Blazing New Paths: Charting Advanced Researcher Patterns

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"Blazing New Paths: Charting Advanced Researcher Patters" is a study by Lettie Y. Conrad and Dr. Mary M. Somerville that aims to graphically represent typical research workflows of advanced students in the social sciences during their literature review. Aiming to depict activity beyond the walls of a single academic database or website, the authors conducted original observational research and generated a Google Analytics-like flow diagram. The findings provide insights into how this type of student navigates the web and the authors offer recommendations for cross-sector ventures by publishers, libraries and related vendors to adapt their products and services to better support this important scholarly activity.

Introduction

What can the online pathways forged by social science graduate students tell us about advanced information-seeking and research behavior? And what do these research pathways mean for libraries, publishers, vendors, and other members of the scholarly community? Also, can we harvest insights that will inspire cross-sector efforts to better support the work of these aspiring scholars? This study investigates and documents a representative academic workflow of social sciences researchers (masters' and doctoral students) in their search, discovery, retrieval and management of scholarly publications. First, drawing on web analytics from the authors' own organizations—most notably Google Analytics' "Visitor Flow" report[1]—the authors extrapolate observations about researcher behavior from the data commonly available to most publishers and libraries. Then, using original research data from interviews and observational sessions with 11 social science students (3 masters' and 8 PhD candidates), data is presented in Google Analytics-like diagrams, which aim to capture a broader view of online research workflows. These insights are framed by and interpreted within the broader context of existing literature on researcher behavior.

This study offers an innovative approach to representing the advanced researcher workflow through a visualized diagram that goes far beyond anything currently offered to information providers and academic professionals. By turning focus to a fuller picture of the researcher experience and process, this work contributes to a broad conversation about enabling discovery beyond the walls of any one organization. The ultimate goal of this study is use these research findings to generate actionable recommendations for collaborative cross-sector initiatives that serve to enhance discoverability and academic progress.

Literature Review

Peer-reviewed literature and commissioned studies on information-seeking behavior and online information experience of advanced researchers frame this inves-

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tigation of graduate students' decisions and activities during the conduct of a literature review for a masters' thesis or doctoral dissertation. The importance of this initial step in the research workflow is considered critical across the disciplines. "The first thing that you must do is to conduct a comprehensive literature review."[2] This study contributes to a growing, important body of work on discovery through the literature review, a highly significant induction activity in which a graduate student commences a journey of original research and thought grounded in academic theory and relevant methodology.[3]

Results of a three year study of 17,000 Generation Y doctoral students from more than 70 higher education institutions, commissioned in 2009 and released in June 2012 by the British Library and JISC, shed light on these advanced researchers' behaviors while finding and using research resources. Using a critical incident methodology focused on last significant information-seeking activity, researchers asked subjects what kind of research information or material they were seeking, what they eventually found of value through this incident, and the main way in which they located what they sought.[4] In that critical incident, around 80% of students across disciplines were looking for bibliographic references on their topics, both during the first year "ground clearing"[5] literature review phase and beyond, validating "continuing reliance on text-based and secondary published information throughout all the different stages of the students' research."[6]

"Given that graduate students are deeply engaged in their research, and are forming life-long research habits during their dissertation work, this area emerged … as a vital area for further attention"[7] and cross-sector collaboration for librarians, publishers, and vendors.[8–10] In support of advanced researchers' present and potential navigation pathways, a recent study explored first-year college students' mental models of search, with the aim of identifying implications for academic librarians and database developers.[11] Other studies have investigated researcher trends and patterns and generated discovery resource categories, also intended to inform and advance new synergic collaborations within the scholarly ecosystem. Of particular value in this study, Gardner and Inger identified discovery resource characteristics, which recognize that "readers have a wide choice of where they undertake content discovery, so it is worthwhile considering the characteristics of each starting point, or discovery platform."[12] This categorization provided a foundational classification scheme for coding, analysing, and interpreting this study data.

