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Information Seeking Behaviors, Attitudes, and Choices of Academic Chemists

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ABSTRACT

Chemists in academic institutions utilize a variety of resources and strategies to remain current and to track scholarly information, patents, and news. To explore how chemists in academic institutions remain current, librarians at four Canadian university institutions surveyed 231 and interviewed 14 chemistry faculty, staff, and graduate students on their information seeking behaviors and attitudes. According to survey results, a minority of chemists (13.9 percent) acknowledged that they were successfully keeping up to date, while 50.6 percent indicated that they were somewhat successful. However, a significant number of chemists (35.5 percent) indicated that they were unsuccessful and could do better in remaining current with information. Investigators analyzing focus group data identified three emergent themes related to remaining current: (1) there is "too much information – and not enough time." No single information seeking strategy works; (2) "patents are important – but messy." Chemists find themselves largely suspicious about the value and credibility of patents; and (3) chemists "could do better" in keeping up to date with new and emerging technologies. Chemists continue to be open to new tools and resources yet readily acknowledge that they are too often not sure which information seeking behaviors, resources, or strategies work best. This study helps to shed light on opportunities to identify and meet chemists' evolving information needs.

KEYWORDS

Academic (university) libraries; chemists; faculty; graduate students; information needs; information seeking behaviors; information sources

Introduction

Recent advances in technology have enabled chemists to efficiently acquire and evaluate chemistry information in a timely and sustainable manner. Even so, many chemists continue to struggle to find the right balance of strategies and resources to stay on top of the literature. These concerns raise questions about chemists' information seeking behaviors, attitudes, and choices while attempting to remain current in their areas of expertise. This paper explores academic chemists' practices and feelings when seeking, evaluating, and managing

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information resources. Of specific interest is a desire to hear from practicing chemists on how they overcome obstacles to satisfy their information needs.

Literature review

The study of "information behavior" has expanded since its inception during the 1960s when most research (Bruce 2014; Case and Given 2016; Ford 2015) was directed towards understanding how professionals searched for information and the resources they consulted. Current research (Chowdhury and Chowdhury 2011; Fidel 2012; Fisher, Erdelez and McKechnie 2005; Julien and O'Brien 2014; Ruthven and Kelly 2011) has increasingly focused on investigating the context in which these interactions happen. This type of research not only increases the complexity of choices available and resources consulted, but increasingly investigates how people feel about these processes. A more holistic approach to investigating how researchers interact and engage with information has evolved to explore "…an interplay of thoughts, feelings and actions" (Kuhlthau, Maniotes and Caspari 2015, 17). Within this new research paradigm this study attempts to investigate chemists' information behaviors "…in which humans interact with information, in particular, the ways in which people seek and utilize information" (Bates 2010, 2381).

Recent studies exploring scientist information seeking behaviors have involved engineering (Doraswamy 2009; Engel, Robbins, and Kulp 2011; Freund 2015; Johnson and Simonsen 2015), basic sciences (Bartlett, Ishimura, and Kloda 2011; Haines et al. 2010; Niu and Hemminger 2012; Niu et al. 2010), computer science (Athukorala et al. 2013), health sciences (Abubakar and Harande 2010; De Groote, Shultz, and Blecic 2014; Dee and Stanley 2005; Gavino et al. 2013; Lialiou and Mantas 2016), mathematics (Brown 1999; Sapa, Krakowska, and Janiak 2014), and veterinary research (Nel and Fourie 2016). These studies collectively agreed that scientists (including chemists) aspire to stay current in their research fields, need to remain flexible, use a variety of resources, and be open to different strategies when exploring unfamiliar and new research areas.

Other studies have explored the information behaviors of faculty and doctoral students; they agreed that in order to be successful, people need to continue to adapt to an ever-increasing growth in the number of publications, different technologies (Bauder and Emanual 2012; Larsen and Von Ins 2010), and recognize subject-specific peculiarities (Booth 2008; Jamali and Nicholas 2010) while managing a multitude of digital choices (Borrego and Urbano 2007). Graduate students were found to be less proficient in developing search strategies and doubted the trustworthiness of information resources they retrieved (Catalano 2013; Liyana and Noorhidawati 2014; Shipman, Bannon and Nunes-BufFord 2015). Additionally, graduate students may be adversely affected or susceptible to environmental and cultural issues

when negotiating information seeking choices (Al-Muomen, Morris, and Maynard 2012; Kayongo and Helm 2010; Korobili, Malliari and Zapounidou 2011; Zhang 2017). Recent studies found that millennials' information seeking behaviors may be problematic, resulting in new or naïve researchers moving away from subject specific resources and towards Google and similar digital tools (Lacovic 2015; Lo and Chu 2015; Salisbury, Gupta, and Kumar 2006; Taylor 2012; Walter and Pennavaria 2015; Zass 2014).

