New Pathways in Scholarly Discovery: Understanding the Next Generation of Researcher Tools

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This exploratory study examines doctoral and master's student use of research tools and their scholarly information experiences with such research tools as EndNote, Mendeley, and Zotero. While the data does not suggest new researcher behaviors and trends related to use of these tools, the study does illuminate a growing demand for academic and library systems integration to enable more efficient and effective research practices among graduate students.

Introduction

Within academic institutions and publishing communities, much is said about changing research trends as technology continues to impact software solutions and user behavior, particularly impacting the discovery of scholarly information dissemination, organization, and fulfillment. This exploratory study examines the usage of and preferences for research tools by graduate students and post graduate researchers. Special attention is paid to software tools and web applications that support tasks performed by graduate students conducting literature reviews.

Specifically, we surveyed use of tools that enable discovery and use of scholarly literature and the management and retrieval of associated bibliographic data. We set out to answer questions such as: How are students using the tools provided by their institutions, often via the library? Do they prefer web-based applications, which are often free of charge and offer innovative new features? How are these new tools, such as ReadCube or Mendeley, being used in contrast to the early entrants in the research software space such as RefWorks or BibTex?

The majority of participants were graduate students and postgraduate researchers in the social sciences; therefore, the conclusions of this project best illuminate the usage trends of research tools within those fields of study. The top research tools in use by participants were Google Scholar Citations, Mendeley, Zotero, and EndNote. Our data shows that some graduate students are not using any specialized tools and some graduate students are achieving new levels of research efficiency with cloud-based and automated computing (e.g., leveraging mechanized features within and across research applications). Yet, most students are only performing routine research tasks in well-known applications, primarily saving scholarly citations in tools that have a range of options for citation output.

The majority of participants reported that all research needs were not being met by a single tool—noting that citation management tools are not their

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ideal collaboration environments, for example. While most students indicated measurable time savings in their use of these tools, many spoke of the significant time investment required to achieve optimum performance of these software applications, which is a factor in their selection and adoption. The data resulting from this study does not reveal new research methods or tactics driven by new web-based software offerings; instead, new tools are creating a higher expectation for systems integration and interoperability.

Literature Review

This study contributes to the growing body of literature that addresses academic users' information experiences. Akin to user experience best practices, we understand information experience to be "a complex, multi-dimensional engagement with information,"[1] which incorporates a broader context for people's experiences with information; in this case, the student experience with information seeking or sharing via research tools.

There is increasing evidence that libraries, publishers, and other scholarly communication professionals have a tactical and strategic need to understand their users' experiences. In that spirit, this study aims to advance understanding of the evolving information experiences of academic scholars and students. We attempt to answer the call to listen to the voices of students and researchers—as Stephen Abrams urges, librarians and publishers must "seek to understand how learning, research and/or decision-making happen…describe and map your user's real workflows and not just our understanding of the small segment we see."[2] This same sentiment can be heard in direct pleas from scholars themselves.[3]

Placing this understanding and end-user perspective at the center of our work ensures our ability to deliver effective products and services for our higher education communities. A compelling rationale for user-centered research is outlined in the introductory paragraph of *Information Experience*: "Understanding people's information experience has importance for developing or enhancing environments, systems and services that are responsive to and supportive of that experience."[4] In the case of this study, the examination of PhD student usage of academic research tools treats their information experience as the primary research object, "sitting alongside other information research objects such as information sharing, information seeking, information literacy and information practice."[5]

This research builds upon earlier data-driven studies of doctoral students' information experiences and examines potential impacts on their workflows. For example, a 2012 longitudinal study of 17,000 UK doctoral students reveals participants' attitudes about information and communications technologies, including their interest in time-saving research applications.[6] Similarly, studies into how digital tools[7] and search engines[8] are impacting students' information seeking and retrieval behaviors help place our study in a wider scholarly context.

Methods

Three primary data-gathering techniques were applied in this study. First, desk research was completed to determine the scope of research tools to be examined (the final working list of tools included in this study appears in Appendix A).[9] Secondly, in fall 2014, an online survey of masters and PhD students and post-doctoral research fellows was conducted that resulted in 344 completed surveys. Finally, thirteen 30-minute interviews were conducted via Skype and by phone with survey respondents in December 2014.

