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Is information-seeking behaviour of doctoral students changing? : a review of the literature (2010 – 2015)

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Keywords: information seeking; doctoral students; PhD students; information behaviours

Abstract

The advent of the Internet and networked communications in the last 15 years has arguably considerably changed the information behaviours of doctoral students, including the discovery process.

Information seeking includes initiating a search, constructing search strategies, locating and evaluating the identified sources. Current research on information-seeking behaviours is focusing on understanding how the Internet, social media and other technological and communication-based changes, including mobile technologies, have changed the way students seek information in order to understand the information behaviours of the students of tomorrow.

This paper offers a review of the literature on information-seeking behaviours, with a particular focus on recent years (2010-15). It aims to determine whether notable changes in the information-seeking behaviour of doctoral students have emerged in recent years.

The study shows that the information-seeking behaviours of doctoral students follow a steady trend, with some subtle changes, particularly in the (patchy) use of social media and networking sites. There appears to be more similarities than differences across disciplines in the information-seeking behaviours of doctoral students. Considerations to their information literacy skills are given to understand better the role supervisors and library staff can play to support the doctoral students population in the early stages of the research process.

1. Introduction

The advent of the Internet and networked communications in the last 15 years has arguably considerably changed the information behaviours of students.

Information behaviours are usually seen as the process by which individuals search, identify, access, evaluate, use and cite information sources. This field of study has traditionally been attracting an important volume of research; this is even more true today as Information and Communication Technologies (ICTs) seem to change at a fast pace and thus the need to understand how this is effecting the various facets of information behaviours and develop support services accordingly.

Information-seeking behaviours belong to this field of research. It focuses on the initial steps individuals, and particularly students, will take to identify sources

that may be relevant to their information need, i.e. the task at hand, be it an assignment or a research paper. Those steps include initiating a search, constructing search strategies, locating and evaluating the identified sources. Current research in information-seeking behaviours is focusing on understanding how the Internet, social media and other technological and communication-based changes, including mobile technologies, have changed the way students seek information. It helps uncover emergent information-seeking behaviours, and possibly anticipate the information behaviours of the students of tomorrow.

This paper is concerned with the information-seeking behaviours of a specific group of the student population, doctoral students, although consideration will also be given to researchers in general. It offers a review of the literature on information-seeking behaviours, with a particular focus on recent years (2010-15). It aims to determine whether notable changes in the information-seeking behaviour of doctoral students have emerged in recent years in light of ICT developments.

2. Background to the research

In the last 15 years, the pace of change in ICTs has been astounding. Not only were the technological changes happening in frequent waves, but also they profoundly shook up the academic publishing environment, and the way users interact with information sources. We witnessed a series of sizeable changes in the scholarly communication environment: the quick and massive take up of Google; the emergence of open access in early 2000s, given way to new publishing models (e.g. gold/green open access, mega-journals) and recent funder open access mandates (mostly for publications, but increasingly for data management too); the digital humanities; social medias and networking sites; mobile technologies; Web-scale library discovery services etc.

Loughborough University started a two-year review of doctoral students' experience of the Loughborough University Library (2015-16). The literature review of the information-seeking behaviours of doctoral students we propose in this paper informed directly the review. The review of literature presented here consisted in desk-based research, using keyword searches on academic databases (ERIC, LISA, LISTA, ASSIA), library-subscribed e-journals and open access material. The focus of the research is specifically on information-seeking behaviours; we do not intend to examine use, reading or citation practices. Those are important, adjacent but distinct fields of study within information behaviour research.

2.1. The doctoral students population

As the focus is on doctoral students, it is safe to assume that most of them would belong to the Generation Y, also called the Millennials. Generation Y is the large demographic cohort born between 1980s and 2000s. The post-1993 end of the cohort shares similar characteristics with the Google Generation phenomena, as they do overlap, to the point that some authors do include the post-1993 students in the Google Generation - Rowlands et al. (2008), for instance. Back in 2001, Prensky (2001) proposed the digital natives/immigrants typology to map out individuals' engagement with the Web, typology now revisited by White and

Le Cornu (2011) as digital visitors/residents. Today's doctoral students, which would primarily constitute the very end of the Generation Y cohort, are regarded as digital natives: they grew up with the technology more or less in the form we know it today. According to Bolton et al. (2013), the key characteristic of this generation, who was exposed early and frequently to technology, is often found in the motto 'want it all, want it now'. Such attitude, say the authors, is reflected in all segments of life, be it personal or professional. Rowlands et al. (2008) claim that the Google Generation is characterised by the fact that Internet and Web search engines are the primary gateways to knowledge of this generation. Doctoral students are a relatively small but nevertheless very important subset of the student population. They reflect the research quality and capacity of an institution. Doctoral students form an interesting group to study in that they share characteristics with both the larger group commonly referred to as 'graduate students', which groups Master and PhD students together, and the group of researchers (including post-doctoral fellows). The complexity of deciphering the information behaviours of doctoral students probably lies in the fact that they seem to have one foot in each camp. This ambiguity is reflected in the literature: some studies explore the information behaviour of doctoral students as part of the graduate student group; other studies look at doctoral students, post-docs and faculty together. Both groups will be presented in this study in order to gauge the full spectrum of information-seeking behaviours pertaining to doctoral students.