Researchers strive to be efficient and productive, noting that keeping up on research is crucial for success. However, staying current continues to be a daunting task for scientists and chemists alike (De Groote, Shultz, and Blecic 2014; Niu and Hemminger 2012; Pontis et al. 2017). While technology is supposed to help researchers work faster and more efficiently, researchers are increasingly feeling inundated and overwhelmed by information choices (Cantrill et al. 2017; CAS 2017; Larsen and Ins 2010; Levitin 2014; Pain 2016; Siebert, Machesky, and Insall 2015). Chemists conducting research within the unique culture of chemistry face additional challenges to locate, organize, evaluate, and use information (Brown et al. 2006; Currano and Roth 2014; Davis 2004; Laszlo 2013; Noble and Coughlin 1997). These additional challenges involve the emerging importance of patents, chemical data exchange practices, standard specifications, algorithm-driven search engines and expert systems, cheminformatics, bioinformatics, interdisciplinary data depositories and open databases. Therefore, chemists needing to remain current recognize that "… there is room for improvement in these passive, serendipitous discovery mechanisms" (Long and Schonfeld 2013, 23). The authors question whether struggling chemists are losing their information finding skills and what other forces are at play in an increasingly open data world where chemistry databases continue to remain "large and complex" (Baysinger 2016, 403).

This study attempts to investigate the information behaviors of chemists in their need to remain productive and informed and discover any obstacles they may face.

Methodology and data collection

Research design

This study presents original research designed to explore selected aspects of the information seeking behavior of practicing academic chemists. The study adopts a two-phased, mixed-method design to collect data on practicing chemists' information seeking behaviors, attitudes, and choices. The purpose of using this naturalistic design is to create a wealth of ethnographic data for analysis and interpretation. The first phase of the study involved collecting data on chemists' information seeking behaviors, attitudes, and choices using an online survey tool, FluidSurveys. The collected data includes chemists'

comments in response to ten multiple-choice questions. The second phase of the study, concluded shortly after the completion of the survey, involved focus group sessions at each institution. The purpose of focus groups was to initiate discussions based on preliminary survey findings, but also to help investigators explore in more depth how chemists keep on top of information and how they feel about these choices.

This study adopted a multi-site design by inviting chemists from four Canadian research-intensive universities to participate. The purpose of widening the scope to four institutions was to increase the number of potential participants and ultimately to help generalize findings of this study. The use of a two-phase research design was essential since the first phase would provide a summary of relevant and timely findings to be reviewed and discussed at follow-up focus group sessions. Transcribed focus session data from all groups were combined into a single database for analysis, reflection, and identification of emergent themes.

We will not attempt to theorize information experiences, test established grounded theory, prove or disprove current models or theories of information behavior, nor rigorously follow established and codified qualitative means of analysis. We have intentionally limited the scope of this study by not collecting data—or reflecting on participants' gender, length of service, time taken for information searching, size and nature of research teams, or scholarly productivity. When tasked with coding and interpreting focus group data we followed standard qualitative methods (Creswell and Poth 2018). Investigators were open to each other's qualitative style of inductive coding, use of descriptors, and identification of emergent themes. The overarching goal of this study was to collect relevant data in a simple and straightforward manner and collectively agreed upon at least three themes of interest to participants, investigators, and stakeholders.

We ultimately desired to hear and document the voices of practicing chemists and how they felt about their information seeking situations.

Having a collective experience of over seventy five years in academic libraries the investigators were well positioned to lead this investigation and, understand the unique culture of practicing chemists, facilitate focus group discussions, analyze, interpret, and identify emergent themes.

Participants

In some cases, potential participants were recruited with the assistance of chemistry department chairs who provided a list of departmental faculty, graduate students, postdoctoral fellows, and staff email addresses. In other cases, facilitated access to a departmental email listserv was available to investigators. Mass e-mailings and posting of email invitations to potential participants on email listservs included a link to the survey, proposed

deadlines, an invitation to participate in an upcoming focus group session, ethics approval, and contact information. Focus groups were limited to three to five participants who were selected from those who completed the survey. We attempted to create focus group sessions with an equal representation of faculty, graduate students, postdoctoral fellow, and staff.