FIGURE 1
Sample Visitor Flow report from Google Analytics

Research Methodology

This study examines sample web analytics data and original research data in order to identify trends in online research workflows and, based on these patterns, extrapolate recommendations for cross-sector enhancements to online discoverability routines. The research data is presented in a Google Analytics-like pathway diagram, using the "Sanky" model[13] which aims to represent common online research workflows of advanced social sciences graduate students. In order to generate these diagrams, the authors charted online research activities observed in 11 social science post baccalaureate students during the literature review phase of their work.

Study outcomes are visualized in a format similar to the Visitor Flow reports in Google Analytics. The purpose of Google's path analysis reports is to offer a "graphical representation of visitors' flow through the site by traffic source (or other dimensions) so you can see their journey, as well as where they dropped off."[14] (See Figure 1.) The goal in applying this model is to offer a more holistic view of advanced student workflows beyond the data that can be seen through the Visitor Flow reports for any single website account, whether publisher or library. By way of further clarification on research scope, process, and outcome, it's important to note that the study only records and diagrams online research activities. It does not attempt to capture, analyze, or present concept maps or investigate the intellectual processes involved in literature review or online research experiences.

Data Collection

Sample web analytics were drawn from online usage reports from SAGE and Auraria Library websites as delivered by affiliated Google Analytics accounts. The authors assume this data to be representative of a primary publisher and an academic library, and we expect similar institutions are routinely capturing and observing similar behavioral patterns of researchers that use databases and other online scholarly products/services. In compiling this data, the authors leverage access to their organizational statistics, withholding proprietary information where necessary.

In addition, through scholarly listservs and with the assistance of individual faculty and librarian colleagues, interviews of 18 potential graduate student subjects led to recruiting a total of 11 participants. Qualification depended on current engagement in the literature review portion of graduate studies within a social science masters' or doctoral program. This initial screening activity ensured that participants met the target persona profile (see more below). A total of 11 interviews were conducted and, following this step, screen recording was arranged. All 11 recordings were submitted. In most cases, interviews or question / answer exchanges via email were also conducted following observational sessions, in order to clarify researcher experiences and navigational choices, for an approximate total of 15 hours of interviewing.

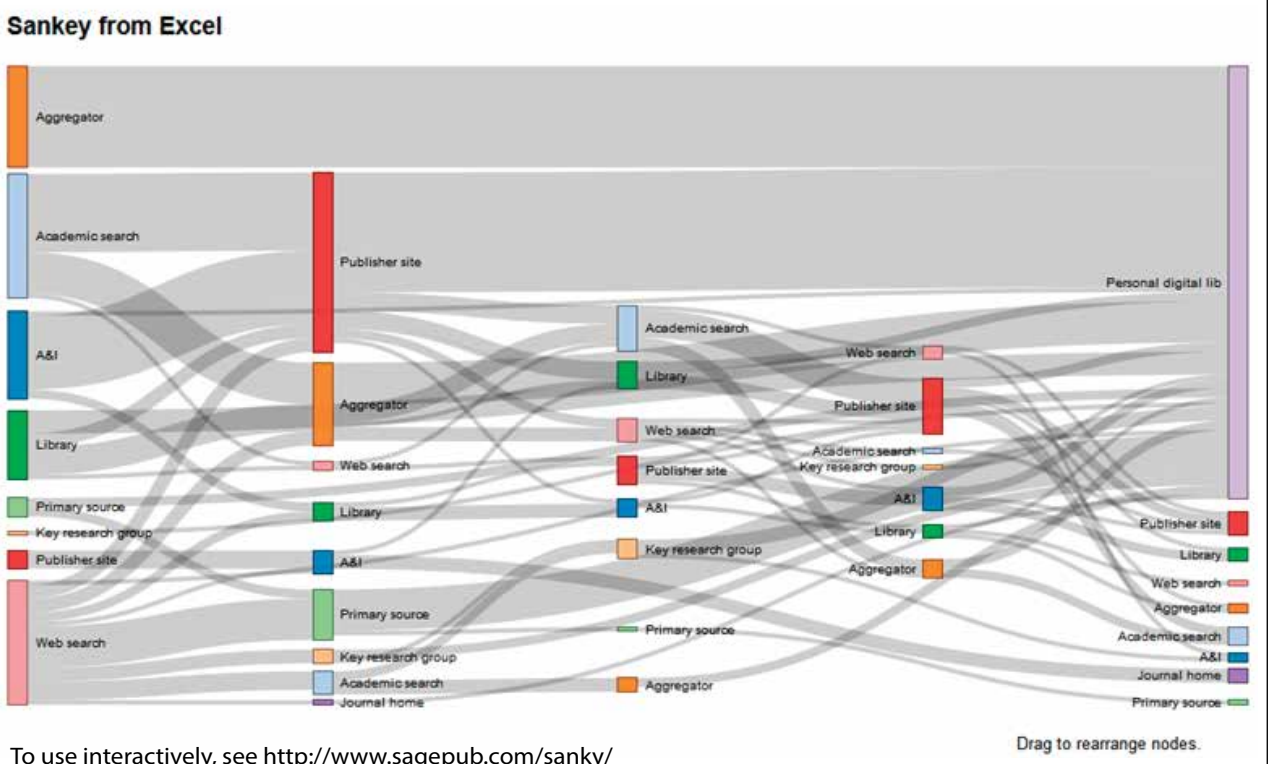
In-person and recorded structured observation of the participants were employed to investigate and then chart information search and retrieval behavior during the literature review process. Some observations were conducted in person and most captured via screen recording, for a total of 13 hours of observation. The recorded sessions of 120 hours did not include audio or other formats to capture the thoughts and decisions during the research sessions.