A detailed review of the literature on the information-seeking behaviours of graduate students, based on empirical research conducted between 1997 and 2011, is given in Catalano (2013). The aim of this paper is to augment Catalano's review of literature - although we do not follow the meta-synthesis methodology - and provide an update of the literature from 2010 onwards. Catalano's review of literature covered the 1997-2011 period, with a peak in articles dealing with this specific topic between 2007 and 2010. It is therefore timely to revisit the literature in information-seeking behaviours of doctoral students, with a particular focus on more recent years. Although we did not restrict our research to empirical articles, it is interesting to note that the studies we retrieved were mostly small case studies at a given institution. Only a very few large-scale studies were identified - this may have implications on the ability to isolate trends. As part of the update, social media and networking sites will be included as there are signs that they are being used by doctoral students and researchers in general.

2.2 Sources of information that matter to researchers

Without going too much into scholarly communication(s) and the sources of information that are essential to researchers to conduct their research, we need however to say a few words on the materials researchers use in their research to understand better their information-seeking behaviours. There is a substantial body of literature investigating the information behaviours of scholars. The numerous Tenopir and King's studies have contributed substantially to the body of knowledge in this area. Research looking at information behaviours and academic reading preferences have shown the centrality of academic journals in the research process and scholarly communication (Tenopir et al. 2009; King et al. 2009; Tenopir et al. 2012; Fry et al. 2009; RIN 2007; Nicholas et al. 2010).

Indeed, in Nicholas et al. (2010)'s study, surveying 1,400 researchers across 6 subjects at 9 institutions, the authors reported that 90% of researchers rate peer-reviewed journals as 'very important'. The same study shows that over one-third in all subjects consult journals 'every working day' - except historians who reported 'most days', while in life sciences the percentage rises to 50% of researchers consulting journals every working day. Based on the findings from their longitudinal cohort study of 17,000 doctoral students (a large proportion of them belonging to Generation Y) across 70+ higher education universities, Carpenter et al. (2012) question whether the observed clear dominance of academic journals as primary source of research information in the information landscape of doctoral students means that doctoral research is moving away from primary sources compared with just a decade ago - although there are arguably some differences in use of primary resources inherent to the nature of the discipline.

Thus, the literature converges to report that academic journals are central to the research process, although other outlets - maybe more discipline-specific ones - follow closely. Indeed, Niu et al. (2010) found that researchers identify research information primarily through academic journals, but also through Web pages and personal communications with their peers. It is worth noting that their large-scale US study covered 50 departments across natural sciences, engineering and medical sciences; this may go some way to explain why Web pages and personal communications figure highly amongst the sources of information reported by the researchers in their study. Overall, journal articles represent the most frequently used source of information by faculty (Tenopir et al. 2015a). Indeed, the authors found that faculty read just over 20 journal articles every month, spend on average 32 minutes per article, and 74.3% of faculty actually knew about the information the article contained before reading it, for instance through citations in other articles. More articles tend to be read in sciences, particularly in medical or life sciences (Fry et al. 2009; Tenopir et al. 2015a).

In the digital information environment, convenience is found to be a major determinant in students' information-seeking behaviours, which explains the popularity of Google and Wikipedia as information sources, particularly when students were unfamiliar with the topic researched (Connaway et al. 2013). Google and Wikipedia are seen as a good starting point in that respect, and it is not unusual for students (although not specifically PhD students) to stop their search after the first few sites listed on Google (Connaway et al. 2013) or no further than the first page of hit list. Books, on the other hand, figure highly in the research process of researchers in arts and humanities, with 75% of researchers in those disciplines finding them 'very useful' while the percentage are smaller for social sciences (55%), physical sciences (47%), life sciences (34%) (RIN 2007). The differences between disciplines are even more acute for archives and special collections (RIN 2007).

The following sections will report on how doctoral students search for information, where they start, whether they use Web 2.0 and social and networking sites in their information search, and how they evaluate the information they find. In addition to this, the paper also includes a section on doctoral mentoring which, along with the other findings, may help librarians

understand better the context in which doctoral students evolve at the start of the research process.