Participants were informed of ethics-related guidelines and confidentiality of survey and focus group data. However, anonymity of focus group participants at each institution could not be guaranteed as individual focus group members may be known to each other.

Chemists participating in this study were affiliated with one of the following Canadian institutions: Brock University, University of Waterloo, University of Toronto, and Queen's University. Each participating institution's chemistry department was of varying size, but all departments included sufficient numbers of chemists at all positions. Chemists' at all four institutions were generally aligned with research teams, utilize similar library information and chemistry databases, and share common research areas and specialties.

Survey design and research questions

The survey asked participants to respond to three demographic and seven multiple-choice questions about their day-to-day practices tracking, documenting, and keeping up to date with news, patents, and scholarly information. Most survey questions provided opportunities to provide alternate or "other" responses in addition to personal comments.

Survey instrument questions documenting information seeking data include:

1. How successful are you in keeping up to date with chemistry news, patents and scholarly information in your field?

    (a) How do you keep up-to-date with general chemistry news in your field?
    (b) How do you keep up-to-date with chemistry scholarly information in your field?
    (c) Which databases do you most often use when searching the chemistry scholarly literature?

2. Which citation management system(s) do you use to capture scholarly information and track your research?

    (a) How do you keep up-to-date with patent information in your field? and
    (b) If you search for patents, which databases do you most often use?

Questions documenting demographic information asked chemists to identify their: (1) home institution, (2) position, choices being doctoral student, master's student, faculty, staff, postdoctoral fellow, and (3) field of study, choices being analytical/environmental, biological, inorganic/organometallic, materials/polymer, organic, physical, and theoretical/computational. Field of study categories were based upon common sub-disciplines or areas of chemistry at all four institutions, yet purposely excluded engineering-related fields of study.

Focus group design and research questions

Within two months of the closing of the survey questionnaire, focus group sessions occurred at each institution. Co-investigators facilitated a sixty-minute session at each institution in a space that accommodated voice recording. Focus group participants were shown aggregated survey data and asked a series of semi-structured and open-ended questions largely based on the investigators' interpretation of the preliminary survey data. The anonymized transcribed audio recordings were combined into a single database for further analysis and interpretation.

Five areas of the guided focus group conversations covered the following topics:

(1) Chemists keeping up-to-date with news and scholarly information.
(2) Most often used databases when searching the chemistry scholarly literature.
(3) Using patents, patent databases and patent information.
(4) Keeping current is difficult.
(5) Ways librarians and database producers can help support academic chemists do a better job of monitoring and managing information.

These areas of investigation resulted in focus group semi-structured questions:

a. Survey data suggests that most chemists are somewhat successful and use a variety of resources to keep up with chemistry news, patents and scholarly information. What is your experience?
b. Keeping up to date with chemical information, news and patents seems to be important. I want to make sure I understand, why is keeping up to date so important? Can you explain?
c. Survey data suggests that chemists were found to rely on different strategies to keep up to date with chemical information, news and patents.

i) How do chemists rely on colleagues and students?
ii) Participating in conferences and lectures seems important as well, why?
iii) Can you help explain why chemists don't rely more on online or automated services for this function?

d. Is it fair to say that patents, although essential documents in tracking research, are not critical to the academic community? Why do you think chemists feel this way?
e. Chemists ranked databases of choice from most to least used as SciFinder, Reaxys, Web of Science, etc. is this dependent upon individual chemists' position, length of experience, research area? Why is this so?
i) Why do you use the database(s) you use?
ii) Why do you feel this way?
iii) Can you give examples?

f. Survey data suggests that chemists use a variety of citation management system tools to capture scholarly information and track research, ideas and archive articles. Yet, a significant number of chemists don't use any such a system. Can someone help explain this?

Analysis

Using descriptive statistical analysis on the quantitative data, we compared the similarities and differences amongst the chemists' information-seeking behaviors, attitudes, and choices. We also did a thematic analysis of the qualitative data. FluidSurveys software tracks responses to multiple-choice questions providing aggregated numerical counts, percentages, basic statistical measures, and participants' comments. With it, benchmarking reports may be created to compare one set of survey question data to another. Benchmarking takes an independent variable and compares it to all survey responses. Although there is no statistical test involved, just descriptive data, benchmarking helps to determine trends that may point out significant differences. We benchmarked survey data related to chemists' institutions, position, and field of research, but most importantly, we benchmarked the survey's most poignant question: "How successful are you in keeping up to date?"