Google Analytics' Visitor Flow diagrams record each instance where an individual moves from one website to another, tracking activity across a website and present it in an alluvial diagram. Similarly, the user pathway chart based on this study (Figure 2) is made up of similar records, where discovery resource categories were applied and used to record observed activities as participants conducted online research for their literature reviews. The resulting data from both in-person and recorded observations was captured in the user pathway field notes, which allowed for easy coding (see Appendix I).

Pathway Categories

After some review of how others have generated visual maps of online behavior, the authors adopted—and slightly adapted—the "Discovery Resource Characteristics" framework as published in the series of survey reports by Gardner and Inger.[15] This construct is ideally applied to studies of *how* researchers locate journal content. Given the goal to visually represent a wider view of the research workflow, these classifications were expanded slightly to represent content sources as well as discovery loci. Two new classifications were added (for primary sources and personal digital libraries). Additionally, authors expanded the definition of some categories to incorporate full text hosting information and to support hybrid products—for example, philpapers.org was classified as an

FIGURE 2
User Pathways Observed in this Study of 11 Advanced Social Science Students



To use interactively, see http://www.sagepub.com/sanky/

aggregator, even though it is equal parts abstracting / indexing search tool. With the goal of capturing the key touch-points along workflow routes online, the authors applied the categorizations found in Appendix II.

Participant Profile

The researcher persona selected as a focus for this study was masters' and doctoral level students in social science programs at higher education institutions in the United States and United Kingdom. Given the amount of literature focusing on researchers in hard sciences, technology, engineering, and medicine, the authors found cause to produce knowledge about the research needs and habits of social science students. Based on the literature and the experiences of the authors with this type of scholar, this persona was understood to:

- be driven to complete a dissertation or thesis,
- have a notable comfort level of information-seeking routines, with a few year's experience honing online research skills, and
- be eager to be taken seriously as a scholar.

Data Analysis

Interview data generated both quantitative and qualitative metrics, intended to provide understanding and support for observational data, which was analyzed and coded for quantitative presentation. All observed activities were captured in the above-mentioned user pathway field notes and each step was then analyzed and classified (see Appendix II). Leveraging the enhanced discovery resource categories used in the Gardner and Inger surveys, all steps captured in the user pathway field notes were then assigned a code associated with a category and entered into Excel.

This Excel pathway data was then merged and reformatted to represent strings of activity from the point participants began a new query to the point a citation or article was captured. The goal was to view the path between search and knowledge integration into participants' personal digital libraries (saved PDF articles, recorded citations, etc.). Inter-rater reliability of pathway coding was assured through quality assurance routines. This Excel data was then reformatted and applied to the Sanky diagram model.[16] This application generated the user pathway diagram shown in Figure 2.

