average research session in Google lasted 33 minutes 52 seconds. The average session in the federated search tool lasted 36 minutes 41 seconds.

The shortest research session in Google was 9 minutes 53 seconds. The longest session in Google was 1 hour 9 minutes 32 seconds. The shortest session in the federated search tool was 10 minutes 15 seconds. The longest session in the federated search tool was 1 hour 11 minutes 55 seconds.

Discussion

Search Strategies

The overall lack of variety in students' search queries demonstrates that the crucial first step that librarians focus on—that of examining the research topic to identify key concepts along with a variety of keywords and related terms—is not happening. Nor did students focus on something more specific about their topic, even though some of the topics were quite broad. There was little query reformulation (to broaden or narrow results), no serious reevaluation of search terms or the overall approach to search, and a high reliance on natural language searches. In some instances, crucial keywords or phrases were dropped from the search entirely, thus altering the search's meaning and significantly lowering the

> **…the crucial first step that librarians focus on—that of examining the research topic to identify key concepts along with a variety of keywords and related terms—is not happening.**

subject-relevance of the results. In almost all cases, students relied on the authority and language of the research topic exactly as it was presented to them, perhaps mirroring what happens in the classroom when undergraduates are asked by their professor to choose from a list of topics. This may be because, at the beginning of the research process, students lack a strong understanding of their information need and thus find it difficult to articulate. What seems more likely is that students do not recognize the necessity of expressing themselves in ways other than natural language.[28]

Students' high use of format terms within queries presents an opportunity for librarians to engage with students about how "search" might work differently within different tools, and the best way to limit their searches depending on the tool being used. For library search tools such as discovery tools, students should look for ways to limit or facet their search via the interface options presented to them. For Google, the use of format terms such as "book" or "scholarly article" within search queries makes sense since no format limits are presented, and Google is "smart" enough to direct users to Google Books or Google Scholar. Nonetheless, participants in this study could have been more efficient by actively going to Google Books to search for books, or to Google Scholar to search for scholarly articles. As a result, librarians may wish to guide students into thinking about how information is packaged. Librarians may also encourage students to go directly to specific components of Google or specific library tools (such as the catalog) as a way to immediately focus their search by format.

Students' use of subjective phrases such as "good book" in their search queries suggests that they are already thinking about quality as a criterion even as they begin the research process. It also speaks to undergraduates' understanding of the crowd-sourcing or dialogic aspect of the Internet, whereby user reviews may contain such phrases and thereby lead students to what they deem to be good sources. The use of evaluative terms also raises critical issues that librarians can discuss with their students—the determination of quality and authority, the value of peer review (in all its forms), and the potential usefulness (or not) of such evaluative phrases, depending on the search tool being used.

When students were presented with additional limits and features, they used them. Surprisingly, the option to limit by date was little used, even for time-specific topics, and despite currency being long cited as an important information need.[29] Perhaps students expect that, like Google, all search tools will display only current (rather than comprehensive or historical) results, or they are not aware of currency as a criterion that can vary significantly by discipline.

> **Surprisingly, the option to limit by date was little used, even for time-specific topics, and despite currency being long cited as an important information need.**

The use of the drop-down fields, in particular, seems surprising, given that that there is little in the literature to support this behavior. Field options are there for conducting focused searches, and thus are potentially very useful, but they can also be confusing for undergraduates. Many might argue that all library search tools should default to the Basic (Single Box) Search screen, but the Advanced Search mode within all library search tools is readily available. If students choose to use this mode, they will encounter all of the same options

(Boolean operators, drop-down fields) along with their attendant issues. In addition, linked fields are presented within the results lists of all library search tools, including discovery tools. If students are likely to use them, as this study suggests, the links should be more intuitive, the language should be clearer, and students should be guided by the interface to use them correctly.

The results of this study perhaps counter the observation that students expect all search tools to work exactly the same way.[30] In fact, participants were open to trying most features and limits that were presented to them—anything that allowed them to refine or focus their search—even if they were not previously familiar with how these options worked.