3. Searching for information

With the ubiquity and pervasive use of networked communications and the Internet in the academic and social life of doctoral students, it is important to understand how this is affecting information behaviour patterns, and particularly information-seeking behaviours. This means exploring issues such as where doctoral students start their search, why they chose to take those initial steps and how they follow through from there.

3.1. Where do they start, and why?

The issue we are concerned with here is to understand the process by which doctoral students begin their search and arrive to information sources relevant to their research, as well as the factors influencing those processes. While Niu and Hemminger (2012) claim that academic positions are the most influential determinant of information-seeking patterns, there are strong indications in the literature that *overall* researchers have clear preferences for starting their information search on the Internet or through the library homepage interface (Niu et al. 2010; Carpenter et al. 2012). The variety of material retrieved and the variety of functions available make Web search engines a particularly convenient tool for anyone starting a search (Jamali and Asadi 2010). In their US study (2,063 researchers across 50 departments at 5 research universities), Niu et al. (2010) found that library resources were ranked equal to Web searching in researchers' preferred search tools (50%-50%, respectively). With 40% of respondents in Niu et al.'s study being between 20-30 years of age, it is likely that it comprises a large proportion of doctoral students, and we may therefore assume that the findings are likely to be true for doctoral students too. In comparison, the proportion of US college students using search engines to begin an information search rises to 89%, while only 2% of them will start their search on a library gateway (De Rosa et al. 2006). Three reasons are put forward by the authors of this OCLC study to explain such a massive use of Web search engines by college students: firstly, college students are massively satisfied with their overall information search experience via Web searches (93%); secondly, this way of searching fits their lifestyle; thirdly, libraries are still associated with the physical place and the printed book (De Rosa et al. 2006), although the latter point may no longer be true today as students' perceptions of their (digital) library may have evolved since the publication of the OCLC's report in 2006. Doctoral students' inclination to begin their search on the Internet is not new, however. It was already evidenced as a sustained trend in Catalano (2013)'s review of literature. However, what the recent literature shows is that this trend is now established and recognised. Reports of students' marked preference for electronic sources are plentiful in the literature. For students, convenience and user-friendly interfaces are definitely seen as a significant advantage of Web search engines and similar tools, which make them more attractive than library gateways (Wu and Chen 2012). The open nature of Web search and the freedom it confers are definitely attractive to students and researchers. Back in 2006, Fry (2006) already noted the fact that Web searches offered unprecedented

opportunities for researchers to bypass traditional gatekeepers (e.g. libraries or publishers), particularly when it comes to accessing information; for instance, the information is identified via a library resource but is then located and accessed via Google. In their study of the information behaviours of the researchers of tomorrow, Rowlands et al. (2008) noted that students did not find library-supported resources intuitive (more time was actually spent navigating digital libraries than viewing material), unlike search engines such as Yahoo! and Google, which were, at the time of the study, the top two brands students associated with the Internet. The authors added that, although there was not a great deal of evidence of a generational shift in information searching, Google Generation students were, however, singular in that they sought, and were content with, tools that required the most basic searching skills (Rowlands et al. 2008). This echoes findings in Wu and Chen (2014) who argue that graduate students use both the Internet, Google Scholar in particular, and library resources; but they tend to favour the usability of Google Scholar while valuing the quality of materials retrieved from library databases.

Previous research showed that scholars tend not to start their information search from the library portal but elsewhere (Calhoun 2009; Gardner and Inger, 2012; Inger and Gardner, 2013), leading to claims that they are increasingly using predominantly Web search engines for information discovery. Nonetheless, despite common assumptions of students' overuse of Web search engines, library resources, such as the library homepage interface, A-Z journal/database lists or catalogue, are still very much in use. Naturally, when it comes to library resources, there is, however, a marked preference for electronic and full-text offerings (RIN 2007; Nicholas et al. 2010). This observation is also true, to a great extent, for faculty, who tend to identify and access material electronically. Tenopir et al. (2015a) reports that, in their faculty behaviour survey at five US universities, 76% of scholarly materials read were obtained electronically, and a vast majority of the resources obtained through library gateways were from electronic resources (e.g. e-journals, full-text databases etc.).

Niu et al. (2010) argue that the fact that the use of library interfaces figures so highly in researchers' information-seeking strategies may be explained by libraries' effort across the world in recent years to implement metasearch tools, making it easier for users to search across different platforms and resources, as well as a more general effort to support Google-like search tools featuring natural language searching. Those efforts to integrate meta-searching and Google-like search boxes in a user-friendly platform are embodied in the growing use of Web-scale discovery services in higher education libraries (Spezi et al. 2015). As pointed out by Niu et al. (2010), seeing library interfaces figuring neck to neck with Web searching in the top ranked searching tools is of notable importance, not the least because it provides strong evidence that academic searching is not only done through Web search engines, as commonly suggested in the literature. Niu et al. (2010)'s study is a large-scale study and may point to robust evidence for sustained levels of use of library services. While scholars use a variety of sources to identify material, Tenopir et al (2012) found in their UK