Limitations

While all participants were working toward degrees within the social sciences, the pace of domain development is notably different among the fields represented (anthropology, international law, gender studies, social work, archaeology, business psych, environmental policy, international politics, environmental science and policy, and philosophy). This variation could potentially impact some variation among discovery / retrieval habits during research sessions.

Given limited resources, this study focused on a relatively small sample size (see noted above). Some degree of error is inherent in any study of this size. Additionally, it must be noted that all research using observational data is at risk of distorted data due to the "Hawthorne Effect." When asked, some participants found management of the recording device to be distracting. Others reported they were more focused during recorded sessions than they would have been normally. One participant noted, "I was entirely stopped from my usual practise of getting distracted or going off on tangents, either by checking email or downloading articles that catch my eye for being 'interesting' but are not actually relevant to my research. I wish I could be that focused all the time!"

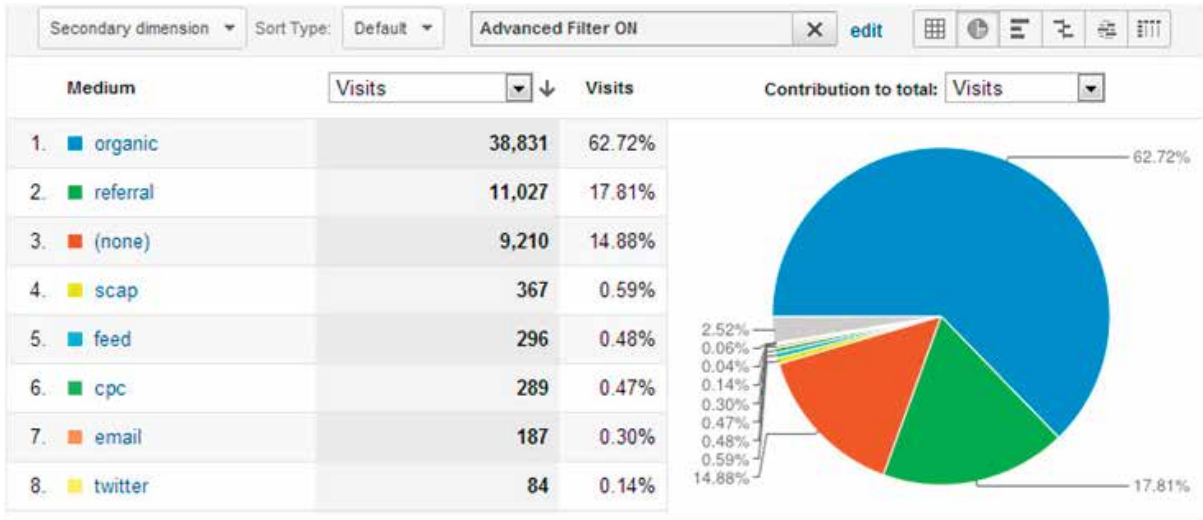
Another participant pointed out situational limitations, such as, "The only difference was when I was linked to Academia.org, I would usually have signed in and downloaded the paper but was working on a different browser without my password so couldn't log in." And another, "The one noticeable difference I can think of is that usually I would read more of a paper before saving it, but didn't want the video to be of me reading a PDF for 20 minutes." Therefore, the authors acknowledge that statistics involved in this study are not precise depictions of researcher behavior, in the way analytics software can record; the data in this study is intended to be representative.

Findings: Web Analytics

While libraries and publishers have options for sources of usage statistics and web trend data, Google Analytics is a free and powerful tool, and is therefore quite prevalent among most industries with a web presence. By installing Google Analytics on a website, various data points are available for measuring the traffic and user trends.

For example, most publishers likely see a majority of the traffic to their sites coming from searches on Google via Traffic Source reports. (See Figure 3.) This is useful knowledge that drives many content architecture and web design decisions, geared toward ensuring Google indexing of publisher sites is of the highest quality possible. Often, traffic from Google is associated with high bounce rates, a metric for understanding user engagement. However, usage data is incomplete on its own. Qualitative user research is needed to understand more about what readers are doing and why. Additionally, web analytic cannot typically capture persona information—so it's impos-

FIGURE 3
Sample Traffic Source Report from Google Analytics



sible to know which types of users have certain usage patterns without the type of qualitative study offered in this paper.