Focus group transcripts were analyzed using standard qualitative methods. Prior to analysis, transcripts were reviewed to detect, correct, and harmonize data that were then combined into a single database. Each investigator worked independently to code, create descriptors, and identify emergent themes based on thematic analysis of the qualitative data. We shared notes and reviewed supporting data to collectively select and report on themes.

Limitations of this means of analysis are acknowledged. However, the variability involved with four varying means of qualitative analysis is thought to be a strength of this study and bring validity and reliability to resulting themes.

Results and interpretation

Survey findings

The survey received 231 responses in April 2016 from an estimated potential target audience of 980 chemists. Participation rates at each of the four institutions ranged from 16.7 to 73.1 percent. Participation rates as a percentage of all participants ranged from 16.5 to 36.8 percent resulting in an overall survey response rate of 23.6 percent.

Chemists described by position were categorized as staff (6.1 percent), postdoctoral fellows (9.5 percent), master's students (24.7 percent), faculty (28.1 percent), and the largest group by percentage, doctoral students at (31.6 percent). Participants' self-identified area(s) of chemistry included: organic (26.1 percent), analytical/environmental (25.3 percent), inorganic/organometallic (21.2 percent), materials/polymer (20.4 percent), physical (19.9 percent), biological (18.1 percent), theoretical/computational (10.2 percent), and other (4.0 percent). Upon reviewing benchmark reports we agreed to limit the analysis and interpretation of survey findings to the survey question "How successful are you in keeping up to date with information in your field."

Survey participants self-described their success in keeping up to date with chemistry news, patents, and scholarly information in their fields (see Table 1). Although a majority (64.5 percent) of chemists believed that they were somewhat successful or successful in keeping up to date with information in their field, 35.5 percent indicated that they were not successful and could do better. When responses to this question were benchmarked against selective positions, 21.9 percent of faculty, 33.8 percent of doctoral, and 49.1 percent of master's students indicated that they were not successful in keeping up to date. Interestingly, a minority of chemists (3.8 percent master's students, 12.7 percent doctoral students, and 21.9 percent faculty) indicated that they were successful in keeping up with new developments in their field of study.

Selected faculty comments include: "But it never ends. One moment's lapse and you are behind the curve;" The "…amount of new information is overwhelming." Regarding patent searching, a faculty member stated "I do not really keep up with the patent literature." Another faculty member went on to recommend "…special courses [are] needed with pressure from a savvy librarian." Faculty successful in keeping on top of information resources indicated that they rely on a mixture of resources and databases, attended

Table 1. Success rate of chemists in keeping up to date with chemistry news, patents and scholarly information.

	Percentage survey responses faculty	Percentage survey responses doctoral students	Percentage survey responses masters students	Percentage of total participants
Not really successful, I could do better	21.9	33.8	49.1	35.5
Somewhat successful, I use a variety of resources	56.2	53.5	47.1	50.6
Successful, I believe I keep on top of new developments	21.9	12.7	3.8	13.9
Number of responses	64.0	71.0	53.0	100

Note: A total of 245 responses were received from 230 participants, percentages rounded to nearest tenth, 20 personal comments received, but not displayed.

conferences, presentations and used citation management systems to capture and track citations.

Selected comments from doctoral students illustrate the difficulty of keeping up with the literature: "I don't really keep up to date with news outside my field unless it's very big. I should as it could relate to my field in unexpected ways;" "There are just too many publications to keep on top of everything." Similarly, another student commented "I use resources like google scholar [sic] alerts, but do not feel that I get the complete picture."

Master's students believe that they were even less successful in keeping up to date, with 49.1 percent reporting they were not really successful, and could do better. This measure of not keeping up was 13.6 percent higher than the percentage reported for all chemists. Similarly, only 3.8 percent of master's students indicated that they were successful with keeping up to date, which was 10.1 percent lower than reported for all chemists.

Survey comments by Master's students included "I don't follow patents, and for myself, if I'm not keeping up with the literature, that's my failing, not the databases." Another graduate student commented, "I could benefit from more instruction on how to exploit search strategies to remain current with the literature in my classwork and as part of a research team." An interesting observation was that graduate students tended to gravitate towards Google Scholar as a way of searching for, and keeping up to date with the information and scholarly papers. It is uncertain why they do so. Do they, and presumably all chemists, use these search engines as a means to finding known research or as a quick search engine resource? Are they using Google products in lieu of chemistry-specific search engines and databases?