Demographics

Of the 344 people who completed the survey, 226 (66%) were doctoral students, 63 (18%) were master's students, 48 (14%) were post-doctoral researchers, 10 (3%) were research associates and 3 (1%) were visiting scholars. From the survey participants, we selected interview subjects; 10 were doctoral students and three were post-doctoral researchers. Four interviewees were also part-time teaching faculty, two as PhD students and two in post-doc positions.

The majority of students surveyed were in the social sciences (73% or 252 students), followed by the humanities (15% or 52 people), 8% or 28 were in the sciences, technology or mathematics, 6% or 20 participants were in medicine or the health sciences, and 10 participants (3%) were in the arts. Of the interviewees, 11 were from the social sciences, one from the humanities, and one from the medical sciences.

The majority of survey participants were in North America (197 participants or 57%), followed by Europe (22% or 74 participants), Asia Pacific (13% or 44 participants), South America (4% or 13 participants), the Middle East (3% or 11 participants) and Africa (1% or 5 participants). Interviewees were mostly in North America (11), with one in South America and one in Europe.

Workflows, Integration, & the Researcher Experience

Most participants reported that they search for scholarly information either several times a day (38%) or weekly (38%), see table 1. This varied depending on what research stage the participants were in, as one person wrote: "When I am in the research phase for a thesis (which can last several weeks), I search for scholarly information daily and more than once. During the writing process, I sometimes need to search for more information (that might occur weekly). When I am not writing a thesis, I do sometimes (maybe once in a month) search for new and interesting articles."

TABLE 1
How Frequently Graduate Students Search for Scholarly Information

How frequently do you search for scholarly information?		
Answer Options	**Response Percent**	**Response Count**
Several times a day	37.6%	128
Once a day	16.8%	57
Weekly	37.9%	129
Monthly	4.7%	16
Every few months	2.9%	10
Annually	0.0%	0

This student's experience seems typical. Other students mentioned that they were writing their literature reviews (and therefore regularly looking for information); other students had written their literature reviews, but maintained search alerts in case there were new articles; and some students had not begun their research. One student wrote: "[I am a] doctoral candidate and teaching, [research] is what we do," suggesting that conducting research is expected to be omnipresent throughout an academic career.

While all the research participants were searching for information, they were not all using that information to write literature reviews, nor did they all have experience writing literature reviews. The majority of participants (90%) had conducted one or more literature reviews, often for their honor's or master's thesis, doctoral dissertation, and also for research papers and for publications, see table 2. All interviewees had experience with one or more literature reviews and about 30% were journal article authors.

Many participants noted that literature reviews are time consuming, and most interviewees spoke of the hours, weeks, and months required to build up sufficient personal digital libraries of literature and citations relevant for a thesis or research project. Some participants had completed multiple literature reviews as their research questions had changed or

TABLE 2
Graduate Students' Experience Conducting Literature Reviews

Which of the responses below best represents your experience conducting literature reviews?		
Answer Options	**Response Percent**	**Response Count**
Not sure what a literature review is	0.3%	1
Never conducted a literature review	2.9%	10
Currently conducting my first literature review	6.5%	22
Conducted a literature review	18.2%	62
Conducted multiple literature reviews	72.1%	246

as understanding of the topic had increased. Despite the time-intensive nature, some commented that they found literature reviews rewarding or satisfying.

Preferred formats & impact on use of tools

The most preferred storage and reading format was PDF, either on screen (58%) or as a print copy (55%), largely because they maintain the primary format, see table 3. The original print format was preferred by 187 survey respondents (24%). Some students mentioned that they like to read the abstract or skim the article online, but prefer to read or store articles as PDFs. Additionally, some students mentioned that while they preferred to read in print, they didn't want to waste paper or to pay to print, so they read on screen. "I appreciate the economy of not having to kill the trees," one PhD candidate shared. A minority of students who use research tools retrieve full text files and/or perform long-form reading within the applications themselves—notably, these are the same students who also store their reading notes alongside the content stored to their applications.

All interview participants spoke of their pathways from discovery to download and the processes they've established to manage their collected citations and full-text PDFs. When a new article or chapter is identified as relevant for a research project, nearly half of interviewees (6 of 13) began by downloading the PDF to their local hard drive and/or cloud storage application, like DropBox. The portion of that group who use research tools integrated citations with their favorite research tool after reading full text. One researcher reflected, "RefWorks doesn't come into play until I know for sure that using that particular artifact for my work. Putting something in RefWorks is like me giving my blessing, that 'ok I find this valuable,' so I'm going to store it for future projects. So, usually RefWorks is my very last step." In contrast, five of the 13 interviewees captured citations and full-text PDF files simultaneously upon discovering relevant literature for their work.