Google makes it "easy" for users—no limits whatsoever are available on the initial search screen, and the Advanced Search option is almost impossible to find. The presentation of limits, or lack thereof, highlights two vastly different approaches to, or philosophies of, search. The Google approach is to get users to results as quickly as possible and *then* present them with options to focus or limit their search, albeit very straightforward and largely Google options (Google Books, Google News, and the like). The Google model has become so ubiquitous that libraries have followed suit—most library search tools, including discovery tools, default to the single-box Basic Search screen where no limits or additional options are presented to students. However, is something being lost by not providing such options? If students can be guided into using Boolean operators correctly, should library search tools present users with this possibility? Especially since students ultimately preferred the federated search tool over Google for doing research?[31]

In writing about discovery tools, Pete Coco stated:

> Our decision to make library tools more similar to commercial Web search can reinforce the idea . . . that information literacy instruction isn't necessary because students know how to get what they want from Google. If the new tool is like Google, then why does it require instruction?[32]

Furthermore, several students explicitly said they wanted Google to present them with more options to limit or filter their results (to books, journal articles, films, or other sources) from the initial search screen. One student said he or she wanted Google to combine Google Books and Google Scholar into one search engine. Such improvements would thus allow users to limit their Google searches to books (both popular and scholarly) and articles (scholarly), yet avoid sites that are commercial or informational.

Given the student search habits and preferences observed in this study, and the fact that searching for scholarly information can never be as simple as looking for information via Google, librarians may wish to work with vendors to create a brand-new interface that falls somewhere between the Basic Search and Advanced Search modes of library search tools—one where Boolean operators and basic limits (Books, Articles, Scholarly Articles, Full-Text, and the like) are immediately available to students, but more sophisticated options such as drop-down fields are not.

Examining Search Results

Students in this study skimmed results quickly, and if they did not see what they were looking for on the first page, they tweaked their search repeatedly (in minor ways) until

the first page yielded a satisfactory result. Reasons for such behavior are all variations on a theme: impatience, lack of perseverance, convenience, and following the path of least resistance.[33] Laura Granka, Thorsten Joachims, and Geri Gay noted that users spent more time studying the citations ranked higher in the search results interface, especially the top two results.[34] Panos Balatsoukas and Ian Ruthven found that students used the most relevance criteria for citations ranked on the first page of search results, and that even as students moved down that first page, they considered fewer criteria for each subsequent citation.[35] In other words, the farther down the first page a result appears, the less critically it is evaluated.

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With Google, students were slightly more likely to visit the second (or later) page of results. Possible reasons for this include the higher likelihood of more relevant sources being generated within the federated search tool, or perhaps that students are now used to the large number of results typically generated by Google and other search engines, so sifting through at least the first few pages has become more common. A third possible reason is that evaluating superficial, popular results such as commercial Web sites can be accomplished more quickly than sifting through dense academic results. If the former, this would be in keeping with the overall slightly lower number of searches performed in the federated search tool (Table 10).

No matter which search tool students use, what comes up on the first page is crucial, even when the number of results is manageable. Only one participant in this study changed the order of the results list or investigated how results were ranked, and that was within the federated search tool. This finding is in keeping with Asher, Duke, and Wilson's observation that students "trust the relevancy rankings of a given search engine" and "are *de facto* outsourcing much of the evaluation process to the search algorithm itself."[36] This, they say, makes "the default settings of these search systems critically important."[37]

> **Librarians may wish to think about ways to encourage deeper investigation of results—not only those on the second or third page but also those lower on the first page itself.**

Few students used the bibliography of one source to find additional sources, even though this is one of the easiest ways to find related information. Librarians may wish to think about ways to encourage deeper investigation of results—not only those on the second or third page but also those lower on the first page itself. If the first few "top-ranked" results are not relevant, students should question why these citations appeared and examine the metadata to search for clues and language that will help refine their search. In addition, all search tools, Google included, could be improved by including a Works Cited list along with the citation (the way that ScienceDirect does, for example), along with a Related Articles feature. Google Scholar does this via its Related Articles links, but students may benefit from an option to quickly view related sources from within Google and all library search tools.

Sites Visited

In terms of *where* students went to look for sources, via Google, a great majority of the students either actively went to or were led to Google Scholar and performed searches there, emphasizing its popularity as a search tool for scholarly resources. Students also used commercial sites such as Amazon as a significant source for information even though one of the things they disliked most about using Google was the presence of ads or being taken to sites where they were asked to buy something.[38] This finding suggests that students can know the limits of a particular resource or actively dislike it, yet they will use it anyway, probably because it is convenient for them to do so. In an ideal world, sites such as Amazon might allow users to limit to books by academic or scholarly presses. Until that happens, it is up to librarians to educate students in using and searching such sites most effectively.