Similarly, libraries make use of Google Analytics to guide website design and ensure e-resources and catalogues discovery. They, too, typically see significant traffic from Google, as well as referrals from university home pages. Many libraries are finding the "Visitor Flow" report to be vital to measuring and better understanding the paths used by students and faculty through library sites. Colleagues at University of Colorado Denver have noted their use of the Visitor Flow report in a recent update to their Auraria Library site that intended to improve the usability and findability of key resources that had previously gone underused. This year, they look forward to using the Visitor Flow report to determine the success of their site changes.

Both libraries and publishers often use the Visitor Flow diagrams alongside traffic source data. This helps both sectors understand where users are on the web just before they enter their sites—for example, open-web search engines or social media. Through these reports, "direct" traffic, where users type the library URL straight into their browser windows, can also be detected. In those cases, it is unclear how well online products and resources fit into researchers' workflows because prior steps and succeeding steps cannot be tracked. This is the type of knowledge gap that this study aims to explore.

Findings: Participant Charting

As noted above, all observed activity in this study was coded using a slightly modified version of the discovery resources applied to the Gardner / Inger survey (2012, see Appendix 2). The resulting alluvial diagram, using the "Sanky" model, visually represents the observed pathways of the participating students.

Using this method, some trends become readily apparent. For example, open-web or mainstream search activity lead participants to a wide range of resources—from primary source materials and key research groups, as well as academic materials. In contrast, dedicated resources like abstracting & indexing databases (A&I) or academic search engines (like Google Scholar) clearly served a dedicated purpose and often did not open up new pathways for students to discover other resources that may be associated with their work.

In this study, aggregator and publisher sites were the dominant resources that lead students to capturing knowledge into their personal digital libraries. This is not surprising, as these two are primarily meant to serve full text scholarly content. However, there are fewer cases where researchers discover new content from aggregator websites, which appear to be missing 'signposts' that point users to related content, tools, or resources found elsewhere on the web. In contract, many article pages on publisher sites were observed to lead searchers to new material of interest to their studies—for example, via links to other articles with commonalities in author, keyword, or citations.

Other findings are not easily seen in the resulting user pathway graphic in Figure 2. For example, several participants encountered problems when they discovered scholarly works via the open web, mainly via Google searches. Some were able to successfully navigate to their library website, login and return to the content located on publisher or aggregator site to retrieve full text. But four participants demonstrated routine difficulties, attempting to login via the publisher / aggregator site, selecting the wrong paths within the library site and instead captured the citation for follow up later. It is no surprise that two of these participants with routine authentication problems retrieved PDF journal articles from specialist websites. Clearly, these advanced students are often unwaveringly focused on their research goal and are willing to be resourceful in gathering knowledge wherever it can be retrieved.

Query Trends

During interviews, participants reported beginning their searches with academic search engines—primarily Google Scholar—and this was born out in the observed research sessions. However, academic services of all kinds were given higher credence during interviews while a much higher degree of open-web search was observed—primarily via Google. This is consistent with dominant traits of this persona, who are often eager to establish themselves as scholars and will likely focus on resources with higher academic credibility. Or, perhaps, this trend is due to the ubiquity of Google in the lives of so many in today's modern world, where we are less conscious of how / when we use mainstream web tools in everyday navigation of internet resources.

TABLE 1
Observed Starting Points
(110 Pathways Observed)

Resource	Raw #s	As %
Academic search	25	23%
Web search	22	20%
Aggregator	21	19%
A&I	18	16%
Library site	15	14%
Primary Source	4	4%
Key Research Group	1	1%
Publisher site	1	1%

TABLE 2
Reported Starting Points
(11 Participants Interviewed)

Resource	Raw #s	As %
Academic search	3	27%
A&I	3	27%
Library site	2	18%
Web search	1	9%
Aggregator	1	9%
Key Research Group	1	9%
Primary Source	0	0%
Publisher site	0	0%

Most library site steps in observed user pathways were used for one or both of these primary functions: 1) to query local holdings for selected content and/or 2) to login to university systems for authentication to full text of selected content. Only two participants reported beginning with library catalogues or discovery services, although observed behavior demonstrated higher use of library web tools as starting points in discovery. This is the kind of data invisible to libraries via standard analytics devices and requires mixed research methods studies like this one (see tables 1 and 2 above).