Given the effort and time involved in compiling content for literature reviews, many participants spoke of the importance of secure data storage and retrieval. Nearly 60% of participants noted document storage as an important feature of research tools, the majority of whom backed-up this data in local hard drives and/or cloud servers. One researcher mentioned the importance of "safe keeping," noting "I've had more than one laptop or computer during my studies that have been broken or damaged in one way or another, and I have been unable to recover my data. So, with Zotero I have cloud storage in which I'm able to upload [my data]." Notably, it was Zotero users who most often mentioned their sense of security in storing their citations and literature to the popular Mozilla application. Another Zotero user said, "I suppose that [Zotero] has made everything faster and it feels more secure, because everything is neatly stored. It's not like it's just a 17-page Word document full of my notes, it's an actual program designed for [research]."

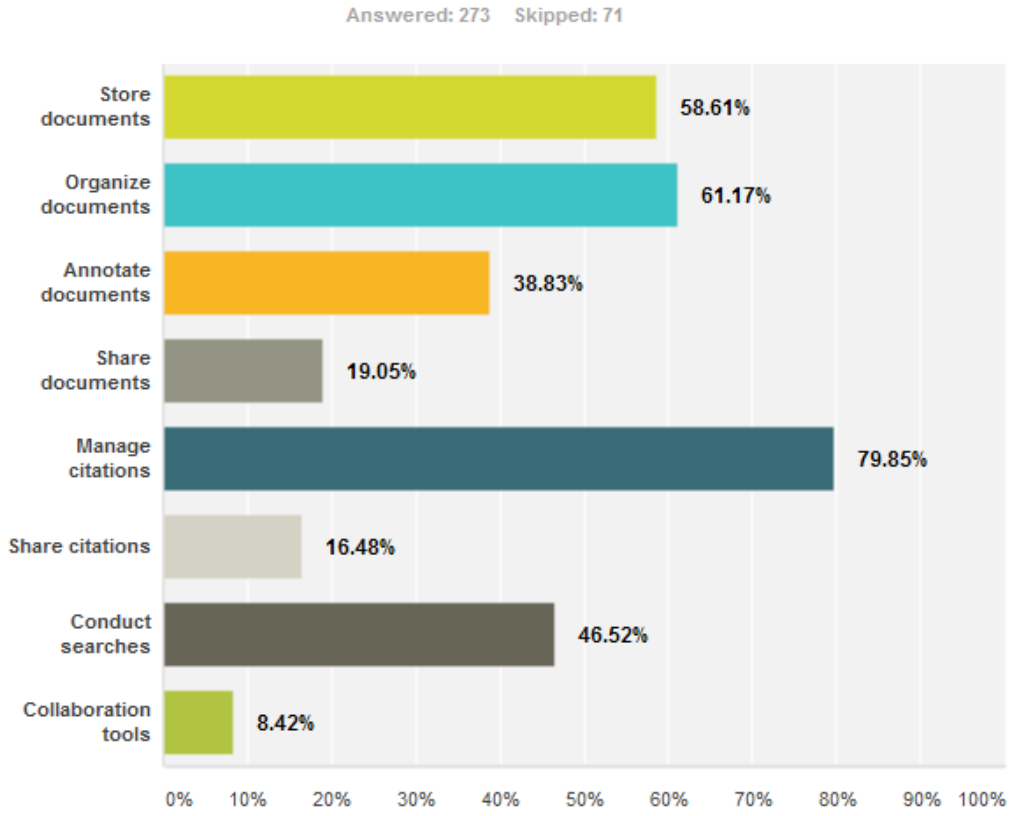
TABLE 3
Preferred Reading Formats

In what format do you prefer to read?		
Answer Options (multiple answers allowed)	**Response Percent**	**Response Count**
PDF (on screen)	58.10%	197
Print copy of PDF	55.20%	187
Print (where this is the original format)	23.60%	80
HTML (on screen)	5.30%	18
Print copy of web page	3.20%	11
No preference	1.50%	5

Benefits and Features

The top functions students used in research tools are managing citations, organizing documents, storing documents, and conducting searches (figure 1). While interview respondent prioritized research tool features a bit differently, the majority noted their must-have features enable efficient creation and management of their "personal digital libraries." Seven of these nine students noted that features must be easy to adopt, with a "low learning curve," and five of the nine mentioned that automation was important, such as having a web browser plug-in for one-click citation import.