study (2, 117 respondents) that they primarily use and read electronic articles that they have found through the library gateway. Nevertheless, other - smaller - studies point to a more nuanced story. For instance, in their small Finnish case study, Gu and Widén-Wulff (2011) report lower levels of use with most researchers using library services on a weekly or monthly basis. The apparent difficulty in finding online books and e-journals in the library collections appears to be a major deterrent to library use, in this study. One needs, however, to bear in mind that those results need to be understood in a context where students and faculty do not always know whether they are locating articles via the library or the open Web, owing to libraries' incredible efforts to provide seamless access to electronic resources.

3.2. From initial search to constructing search strategies

There is good evidence in the literature that, overall, doctoral students' self-reported perceptions of their own capabilities indicate that they are satisfied with their own information-seeking skills (Bøyum and Aabø 2015, Fleming-May and Yuro 2009; Carpenter 2012), although when looked at closely their practice seems to be telling a different story altogether. Search strategies are by definition an iteration process. Use of keywords and Boolean, truncation or proximity operators are examples of common search techniques. However, there is an indication that doctoral students may have difficulty constructing elaborate search strategies. Catalano (2013) reports that beyond the cognitive aspects of formulating a proper search strategy, the following three elements are usually found in the literature to explain graduate students' difficulty to retrieve information sources:

- Lack of time is often called for hastening the termination of a search, regardless of whether the information retrieved may be of lower quality or questionable reliability – this is often referred to 'satisficing', and
- Lack of time for reading library-prepared instructions for database searching or developing more complex search strategies, and
- Overconfidence in one's ability to formulate a search and retrieve information may result in frustration during the information-searching process, thus hampering the overall process.

In their study of graduate students at a Greek university, Korobili et al. (2011) found that new users (38.7%) used different keywords but did not use any Boolean, truncation or proximity operators; average users (45.1%) used phrases, date range but did not use proximity or truncation operators; finally, expert users (12.3%) used all the components of a successful search strategy, and had criteria they applied to gauge relevance. Overall, the authors graded students' information-searching skills as low to medium across all disciplines, without any notable disciplinary effect at play. Graduate students' own perception of their ability to develop search strategies may differ, however. In comparison with undergraduate students, graduate students often find themselves more skilled at developing a search strategy: for instance, they tend to think they are better at narrowing down their search than undergraduates and they make more use of the range of library resources (Fleming-May and Yuro 2009). They also understand better the snowball effect in literature searching, whereby one single

source of information may open a number of search avenues through the information available in the list of references it contains (Fleming-May and Yuro 2009). Despite all this, Bøyum and Aabø (2015) found that doctoral students still lack a systematic approach to information searching. This later point is not helped by the fact that the way researchers search and browse for information has shifted from linear reading to power browsing, the latter characterised by 'bouncing', 'flicking', 'skim reading' and 'super quick evaluation of hit lists' (Nicholas et al. 2010). It is also found that researchers tend to satisfy themselves with 'good enough' information-searching strategies: they tend to use strategies they are familiar with and that have worked in the past, and yielded some useable results (RIN 2007). One recurring point across studies looking at the information-seeking behaviours of the Google Generation is its inability to develop effective search strategies, which may explain to some extent their preference for Google-like search boxes which function with natural language queries (Rowlands et al. 2008).

3.3. Disciplinary similarities and differences

Teasing out the differences and similarities in information-seeking behaviours across disciplines is a complex task, not the least because the existing material to base the investigation on varies greatly in nature and format: for instance, the sciences seem to attract larger investigative studies while other disciplines are often explored with the local case study instrument, which by nature is often smaller in scale. It is therefore extremely difficult to compare findings like-for-like, and the reader needs to bear that in mind. Furthermore, there is the additional issue, discussed for instance in Fry et al. (2015) and Jamali and Nicholas (2008), of interpreting findings at the meta-discipline level when there is evidence that sub-disciplines may potentially exhibit different behaviours than the parent discipline they are commonly affiliated to.

The complexity of reviewing the literature on information-seeking behaviours through a disciplinary analysis lens is flagrant in Catalano (2013). The identification of clearly defined disciplinary differences, similarities or consistent behaviours in the literature of doctoral students' information-seeking behaviours is arguably a difficult task. There exist many small case studies providing insights into the information-seeking behaviours of researchers in some disciplines, but this does not mean that there are necessarily obvious trends that can be easily isolated. If anything, the most obvious similarity across disciplines is the preference to access electronic materials.