A majority of participants noted that currency is a key factor in their agendas while conducting research during literature reviews. Even though they are all students in the social sciences, 80% reported that their fields develop rapidly or moderately quickly and, therefore, ensuring the content they use as the foundation of their work is the most up to date was a top priority. However, 70% noted in interviews that they do not perform any kind of 'double check' to ensure that subsequent versions of cited articles were published after their retrieval event, if they downloaded an ahead-of-print version or if post-publication corrections were issued. A few students were intrigued by this question and noted that perhaps they should perform such a check before submitting their thesis / dissertation.

Most subjects routinely evaluated the authority of content resources online. Even when harvesting knowledge from primary sources outside the traditional academic domain, participants were aware of the risks in biased or unreliable information on the web, seeking proof of reliability before applying information and/or citing. One subject shared his process for validating sources and said, "Google searches I think are helpful as long as they lead to reliable information."

Some sources have documented trends in browser use trends shifting recently from Internet Explorer as the dominant choice to Google's Chrome gaining market share,[17] and that can be seen in this study as well. Some participants noted that they would use Chrome more often, but IE was the most common among library computer terminals and institutionally issued laptops. Some were observed using more than one browser, due to lack of support for some services in Chrome, which was reported to be the most popular browser for these participants.

TABLE 3
Reported Use of Browsers for Academic Research
(11 Participants Interviewed)

	Internet Explorer	Firefox	Chrome	Safari
Primary	4	2	5	0
Secondary	0	0	2	1

Retrieval Trends

Despite a plethora of options for citation and document management software, a striking 100% majority reported and demonstrated a fully manual process for capturing citations and managing their saved documents. Almost 80% noted that they had tried applications, such as EndNote or RefWorks, but found them to not integrate easily into their workflows. A few students mentioned that these applications are tied to their libraries and require institutional logins, which is found to be inconvenient. It is unknown if these same students were aware of or would consider using new reference / file management tools, like Mendeley, Udini, Zotero, Papers and others, which would pro-

TABLE 4
Reported Citation Methods / Preferences
(11 Participants Interviewed)

Method	Primary	Secondary	Tried Software, But Could Not Sustain Use
Manual (rekey or copy/paste into documents)	11	0	
Software (export citations programmatically)	0	0	8

vide a transferrable solution beyond a researchers' affiliation with an institution.

Most participants were observed to briefly browse the abstract and other key article features before deciding to either reject or download full text PDFs. Nearly all read articles in the downloaded PDF format, which has clear benefits in usability and builds researchers' personal digital libraries. However, article PDFs do not contain advanced functionality often found within the article hosted in HTML (hypertext required for online hosting) versions on publication websites, that in many cases would be time and labor efficient for these students. Many utilized citation metrics, if found easily 'above the fold' near the top of the article, often alongside abstracts. However, no participants made use of features often found within the text of the article as hosted online. For example, at least one extra step, and as many as 5 extra steps, are required to manually retype bibliographic information when participants searched for full text of works cited in recently discovered articles. However, if they had spent time browsing the HTML version of the article, they could have utilized many programmatic features offered on publisher and aggregator websites—such as hyperlinks to query local holdings in just one click.

All participants had varying levels of organization for saving retrieved articles and chapters, capturing notes or observations about what they discover, and managing their literature review word processing documents. Most participants used their laptop hard drive for storage and document management. One participant demonstrated regular use of Dropbox for document storage and management across multiple devices. All students in this study reported use of a laptop or desktop computer as their primary equipment for academic work. Approximately 50% mentioned using smartphones and tablets for secondary needs—for example, as a time saving measure, a few mentioned using phones for researching 'on the go' and a few others noted using tablets for deep reading, as it was preferable to printing or reading on their main computer.