Chemists indicating they keep current with the literature, more often than not, participated in conferences and presentations, executing weekly or monthly search strategies, and using database alert services. They gravitated towards SciFinder as a first database of choice for browsing and searching,

and utilized a mixture of other types of databases when appropriate. These chemists were observed to be predominantly faculty and tended to work in organic and related areas of chemistry.

Survey participants kept up to date with chemistry news, patents, and scholarly information. Chemists self-identified a variety of strategies, resources, and services to stay on top of chemistry news, and scholarly information (see Table 2). Chemists keeping up to date with these areas primarily tended to use online databases and digital resources, but also browsed individual publications, as well as attended and participated in conferences and presentations.

Regarding resources used to keep up to date with news and information, one chemist said "[I use] journals in my field, Facebook, news feed posts from societies and journals, LinkedIn, ResearchGate, ConQuest, reddit, and word of mouth." Selected comments identifying "Other databases/sources" include trade magazines, SciFinder, journals, Google Scholar, PubMed, Web of Science and arXiv.org.

A majority (64.1 percent) of survey participants indicated they do not regularly search for patents. This observation together with an appreciable fewer number of responses to the survey question about patent information is an interesting finding. It is uncertain whether chemists by position or area of study just do not care, fail to appreciate, or simply allocate less time, energy, and importance of reviewing current patents and patent information. Another

Table 2. Resources consulted by chemists when keeping up to date with chemistry news, patents, and scholarly information.

	Percentage survey responses news information	Percentage survey responses patent information	Percentage survey responses scholarly information	Responses as a percentage of total responses
News magazines such as C&EN, Chemistry World, etc.	14.4	7.2	12.6	12.3
E-mail alerts, RSS feeds, table of contents services, etc.	17.0	5.5	17.2	14.9
Twitter	4.8	0.7	3.7	3.6
Blogs	2.4	0.3	1.6	1.7
Regular monthly or weekly database searches using keywords, authors, structures, etc.	15.8	9.7	19.2	16.1
I rely on colleagues and students to forward news of interest to me	19.4	4.8	20.0	16.9
Conferences, presentations, etc.	22.9	9.7	22.6	19.3
I use other databases/sources.	3.4	2.4	3.2	3.1
I don't regularly search for patents	na	64.1	na	na
Total number of responses	236	230	230	

Note: A total of 896 responses were received from 236 participants, included 44 comments, percentages rounded to nearest tenth, na is not applicable.

finding of interest to the investigators is the relatively low use of social media, e.g. blogs and Twitter, as a source of current research information.

Survey participants used a variety of databases to search for patents or patent information (see Table 3). As noted previously, a majority (64.1 percent) of responding chemists indicated they do not regularly search for patents. It is uncertain whether chemists routinely exclude patents as a document type, do not regularly use patent-exclusive databases, or simply pass over patents when browsing or reviewing database search results. Those that do use patents or patent databases used SciFinder (23.7 percent of respondents) most often. Selected responses to the question asking about other databases/sources include patent office databases, Organic Process Research & Development (ACS), Patent Lens, PatentScope, and FreePatentsOnline.

Survey participants used a variety of databases to search for scholarly information (see Table 4). Google Scholar was cited most often (61.0 percent of respondents) closely followed by SciFinder, Web of Science/Science Citation Database and Scopus. Selected responses to the question asking about other databases/sources include "my PhD students …," Pub.ACS, journal websites, ConQuest, Google, Feedly, Aggregate Table of Contents services, ScienceDirect, and ACS journals.

It is uncertain how responding chemists use the selected databases. They may be using some for exploratory searching and browsing. They may be using others for quick searching, validating information, identifying property data or reactions, creating structures, and searching for interdisciplinary research.

Table 3. Databases consulted by chemists when keeping up to date with patents and patent information.

	Survey responses	Percentage of total participants
Not applicable, I don't regularly search for patents	136	59.6
SciFinder	54	23.7
Google Patents	46	20.2
Reaxys	22	9.6
Espacenet	15	6.6
I use other databases/sources	2.0	0.9
Total	290	

Table 4. Databases consulted by chemists when keeping up to date with scholarly information.