FIGURE 1
Functions for Which Graduate Students Use Research Tools



Conducting searches via research tools was a highly rated feature. However, interviewees revealed a preference for a specific *type* of search; that is, executing a query against the bibliographic or full-text data stored to an application. Three of the nine participants using research tools noted that having the ability to search across their personal digital library was a must-have feature. A researcher working in the medical sciences reflected on her need to both build up her personal library of citations, and also query that saved data at a later time. "The big thing about Mendeley is how it organizes the content and lets me then *look through it*, which is something I can't get by simply saving a PDF to my computer." Yet, no interviewees reported a wish to search for new scholarly content from the tool.

The driving benefits of using research tools for the students surveyed were having a free application that enables portable, efficient, and central storage of their research data (table 4). Fast, effective retrieval of stored articles and citations was a challenge mentioned by about half of interviewees, a difficulty that was shared both by students who use research tools and those who manage their digital libraries in personal computer file folders. One researcher noted that she would only consider a research tool if it could "do something more than my system already does for me, because mine is working. And it would have to be easy for me to learn how to do it."

The ability to annotate was important to many students, although some preferred to do that online and others preferred to annotate their readings in print. One PhD student uses Mendeley to keep notes while reading full text within the application, but he expressed frustration that these notes were not then easily integrated with the version of the content in backup storage. This student copies / pastes his notes form

TABLE 4
Benefits for Using Research Tools

Answer Options	Very important	Important	Somewhat important	Not important	Rating Average	Response Count
Improves my efficiency	187	57	19	4	1.40	269
Provides central location I can access from any device	139	66	39	17	1.75	267
Information sharing	48	64	88	51	2.57	258
Facilitates collaboration	34	63	90	54	2.68	252
Can use without an internet connection	85	70	48	32	2.11	261
Free	165	59	23	7	1.50	264
Can use when I graduate / transfer to another institution	151	68	23	10	1.57	265

Mendeley into separate Word file, with references and notes listed as topics, which he can store and retrieve in Mendeley. "You just can't highlight and make notes [in a database], but Mendeley does the trick."

Unmet Needs

When asked what students would like to see improved in their chosen research tool, greater cloud storage and formatting accuracy were highly rated. One PhD student, who has tried more than six research applications, noted that no single tool had served all his needs, "especially in annotations and file storage." Another interviewee, who prefers EndNote, noted that she needs her research tool to allow for customizations within a good framework. "It's about being flexible but structured," she concluded.

While two of the nine interviewees using tools noted using EndNote when they need to share citations among labs or research teams, the majority reported favoring other tools for most collaborative research tasks. A few also noted that they use some tools only for citation sharing, while preferring another tool as their primary digital library location. One PhD student, who prefers Mendeley for organizing her thesis work, commented that "I only go back to using RefWorks if I'm working on a collaborative project with someone and they've shared a folder with me in RefWorks that I need to access, so I can look at common articles that we're using for our literature review." She went on to note, "it's hard for me to have people use [Mendeley] for collaboration, I really have to talk them into it." Thirty percent of interviewees mentioned a wish for improved sharing and collaboration features in their chosen research tool. Notably, this 30% were all Mendeley users, who complained that the free version has limited collaborative features available.

Those students and researchers who are not using software support reported similar needs and process pain points,– such as managing their personal digital libraries of stored documents and formatting citations correctly. One student was happy to create citations by hand, but information retrieval was the biggest area of need. "I can't tell you how many times I've downloaded something for one research project, but forgot where I stored it," when reusing for another project. Three of the four interviewees not using tools cited a concern that they'd lose precious time or momentum on their doctoral work if they took the time to add a tool to their workflow.