With regard to searching, it is reported in Catalano (2013) that doctoral students in the social sciences make more use of library resources than in other disciplines, to the exception of business and economics graduate students who seem to favour Internet resources. Bøyum and Aabø (2015) have, however, found in their small case study at the Norwegian Business School that this is not necessarily true. Indeed, the authors found that doctoral students reported using both library resources and Google Scholar, but found library databases more useful for their research. In particular, the author found that databases such as Business Source Complete or the union catalogue of Norwegian university libraries (BIBSYS) were the most valuable resources, followed by Web of science – which was ranked equal to Google Scholar. In a small-scale US case study, education graduate students reported using Internet search engines as much as

library databases, but expressed some confusion and anxiety over the use of library resources despite attending library instruction (Blummer 2012). They however indicated that the reputation of the journal was a determinant factor influencing the use of the articles identified during their search, whatever platform they had been retrieved from.

Understandably, arts and humanities researchers seem to value print-based resources more than their peers in other disciplines (RIN 2007); they also seem to find print-based finding aids more useful, although this may be down to factors inherent to their discipline (e.g. more time dedicated to searching; greater development of searching skills) (RIN 2007). Use of digital-based findings aids is, in contrast, high across all disciplines, according to the same RIN (2007) study, with, again, arts and humanities researchers valuing a lot more the online library catalogue and other cross-institutional catalogues than the average scientist in the other disciplines studied. By contrast, science researchers clearly favour citation databases more than social science and arts and humanities researchers. A 2011 report for the Research Information Network (Bulger et al. 2011) may however shed a different light onto the humanities. The authors claim that the discipline is changing, and traditional attributes ascribed to humanities scholars, such as isolated work in scattered networks or heavy use of physical libraries, archives and special collections, may not reflect the current reality. The digital humanities have undeniably transformed the discipline and today's researchers make the most of the opportunities it creates. As a result, and in conjunction with new funding opportunities, humanities scholars are developing new information and working practices, including the creation of more formal and systematic research collaborations, according to Bulger et al. (2011). Looking more closely at humanities doctoral students, Madden (2014) claim that the information-seeking needs of humanities PhD students are particularly varied and the challenges in the first year of their doctoral studies include defining and scoping their research topic, knowing which library resources are relevant to their research, making the best use possible of the technology, etc.

Wu and Chen (2014) found that science and technology graduate students were more likely to use Google Scholar than their peers in humanities and social sciences; but humanities students were more likely to search by author name, title or keywords than in any other disciplines. Furthermore, the authors found that some graduate students were actually deeply uncomfortable with advanced searches, for fear of missing out on important material owing to the lower number of materials retrieved. Graduate students reported browsing between 1 and 3 pages when searching via Google Scholar in Wu and Chen (2014)'s study. Comprehensiveness is indeed found to be a major influencer in students' perceived usefulness of Google Scholar, according to a US study (using a Technology Acceptance Model) conducted at the University of Minnesota with 1,141 graduate students (Cothran 2011). Using the deep log analysis, Nicholas et al (2009) found that life science researchers are the biggest users of e-journals, ranked open access journals higher than other disciplines but often conducted their article browsing and search via discipline-specific gateways such as PubMed. In comparison, economists appeared to make more use of abstracts than full texts and historians proved to be more active searchers than their peers in other disciplines.

Back in 2006, Jamali and Nicholas (2006) reported that doctoral students in physics and astronomy heavily relied on electronic journals, used libraries very little (if only through journal subscriptions) and, of particular interest here, suggested that doctoral students in theoretical physics and astronomy had different information-seeking patterns than their counterparts in applied physics and astronomy. This is particularly true when it comes to keeping up-to-date with developments in the field or searching for information; the subfields of those two disciplines tended to rely on different methods (Jamali and Nicholas 2010). For instance, in a small case study, Haines et al. (2010) found that basic science researchers have singular practices when it comes to searching for information: they do not generally make use of traditional library services – maybe to the exception of interlibrary loans; instead, they heavily rely on a close-knit network of peers who often act as information sources.