	Survey responses	Percentage of total participants
Google Scholar	141	61.0
SciFinder	128	55.4
Web of Science/Scopus/Science Citation Database	127	55.0
Reaxys	55	23.8
PubMed (MEDLINE)	40	17.3
I use other databases/sources	14	6.1
arXiv.org	12	5.2
Total	517	

Survey participants used a variety of citation management systems to capture and track citations (see Table 5). Notably, 32.3 percent of survey respondents indicated that they do not use any of the listed databases. Of the listed databases, the most highly cited systems included EndNote, Mendeley, Papers and Zotero. Ten respondents used citation databases not listed in the question, captured in the category of "Other." Selected databases include Faculty of 1000, citation alerts from Google, BibTeX, and Google Scholar.

Focus group findings

The second phase of this study involved 14 chemists who participated in one of four small focus group sessions held at each institution in May or June 2016. Focus group participants, self-identified by position: one staff member, three graduate students, three postdoctoral fellows and seven tenured faculty. Transcription of audio recordings resulted in a database of 322 comments and approximately 15,260 words. Focus group session conversations were guided by a series of prepared semi-structured exploratory questions.

We were specifically interested to better understand why and how chemists make certain information seeking choices. Focus group facilitators moving through the five areas of investigation were well positioned to ask further probing questions: How do you as chemists make these choices? Why do chemists use one source more than another to keep up to date? What are the factors at play? How does this make you as chemists feel?

Emergent themes

Focus group data in combination with survey findings were reviewed, analyzed, and presented for group discussion. Three themes emerged from our data: (1) that chemists experience "too much information – not enough time," (2) chemists find that "patents are important—but messy," and (3)

Table 5. Citation management system used by chemists to capture and track scholarly information.

	Survey responses	Percentage of total participants
I don't use any of these databases for this purpose	74	32.3
EndNote	69	30.1
Mendeley	55	24.0
Papers	26	11.4
Zotero	21	9.2
Other	10	4.4
ACS ChemWorx	7	3.1
RefWorks	6	2.6
Total	268	100

chemists as researchers "could do better" in keeping up to date with new and emerging technologies.

Too much information—not enough time

Chemists' information seeking behaviors are as diverse as their individual areas of research. In attempting to stay current, chemists collectively commented that no single strategy worked. At times, there are too many choices, and this makes them feel inadequate and overwhelmed.

Chemists participating in focus group sessions stated they do not have as much time as they would like to keep current on the literature with a busy and demanding teaching, research and service schedule. They continue to use a multitude of information seeking resources, services, and databases to try to manage the information deluge. Chemists commented that the combination of too much information to review and not enough time to evaluate these resources is overwhelming. They continue to make choices on a regular basis as to which resource(s) they know best, provides the greatest reliability, and suits their individual needs. A focus group participant commented "This has become mission impossible given the amount of information out there, it's just not possible to keep up to date with everything, if you are keeping current in your research area you are doing well … we don't have time to do that [searching and analyzing the current literature] anymore." A colleague agreed with this sentiment stating "Time is definitely a big one. The more information and subsequently the more sources there are, the more time it takes to parse all that."

Survey results, as shown in Table 2, illustrate that chemists do not generally rely on a single information seeking strategy or behavior. Surprisingly, only 16.1 percent of chemists perform regular database searches, 14.9 percent use current awareness alerts, RSS feeds, or table of contents services, and less than five percent use social media services such as Twitter and blogs. Chemists clearly struggle with finding the right balance of resources and strategies in meeting their information needs.

A focus group participant commented on this lack of time and resulting choices "…. I think adding to the question about how you make these choices… not why but how you make… it's by attrition. Right? I used to read the journals and then I couldn't do it anymore because I just didn't have time. So, that fell by the wayside, not because I decided that it was a bad thing … I simply didn't have the time for it anymore… I felt guilty for a few years… but then it's not even worth feeling guilty about anymore." Another chemist commented "… it's that there are too many [choices]… I now get in my e-mail box every day invitations to about five conferences and about five journals and it's like 'screw you guys' and it's like 'delete, delete, delete' and

probably one of those in there is a legitimate conference invitation and I'm just deleting it. But the journals are just the same thing…"

Complexities are added to this information overload in the form of new interdisciplinary and multidisciplinary journals and new fields and sub-fields. It makes it difficult to choose where to look. A chemist commented "…. And there are new subfields coming out from traditional things. It makes it so that if you try to keep up with all that is going on, I just don't think you can do it. It's like a growing tree branches, literally branches out into things that makes it very difficult. Things are not clearly divided anymore, the lines are blurring … organic and biochemistry… all the materials science stuff, all of that stuff is becoming one big blur…organic bionanomaterials … that's a real thing."