Research Tools, Use and Uptake

While not all the graduate students used research tools, 85% of the students had tried between one–five tools (figure 2). Interviews revealed that "application shopping" is common, but the majority (seven out of nine) chose to devote their bibliographic manage-

FIGURE 2
Number of Research Tools Tried

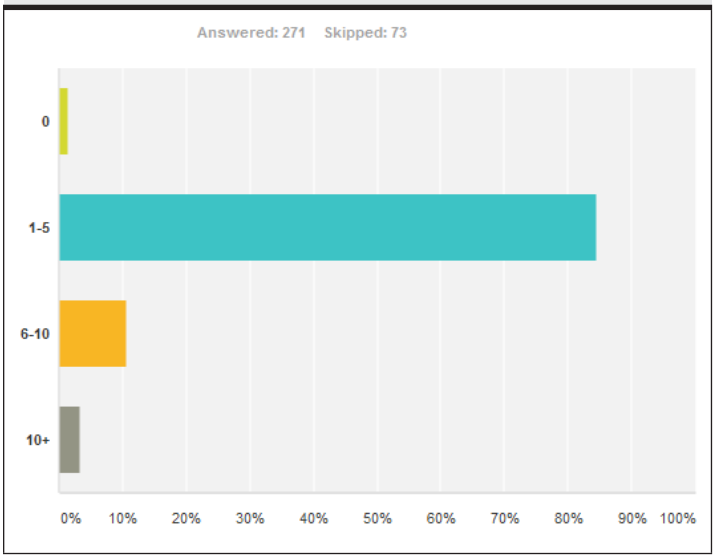


TABLE 5
Top 10 Research Tools Used

Answer Options	Response Percent	Response Count
Google Scholar Citations	47.10%	155
EndNote	37.10%	122
Zotero	18.80%	62
Mendeley	15.80%	52
Google+	15.80%	52
RefWorks	14.30%	47
BibTeX	6.70%	22
Papers	5.80%	19
Reference Manager	4.60%	15
EasyBib	4.00%	13
I don't use any tools	19.10%	63

ment and data-entry energies to one primary app for maintaining personal digital libraries of citations and papers. Eight of the nine interviewees using research tools noted that easy import of citations and PDFs was a key factor in their selection and loyalty to an application. Half of these participants noted that having the ability to customize this library was a deciding factor.

Other research activities, like content discovery and sharing or collaboration, were often not served by the same tools. Only 4% had either never tried to use a tool or were not sure what a research tool was. Most interviewees who used research tools (five of the nine) have been using this type of application for a range of two—four years; and four interviewees have been using research tools for five or more years.

The top tools for all respondents were Google Scholar Citations, Mendeley, EndNote, and Zotero, see table 5. EndNote was the most common tool reported to be discontinued by interview participants, but EndNote was also most commonly mentioned as a necessity for collaboration at some institutions. A small percentage of respondents did not use any tools—19% of students surveyed and 23% of students interviewed—with some commenting that they had not heard of any of the tools listed. (See Appendix A for full list.)

Several interviewees noted that they tried a range of tools to find one that would fit their needs and work style. One post-doctorate fellow laughed, "I've been on the hunt for a tool that has it all without costing a lot…something that will integrate" with other systems she uses for her research and writing work. Several participants noted their preference for tools that deliver their must-have features with ease and simplicity, for instance, web browser plug-ins for one-click citation downloads, which were mentioned by half of interviewees who use tools. Some researchers stayed with a tool because they got used to it and didn't want to start from scratch with a different software option. One PhD student noted "familiarity goes a long way with research tools."

A few interview participants maintained use of multiple applications for two or more years, because they found value in different scenarios and use cases. For instance, one researcher has tried six tools and has come to prefer Mendeley for citation management, Google Scholar Citations for search and automated alerts, and academia.edu for collaboration. And one PhD student in the medical sciences uses three applications regularly—EndNote for sharing data with lab partners and others "across the community"; Mendeley for her own personal thesis work, where she needs to "build a whole body of literature"; and Google Scholar Citations for "quick reference lists that I may not need for a second or third time, I pull citations

and store them there temporarily." However, most students were not willing to maintain more than one tool. A PhD student noted, "I don't have time to manage multiple applications, and now I've got so much time invested in Mendeley."

Saving time in the management of citations and documents is a driving motivator for most interview participants who use research tools, discussed in more detail below. However, the time required to select and personalize a software application was noted by about half of interviewees as not trivial and a factor in their selecting a tool to support their research. A post-doctoral researcher noted that they discontinued use of one application because it "was a big time commitment, there was a lot to learn." There's a risk, especially when time is tight, of investing notable time in an application that turns out to not be usable or valuable in the long run. One student who chose not to use research tools noted, "I would love to have a tool to make things easier, I just don't have time to investigate it." One of the four interviewees not using a research tool was afraid to waste her time as she teaches and holds research positions across three different campuses. She said, "I'm in between universities right now and I don't want to start with one [research tool] and have to rebuild it" at another institution.