The heterogeneous aspect of physical sciences as a broad discipline is emphasised in Meyer et al. (2011) who found that despite the discipline overall showing greater acceptance and use of novel digital tools and methods to work with information and data than other disciplines, the study of the practice of the sub-disciplines reveals different levels of acceptance and use. In other words, despite harnessing information technologies to their research process, the set of tools used by researchers in the sub-disciplines varies greatly. According to Meyer et al. (2011), only Google retains high level of use as information sources across all sub-disciplines for the purpose of searching new information. Google Scholar, on the other hand, attracts uneven levels of use: researchers in earth science and nanoscience report using Google Scholar while in particle physics and gamma-ray burst astrophysics it is very little used (Meyer et al. 2011). Similarly, chemistry, earth science and nuclear physics rely heavily on browsing e-journals, while particle physics researchers indicate a strong preference for preprints, because they feel they cannot afford to wait for the publication to be published in a journal as their field of research is moving fast (Meyer et al. 2011). There is also an indication that the more specialised and self-contained the sub-discipline, the more specialised the search tools, and conversely the more interdisciplinary the sub-field of research (or the more scattered the literature), the more general the search tools and methods (Jamali and Nicholas 2010). Mathematicians share similarities in their information-seeking behaviours with the physical sciences in that they make little use of library services but rely heavily on the Internet to find journals and books, and this information behaviour pattern has remained constant over the last 15 years, according to Sapa et al. (2014). One specificity of mathematicians' information behaviour pattern is that they often list their publications (with links to the full text) on their personal webpages; it is therefore very common for this group of scientists, according to Sapa et al. (2014,) to use Google and browse personal webpages to find the latest publications from fellow scientists rather than starting their search with abstracting services - although they (researchers more than students) do use discipline-specific portals like MathSciNet in the later stages of their information search.

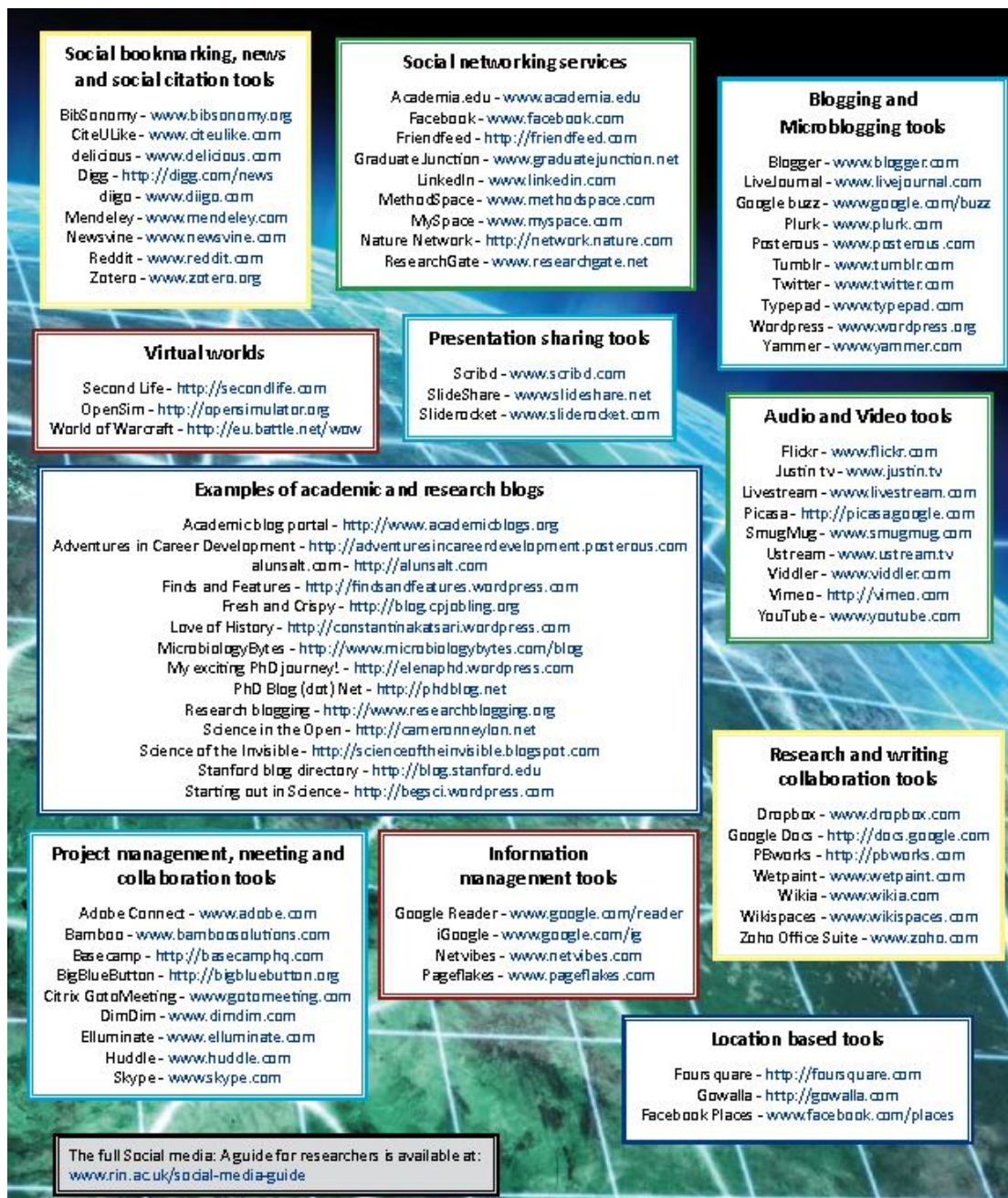
Overall, disciplines seem to share more similarities than differences in terms of information practice. They all appreciate the convenience and speed of access enabled by the digital information environment. The differences are probably more noticeable when one looks at a more granular level, possibly at the sub-

discipline level in order to incorporate the influence and characteristics of the digital information environment for a given sub-discipline, i.e. the scholarly communications that take place in a specialised field of research, as well as the disciplinary culture that makes up the fabric of the discipline.