These query and retrieval trends suggest rich opportunities for cross sector collaborations, which would support advanced researchers' blazing new pathways. Highlights and conclusions are presented as recommendations in the following section.

Conclusion and Recommendations

This study is timely, given the sustained cross-sector attention now focused on the discovery ecosystem, which holds considerable promise and associated challenges amidst disrupted researcher workflows, best practices, industry standards, and business models. This investigation of user behaviors—and, more specifically, the consideration of how better to support advanced researchers' present and evolving navigational pathways—recognizes the importance of increased collaboration among libraries and their vendors, and publishers and their vendors, toward our common goal of enhancing discovery, access, and usage of the scholarly corpus.

Therefore, the user pathways found in Figure 2 and analyzed above, as well as associated recommendations below, aim to inform improved discovery for graduate students in the social sciences—and, by implication, all researchers. These concluding observations highlight opportunities for enhanced cross-sector cooperation in usability and discovery improvements via design enhancements, standards compliance, and authentication routines.

- Recommendation #1: Ensure article / chapter PDF documents are as dynamic as possible—with web-based tools integrated for version control (such as CrossMark) and reference hyper linking, including aggregator and publisher content.
- Recommendation #2: Further drive semantic technologies for more refined recommendation features within all points along the research pathway.
- Recommendation #3: Refine cooperative enhancements to authentication and login routines.

- Recommendation #4: Explore citation and document management systems for personal digital libraries *with researchers* to evolve available products, further workflow integration, and advance researcher adoption.
- Recommendation #5: Add 'sign posts' in all scholarly resources that construct pointers to additional / related content to further resource discovery (rather than assuming, for instance, that publisher and aggregator content are destination sites).
- Recommendation #6: Conduct additional studies that include 'talking out loud' protocols and in-person observations of research sessions, to gain greater insight into the thoughts / judgments during charted pathway sessions.

These recommendations occur within an increasingly fertile environment of cross-sector collaborations, in which publishers, vendors, and librarians are initiating cross-platform investigations to identify best industry practices, promote information standards, and apply knowledge about researcher behavior to improve academic databases and websites. Implementing more open, standardized approaches to online hosting that allows published content to be used as a platform upon which others can innovate depends on vigilantly monitoring "knowledge of researcher needs and habits (which will inevitably change as discovery and delivery functions evolve) to improve the connections between readers and knowledge."[18]

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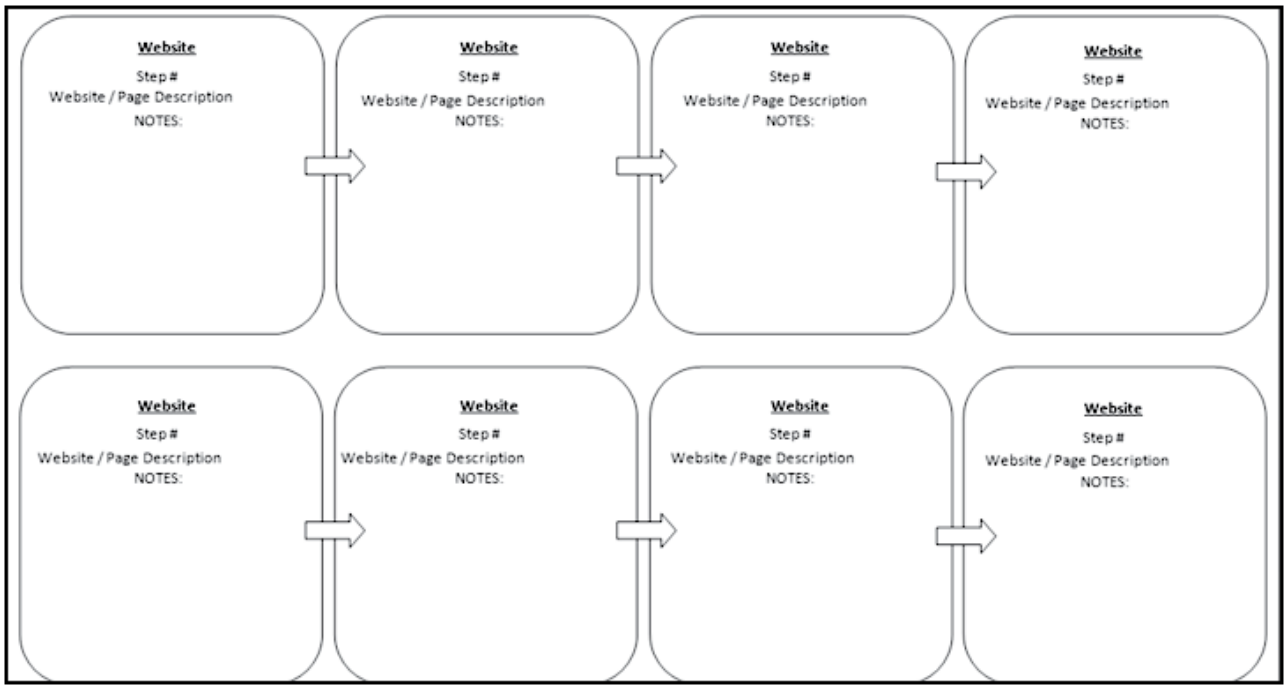
Appendix I: User Pathway Field Notes