The number of informational sites that students visited and searched when using Google is perhaps a greater cause for concern. The most frequently consulted informational site was About.com—a free site (funded by plenty of ads)—commonly known as a content farm—that provides articles written by freelance writers on a variety of subjects. Though such a site might potentially be useful for background information, students need to consider the appropriate context for use. Students should also be encouraged to question how content is generated for such sites, given that the majority is created by nonexperts and therefore can vary widely in quality and accuracy. Indeed, the popularity of sites such as Yahoo! Answers—a social or community question-answering site—presents an entirely different type of information to students, one in which "answers" and quality do not necessarily correlate.[39]

The frequency with which students visited and searched sites such as Questia and HighBeam (both owned by Cengage Learning) also needs to be addressed. These sites refer to themselves as "research" sites because they provide users with vetted content (millions of books and articles from various publishers) and tools for doing research such as tutorials, search alerts, and citation management capabilities. Sound familiar? Such sites even refer to their content as "libraries," yet unlike libraries, users must subscribe to the site for a monthly or yearly fee to access its content. Students must look critically at sites that purport to provide "research" but that may not be authoritative, reputable, or academic in any way. Sites such as Questia and HighBeam may provide reputable sources, but they are funded by subscription fees and thus are essentially asking students to pay twice for content, since there is a high likelihood that their academic library already owns the content. In this respect, even though these sites are being referred to as informational for the purposes of this study, many of them are in fact commercial sites, leading students to sources that require them to pay a fee for full-text access. By extension, the same thing could be said of Google Scholar, and so the notion of information as commodity becomes crucial for students to understand.[40]

In addition, via Google, many students were seamlessly taken to subscription databases such as JSTOR and Wiley, since the research sessions were conducted on campus and did not require students to authenticate. Once again, students may not necessarily understand that *the library's subscriptions* were enabling them to access particular content. As a result, Google's ability to lead students to library resources via Google Books and

Google Scholar gives new meaning to the phrase "I found it on Google." Google is merely a gateway to sources and does not provide original content, but its success in brand-ing itself makes it *appear* as though it does. Librarians need to ensure that students can distinguish between search interfaces and content providers, and continue to press vendors for increased customizability of subscription resources (databases, discovery tools, e-books, e-journals, and the like) so that a library's logo or branding is always clearly and immediately visible.

> … students may not necessarily understand that *the library's subscriptions* were enabling them to access particular content.

Indeed, there may come a time when Google and library resources are so fully inte-grated that whether a student starts with Google or at the library's Web site, the searches will lead to the same results. Even though such an integration might be desirable, of-fering students the possibility to search an interface that will, as Payette and Rieger say, "build bridges to connect disparate information sources"—it will still be important to make clear who is providing the content. Ensuring that libraries receive such credit has become especially important when their perceived value has decreased precipitously along with their budgets.[41]

This lack of understanding about where information comes from was also apparent in students' use of the federated search tool. For example, one senior was led from the federated search tool to JSTOR, where he spent about twenty minutes searching that collection of academic journals for a book. Because the student did not understand what JSTOR was, he did not know what he would or would not find there, and he blamed the starting point (the federated search tool and, by extension, the library) for his inability to find a book. This student's experience likely mirrors the experience of many of our users. To alleviate such frustration, librarians need to focus on increasing students' do-main knowledge. In addition, search interfaces need to make clear to users what kind of content they can expect to find there (for example, JSTOR Articles).

Number of Searches and Length of Sessions

The slightly lower number of overall searches in the federated search tool suggests that, perhaps, more relevant results were presented there, thus enabling students to assemble a list of research sources more quickly. This result is in keeping with the fact that participants spent less time overall finding sources via the federated search tool, even though Google is much faster in terms of generating results.

The overwhelming majority of the students were "faster" using the second search tool, regardless of whether it was Google or the federated search tool with which they had started. As reported by Daniel Russell, senior research scientist for search quality and user happiness at Google, the single most important factor in determining search efficiency is subject knowledge.[42] The fact that participants in this study spent, on aver-age, ten fewer minutes in the second search tool perhaps confirms Russell's statement. It certainly suggests that either familiarity with the research process (which students would have gained using the first search tool), or the development of some subject knowledge (having already searched for and evaluated sources on their topic), or a combination of

both, are important elements in conducting efficient research. Curiously, the picture is complicated by the fact that many of the students had selected topics directly related to their majors. Nonetheless, they might not have had prior subject knowledge specific to their topic.