4. Web 2.0, social media and networking sites

Back in 2008, Rowlands et al. (2008) explained that the digital transition was characterised by the fact that students and researchers had become information consumers, and as such they tended to switch from commercial Web search engines, social networking sites or library-supplied electronic services, making it incredibly more difficult for academic libraries who now had to compete for users' attention through personalised content, improved user experience etc. At the time of the study, the authors could not see a clear impact of the use of social networking sites in the discovery of information. Although they suspected that there was a potential for social networking sites to fill the gap left by the dis-intermediation of the academic information environment, there were no clear findings showing that this was actually happening (Rowlands et al. 2008). In the space of a few years, things seem to have started to evolve. According to Bolton et al. (2013), today's cohort of doctoral students tends to be avid users of social media and other Web 2.0 tools, both in the marketplace and the workplace. With Web 2.0 tools, social media and networking sites becoming prevalent and ubiquitous in every day's life, it is important to understand how those are permeating doctoral life. Figure 1, prepared by the Research Information Network (Cann et al. 2011), provides an excellent illustration of how social media and networking sites can align onto the research lifecycle. Rowlands et al. (2011) observed that Web 2.0 tools and applications can now be anchored to any points in the research lifecycle and the most popular tools and applications are for now those dealing with collaborative authoring and communication channels (e.g. conferencing or scheduling meetings). This is echoed in Nández and Borrego (2013) who found that three-quarters of their survey respondents used all sorts of Web 2.0 tools and applications. For instance, 75% used citation indexes such as Google Scholar, CiteSeer or getCITED; 75% used Web 2.0 tools helping with document creation and sharing (e.g. Google docs or Dropbox); another 74% used Web 2.0-based communication tools such as Skype or Google talk; 68% used reference management software (RefWorks, Mendeley, EndNote etc.); another 65% used time management software (e.g. Google calendar, Doodle); 59% used social networks (e.g. Facebook, LinkedIn etc.). Those are only a few examples of how Web 2.0 tools and applications can be associated to any phase of the research cycle. Interestingly, social media sites such as Mendeley can also be used to better understand readership levels. For instance, Mohammadi et al. (2015) argue that Mendeley may be substituted to existing citation-based indicators which have shown limited reliability in some disciplines, e.g. social science, arts and humanities.

Figure 1: Social media in the research process



Source: © Research Information Network, 'Social Media: A guide for researchers', 2011

Given that the majority of doctoral students are reported to work on their own rather than in research teams (Carpenter et al. 2012), the increasing availability of social media (e.g. #phdchat hashtag on Twitter) and networking sites (e.g. Mendeley or ResearchGate) may have benefited doctoral students in that they have facilitated the creation of those much needed social and professional support networks. In their 'Social Media: a guide for researchers' report for the Research Information Network, Cann et al. (2011) conducted a series of case studies on the integration of social media in the research practices of faculty and doctoral students. The study reveals that social media and networking sites are mainly used to discover materials and keeping up-to-date with developments in a field (new publications, news about research communities etc.). The authors claim that social media and networking sites have undeniably an important role to play in:

- lessening the feeling of information overload that is commonly reported by researchers – effective filtering out through the use of social media;
- managing information more effectively – Mendeley is an example of access, storage and reading tool; ‘delicious’ is another example of bookmarking tools; and
- enhancing researchers’ research capacity altogether by enabling them to use their time more efficiently – although the authors note that researchers need to be aware of where the trade-off between getting an information and the time spent on Web 2.0 sites is.

More precisely, research conducted by CIBER (cited in Cruz and Jamias 2013) showed that researchers use social media at all stages in their research workflow, but particularly for:

1. identification of research opportunities
2. identification of potential collaboration with peers outside their immediate network
3. securing research funding support
4. review of literature
5. collection of research data
6. analysis of research data
7. dissemination of findings
8. management of the research process

4.1. Rate of adoption of Web 2.0 technologies

While Generation Y is often referred to as “*competent and ubiquitous users of information technologies*” (Carpenter et al. 2012, p.6), it becomes apparent that this does not necessarily permeate their research processes across all levels: surprisingly, Generation Y students are not necessarily early adopters of new technologies, applications and tools. On the contrary, they tend to exhibit traditional and conservative work practices and adopt new applications only if they can be riveted easily to current working practices and processes (Carpenter et al. 2012). In their survey of 1,477 UK researchers (of whom 27% of PhD students), Procter et al. (2010b) reports that take-up levels are still low and frequent and intensive use of Web 2.0 services is atypical, with only 13% of the researchers surveyed using such tools once a week or more. At best, researchers use occasionally one or more Web 2.0 applications for their research (45% of respondents), while 39% do not use them at all. This echoes the findings from a Finnish study which found that faculty members and doctoral students were using social media and networking/sharing sites more in their everyday life than for teaching or research purposes (Gu and Widén-Wulff 2011).