Focus group participants clearly stated that they are coping as best as possible, but at times feel overwhelmed and inadequate in the choices they make in staying current in their field.

Patents are important—but messy

A second emergent theme is that chemists find that "patents are important – but messy." Michael White commented on the uniqueness and importance of patents in chemistry research when stating that "…patents are a window onto chemistry research that would not otherwise be visible" (White 2014, 56–57). Irrespective of recognizing the place and value of patents in general, chemists in this study were found to be largely suspicious about the value of patents as scholarly resources. They felt dismissive about incorporating patents into database search strategies or executing current awareness strategies. Chemists, for the most part, are not convinced that patents and patent databases are a priority.

Most focus group participants bluntly agreed that "I think that most chemists that I speak with don't trust patents in general … if you are just looking for information, the patent literature is not going to help you." Another chemist commented "I feel dismissive – I'm not convinced patents are a priority." Chemists further remarked that patents are too often notorious for having irreproducible results, are not so much scientific as legal documents, are not peer reviewed, can be painful to read, complex to follow, involve many claims, are difficult to track in interdisciplinary and emergent areas of chemistry, and seem to intentionally lack scientific accuracy and rigor. Most chemists simply do not trust patents.

Academic chemists believe patents are less scientific when compared to other forms of chemistry information. This may be because patents by their very purpose, language and intent makes searching and reading difficult when compared to the scholarly literature, attending conferences, connecting and discussing ideas with colleagues. This dismissive feeling was captured best by a focus group participant "[responding to a comment that chemists

and database providers push patents] …that's not true …. You know, in a sense, it should be because the latest developments are covered in patents, but because they're commercial in nature there's a distrust amongst academics of what exactly is going on in the real world. We publish things because we think it's going to be important to other scientists, whereas the patents are issued because people want to make money."

A chemist commented on the value of patents "I'm not sure chemists necessarily think that patents are not as important, in so much as chemists tend to look at the literature as a better, more easy to access source of information, or if they are not necessarily in areas that might have intellectual property that is worth patenting themselves, they may not be searching it. For me, we file (or suggest to the university) different patents, so we are constantly looking at the patent literature to make sure we are not infringing and that there is no prior art we need to worry about." Some chemists do regularly search for patents because they themselves do file patents and therefore are looking for prior art to avoid infringing on other patents.

A chemist taking an alternate view stated "… there is [sic] a lot of chemists that never really learned about patents… they don't know what is patentable and what's not." This chemist went on to say that understanding patents and what is patentable is "a skill that takes some learning and the average academic chemist has not had that learning … They may not realize that there might be useful information in the patent literature."

The chemists' survey and focus group comments indicated that patents are a contentious source of information. This is a significant area for further exploration in addressing and possibly challenging information seeking behaviors, attitudes, and clearly stated feelings about how patents could help chemists.

I could do better

A third theme is that chemists as researchers "could do better" in keeping up to date with new and emerging technologies. This attitude manifests itself by chemists being open to new tools/resources, acknowledging that they are too often not sure which choice is best, and as a result continue to struggle with feelings of frustration – especially outside their field. The survey found only 13.9 percent of chemists on average are successful, 35.5 percent indicated that they are not successful and could do better in keeping up with the literature. Chemists indicated that they utilize a variety of resources, databases, and strategies including browsing magazines, creating e-mail alert search profiles, regular database searches, connecting with colleagues, participating in conferences, and attending departmental presentations. Even though chemists may use one or more resources, a significant number fail to find the right combination or balance and as a result, they feel overwhelmed.

Chemists by nature are resourceful people who attempt to stay abreast of current technologies, ways of conducting research, and finding information whether in the lab, classroom, or when responding to a myriad of challenges. One chemistry librarian reflected on this characteristic that

> Faculty, far from being slow to adapt, are leading the way, continuing to direct their research groups' information-seeking in the new environment. While there is certainly two-way flow in the groups as faculty and graduate students learn from and teach each other in many informal ways, faculty resist depending on others for their information needs. The faculty's level of sophistication in seeking information should not be underestimated. They are creative, canny consumers and searchers (Flaxbart 2001).