Conclusion

Students in this study seemed to have little conceptual understanding of how information is structured and how searches work in either Google or the federated search tool (and by extension, all search tools), yet they all ranked themselves highly in terms of their own research skills.[43] Admittedly, the findings might differ for those colleges that have a comprehensive library instruction program.

But for those colleges where students' understanding of the research process may vary widely, it is critical that the observations of this study and other similar studies be brought to classroom faculty, instructors, and writing tutors. Faculty should be made aware of the value of direct

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conversation with students about research—how content is created and by whom, how it is packaged, how searching for it will differ depending on the context (the discipline being studied, the search tool being used)—and the importance of incorporating elements such as topic analysis and terminology development into the assignment itself.

In terms of search tools, Google's interface is close to ideal in that it is flexible, forgiving, and able to respond to a variety of actions. Even so, students saw room for improvement.[44] According to Ian Rowlands and his coauthors, libraries must also "understand and design systems around the actual behaviour of today's virtual scholar."[45] Database developers insist that they have been creating tools that are better suited to users, but have they gone far enough? Even discovery tools—a huge improvement over federated search tools—are still not capable of handling natural language searches, and in certain cases they have not been effective at handling basic keyword searches either.[46]

Some researchers have called for radical improvements to information-retrieval systems, including what Du and Evans call the ability "to assist users in devising different search queries at different stages of their information searching process."[47] In 2004, when Angela Weiler asked students to envision their "dream information machine," they imagined a device that was a "mind reader," that was "intuitive," and that "could determine their information needs without them having to verbalize them."[48] Almost ten years later, this dream has yet to happen—even Google is nowhere close—and students still have not become better articulators of their needs.

In many cases, library subject databases are still the most robust resource for a particular topic, even outperforming discovery tools.[49] Some studies have determined that discovery tools outperformed Google Scholar.[50] Google Scholar content was found to be superior to most individual subscription databases and has outperformed federated

search tools.[51] Other studies have found that the quality of Google Scholar's content varies depending on the discipline.[52] Still others have cited Google and Google Scholar's ability to reveal open-access materials as a benefit over library search tools.[53] In comparing content in both Google and library databases, Jan Brophy and David Bawden found, "Both systems are needed to achieve anything approaching comprehensive recall."[53]

"With many budgets in crisis" and Google Scholar increasingly leading users to subscription content, it may be helpful for libraries to strike a balance, Gail Herrera says, "between investing in discovery tools versus licensing additional content."[54] Google or, more rightly, Google Scholar could be a way for students to be led back to scholarly subscription resources. It may provide a way, perhaps, to "rediscover" the academic library.[56]

> **Google or, more rightly, Google Scholar could be a way for students to be led back to scholarly subscription resources.**

In short, there is still no single search tool—not even a discovery tool—that consistently outperforms all the rest in every context. Libraries will still need to maintain a discovery or federated search tool as a necessary complement to Google and Google Scholar, along with individual databases for more robust and advanced searching within a particular subject area. Libraries must do this while continuing to work with vendors to improve these resources with the user in mind, providing increased findability, flexibility, search algorithms, relevance of results, and ease-of-use.

The third part of this study will analyze the quality of the actual sources (books and articles) that students found via each of the search tools. Can students still do a "good enough" job at finding information despite their lack of search sophistication?

Acknowledgments

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Appendix

Research Topics

Start by choosing ONE of the following topics. You will be working with this topic throughout the session, so please choose the one that's of greatest interest to you.

Topic #1: Business

In your Business class, your professor has asked you to do research on the American auto industry and how it's faring during the current economic recession.

Topic #2: American Literature

In your American Literature class, your professor has asked you to do research on a significant theme in the novels of William Faulkner.

Topic #3: Computer Science

In your Computer Science class, your professor has asked you to do research on the ethics of artificial intelligence.

Topic #4: Anthropology

In your Anthropology class, your professor has asked you to do research about the children of Holocaust survivors.

Topic #5: Education

In your Education class, your professor has asked you to do research on the acquisition of English-language skills within immigrant families in the United States.

Topic #6: Environmental Studies

In your Environmental Studies class, your professor has asked you to find scientific evidence that either proves or disproves climate change.

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