The following original template was used for field notes during observation of participants conducting online research during their literature review phase. The sequence of activity observed on websites and personal digital libraries was captured in a step-by-step format, which was then coded into Microsoft Excel to create the user pathway charts in this paper.



Appendix II: Discovery Resource Classifications

The following was adapted from Gardner / Inger (2012), with some modifications, and was applied to the user pathway charts presented above. **Abbreviations** used in pathway charts are listed here as well. Notes regarding modifications to the Gardner / Inger model appear in the table below. Note: categories that were not observed in this study are not reprinted here.

Resource	*Gardner / Inger Definition*	*Modifications*
Abstracting and Indexing Services **(A&I)**	"…Focus on structured access to the highest quality information within a discipline… Their utility flows from the one-stop-shop nature of the service that they offer and perceived … authoritative source of search results." (specialist bibliographic databases)	
Library web pages **(Library)**	"…Library controlled web space has the advantage of linking only to content that has been paid for by the library and meets library selection criteria." (previously 'Library OPAC')	
Journal Collection or Aggregation **(Aggregator)**	"…Collection of journal content licensed to an aggregator and sold and delivered independently of a publisher's primary content incarnation."	Includes all scholarly publications—ebooks, datasets, theses, etc., e.g., JSTOR or Google Books
Key Research Group **(Key Research Gp)**	"…Informally-produced web sites run by research groups around the world who record details of articles at they or their peers have created…include some form of recommended reading."	Includes scholarly blogs
Publisher Web Site **(Publisher)**	"…Only a fraction of the available literature in a given subject area…often superior interface design make these sites appealing to users."	Includes commercial and scholarly publisher platforms, providing access to full text journal, book and other published content, e.g., Amazon or Wiley Online Library
Journal Homepage **(Journal Home)**	"…resource [that] has already gained the user's trust…"	Limited to journal information / marketing pages only
General Web Search Engines **(Web Search)**	"…search engines such as Google…simplicity, broad coverage and…free to use. Their speed allows for search to be refined and retried quickly…reason for their popularity."	
Academic Search Engines **(Acad. Search)**	"…Achieve some measure of quality by selection and the addition of citations to results is a clear differentiator over the general search engine." (e.g., Google Scholar)	Includes free, discipline-specific indices or open-source databases, e.g., philpapers.org or figshare.org
Primary Sources **(Primary So.)**		This new category covers a broad range of evidentiary content, e.g., government websites / reports, cultural archives, newspapers, etc.
Personal Digital Libraries **(Personal Lib.)**		This new category covers any action that integrates knowledge found online into personal digital libraries, e.g., file storage / retrieval, capturing citations, etc.

Notes

1. Visitor Flow reports are alluvial diagrams that provide visual representation of users' pathways through a website. More about these reports can be found in this Google Analytics help page, accessed on January 21, 2013, http://support.google.com/analytics/bin/answer.py?hl=en&answer=2519986.
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