Focus group participants commented that keeping up with information in their field can be challenging, but as a group, they expressed opinions that they were open to new tools that would help make them more successful. A focus group participant commented that they "Use multiple [strategies] … depending upon the goal of my search, whether I'm trying to follow what's going on out there, or if I have a specific goal." Another chemist, responding to a question on why chemists use one source more than another to keep up to date, commented "It's probably because it's what they're used to doing. I find people like me might use things like conferences … [but] I don't go to conferences anymore. I think that the younger guys are more likely to use Google."

Focus group participants echoed survey results in being flexible, willing to explore new resources and open to different choices. A chemist commented "Everyone has their own specific field of research. Chemists are generally up to date in this field. For example, if you are working in nucleic acid research, I know the journals for research and publishing, I'm up to date with these journals, also we have mobile apps, immediately we are getting information from all these journals … otherwise you are not up to date." Chemists continue to value traditional chemistry databases such as SciFinder and Reaxys, yet realize they need to be open to new research strategies, expand their horizons, figure out what works best, and feel comfortable to move outside their fields of expertise.

An example of practicing chemists being open to new resources is the surprising take up of Google tools. A focus group participant commented "… the advantage of Google Scholar … is that its algorithms for searching are so much broader in terms of the results." The participant went on to explain that sometimes you get search results you would not find in SciFinder or Web of Science because Google Scholar used either the more precise or the much less precise terminology. This participant "… always add[s] Google Scholar to my searches because while you have to dig a little bit deeper through the 300,000 pages of stuff…you sometimes find those journal articles that you've missed …" Another chemist commented, "Google Scholar's better than Web of Science

because it has more things that it searches like books … and the more obscure journals [that] are not in Web of Science." The chemist went on to say "if I want … my annual report say how many times I was cited last year or on my résumé or on a grant proposal, I always use the numbers from Google Scholar because they're larger than the numbers from Web of Science." Additionally, another colleague stated "And from Google Scholar you can find the very new paper. I mean the paper just accepted. But you can't find this kind of paper from Web of Science sometimes." Chemists wanting to be better informed of research in their areas continually make choices.

Being up to date, complete and current is an ambitious goal especially when academic chemists as scholars are constantly adjusting their research, teaching and service priorities—resulting from information overload. A chemist reflected this notion of seemingly always falling short of keeping up to date stated that "I feel ok for areas that I work in, I make sure I cover all these area, to keep updated with other areas is possible, but that is just not going to happen." Chemists recognize that they struggle to stay current with the literature, are constantly making choices, and feel incomplete especially outside of their area of expertise.

Discussion and conclusions

Through a process of conducting a survey and follow-up focus groups, talking with chemists, reading the literature, and reflecting as a group on these experiences, we observed that a significant number of chemists continue to be anxious about their ability to remain in control of their information needs. Although open to new tools and resources, many chemists fail to develop new information seeking behaviors to remain informed and grasp developments outside their narrow field of expertise. Additionally, most chemists also fail to see the value of chemical patent information and patents in general.

Academic librarians are well placed to address these information gaps when supporting research, scholarly and teaching enterprises. Additionally, librarians are well placed to address the need for implementing chemical information literacy standards into the syllabus (Currano 2016). In a recent review of a report on U.K. chemists' practices, Dupuis commented that librarians can help address information gaps "…in areas such as research data management, knowledge management, discovery services, research interest-based alert services … integrating the library into the chemistry curriculum, where librarians can very directly exploit these opportunities and have a crucial role in educating the next generation of chemists" (Dupuis 2013, pp. 260–261).

As science and chemistry librarians, we gained a better understanding of how chemists choose, evaluate, manage and feel about information resources

and came to view the study of chemists' information seeking behaviors and attitudes as an important aspect of chemistry research practice.

Future directions

In analyzing and synthesizing our results, several interesting questions for future or related studies presented themselves. One area is in gaining a deeper understanding of chemists' information seeking behaviors is to investigate how and why they use patent information; are there obstacles to patent use? Another area is seeking to understand why particular database(s) are selected, what search strategies are used, and how chemists felt about these experiences. Are there obstacles to use? In addition to this, chemists often search specialized databases for very specific information or data types such as structures, reactions, or chemical property information. How does this differentiate chemists' information seeking behavior from other scientists? Additionally, further studies may want to explore the merits of non-chemistry or interdisciplinary databases to chemistry research, including how much time they take to learn and use. Finally, it might be interesting to investigate the information seeking behaviors of novices in comparison to long-standing experts in chemistry, perhaps along sub disciplinary lines. Answers to any of these questions would help inform librarian practice and outreach to chemists and to those researchers in other disciplines that are collaborating with chemists.

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