Some students created their own systems in lieu of a software tool, such as Excel spreadsheets or folders (in print or on their computers). One student wrote that she goes "old school: I use 3x5 cards and digitize them." Another noted that he has stuck to his "habit" of manual citation and data management, in part because he notes, "I haven't been exposed to anyone who's said 'you have to try this software, it helps me out a great deal,' it's just never come up in conversation."

Awareness of Tools

Awareness of the tools came from several different means, including from a friend, instructor, librarian, or internet search. Additional ways that students learned of the tools include from the library's website, or from a spouse, boss, doctoral supervisor, or colleague (table 6).

TABLE 6
How Graduate Students Learned of the Tools

How did you learn about the tool(s) you selected?		
Answer Options	**Response Percent**	**Response Count**
From a friend	35.8%	95
From an instructor	35.8%	95
From a librarian	35.1%	93
Internet search	41.1%	109
Saw an ad	1.9%	5
Saw a link on a database	4.9%	13
Saw a link on a journal website	6.4%	17

Of students surveyed, 71% stated that their institution provided access to one or more of the tools listed; 15% stated their institution did not provide access; and 14% did not know if their institution provided access. In interviews, some of the students knew that they were using a tool that their institution supported, but with variable satisfaction with that support. And about 40% of interviewees were unaware that their institution provided them access to RefWorks.

Participants commented that having free access to a tool did influence what tools were adopted. "Cost definitely has an impact," on the software decisions for one PhD student, "especially if you're still a student, like I am, money is just always tight." Three of the 13 interviewees were on campuses that did not provide any research application. One such student, another Mendeley user, noted that he was fine without a campus-supported application, because he knows all his stored data is easily portable when he transfers to a tenure-track position at another university. One PhD student noted that she is unwilling to use institutionally sponsored tools, because she'd lose access if she changed campuses and "it would be a big pain to change apps now."

Conclusion

The paths that graduate students take through their academic journeys, from selecting a research question through to the writing process, is complicated

and often organic. There are a plethora of web-based and localized software solutions that can offer necessary efficiencies. However, the experience that graduate students have with these tools varies widely and is often based on what they hope to gain by using the tool, as well as how well the tool integrates with other systems and workflows.

For organizations supporting the processes of academic discovery, scholarly creation, and scholarly dissemination, the complexities of the scholarly ecosystem are hopefully eased by software solutions and research tools, such as Zotero and EndNote. However, the need to integrate these solutions more into the natural pathways of emerging scholars, to communicate why and how any tool can be used, is growing—even as the number of tools and the amount of scholarship grows. Today's emerging scholar is asking for more portable tools, tools that go where they are going (physically and virtually) and that do so seamlessly. As they experience ever-more sophisticated solutions in their personal lives, they increasingly expect it in their academic work lives. We should all strive to assist them in their complicated journeys, scaffolding the work of the future scholar.

Appendix A. Research Tools

The following applications were examined in this study, compiled via desk research from sources such as these: 1) Transforming scholarly communication, a Microsoft Research eScience Workshop co-hosted by Harvard University & Microsoft Research (New England). October 2011 postings. Retrieved from: http://msrworkshop.tumblr.com/. 2) Elizabeth Gibney, "How To Tame the Flood of Literature," Nature Toolbox, September 3, 2014. Retrieved from: http://www.nature.com/news/how-to-tame-the-flood-of-literature-1.15806. 3) Digital Research Tools Wiki: https://digitalresearchtools.pbworks.com/w/page/17801672/FrontPage.

Bookends
EasyBib
EndNote
Reference Manager
RefWorks (soon to be ProQuest Flow)
Zotero
Sente
BibMe
Qigga
Referencer
Heurist
JabRef
BibDesk
Bibus
Citeline
NoodleTools
OttoBib
BibTeX
eStacks
Symplectic
Mendeley
Udini
ScienceScape
DeepDyve
Kudos
Colwiz
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MyPeers
Knimbus
PubChase
Sparrho
Google Scholar

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