A trend has however been emerging in the last few years. For instance, Mendeley and Twitter are becoming increasingly well integrated in researchers’ workflows and processes. Mendeley seems to be particularly useful for reviewing the literature, along with wikis, Google Docs or Academia (Cruz and Jamias 2013). Other studies - for instance, Coppock and Davis (2013) – argue however that social media do not bring anything more to the discovery of research information as this function is already well performed by existing commercial

platforms and associated tools. Costas et al. (2015) reports that Mendeley is particularly present in the social sciences while Twitter has a broader and more varied base: social sciences, psychology and medicine have a particularly high density of tweets per publication, according to the authors. The singularity of Mendeley rests upon its collaborative feature, e.g. information sharing or creation of groups with similar interests, and this collaborative aspect of Mendeley is said to be directly in line with emerging research practices, according to MacMillan (2012). By contrast, Costas et al. (2015) report that social media are not as much used in humanities, natural sciences and engineering, although other studies points to a different direction (particularly for engineering in Mohammadi et al. 2015, for instance). Interestingly, it is in the multidisciplinary sciences that social media metrics are the highest: the authors explain that the fact that blogs and other social media cover and comment on new publications released in journals such as Nature or science may explain the multidisciplinary effect (Costas et al. 2015).

Despite the centrality of the academic journal (and other publication outlets such as conference proceedings or books, depending on the discipline), social media are increasingly reported to be used as complementary channel for the dissemination and discovery of research (Rowlands et al. 2011). Today's information environment is without precedent in terms of the volume of digital information available to researchers. As reported earlier, researchers still place great value on traditional and reputable publishing outlets; at the same time, they also want to expand their information horizon through the myriad of new information sources and information channels available to them via Web 2.0, social media and networking sites (Procter et al. 2010a), with some notable disciplinary differences, however.

Other reasons for using social media and networking tools include learning about research communities beyond one's personal and professional, as reported by Procter et al. (2010a), and keeping up-to-date with new information. Niu et al (2010) found that over one third of researchers (36%) use alerting services, with the most popular services being PubMed, Nature, Science Direct, ISIS, eTOC or Faculty of 1000. However, alerting services can also be source of information overload, particularly with more junior researchers who may find it more difficult to distinguish between relevant and irrelevant information. In their case study of 18 graduate students, Wu and Chen (2012) found that students were generally not keen on alerting services because those services were pushing forward too much irrelevant information.

4.2. Factors shaping adoption or rejection

Web 2.0, social media and networking sites are permeating all stages of the research life cycle and it is essential to understand the factors that encourage or discourage adoption of those communication channels. One reason for such low levels of take up may be found in the costs, e.g. time effort, critical mass, disruptive aspect of social media etc., outweighing the perceived.

There is still, however, a limited understanding of the factors shaping the use (or non-use) of Web 2.0 tools and services; however, the factors shaping adoption of Web 2.0 tools can generally be grouped in two main categories: 1) collaboration (including support network, skill development), and 2) new forms of scholarly communication (including open science and new forms of peer-review),

according to Procter et al. (2010b). Collaboration – as in getting in touch with other researchers - is also presented as a major determinant (67% of respondents) in the use of social networking sites such as Academic.edu by Nández and Borrego (2013), along with dissemination one's research outputs (61%) and following the research of peers in the field (59%). Procter et al. (2010a) report that frequent users of Web 2.0 services particularly appreciate those services when it comes to finding information in a new research area, i.e. in the early stages of the research. Web 2.0 services are regarded as an useful tool to scan wide areas of unfamiliar literature (particularly when it comes to filter out the vast amount of irrelevant information), as well as getting to know the research communities that work in those research domains; the scanning of the literature and the getting-to-know the research environment and communities are similar to what is reported in the literature about the information behaviours of doctoral students in the early stages of their doctoral studies.

4.3. User demographics

Back in the early days of electronic communications, Covi (2000) claimed that doctoral students that belonged to the Nintendo generation (roughly post-1980) only adopted new electronic communication practices if they reinforced existing research practices, thus demystifying the myth of the Nintendo generation. Likewise, the users of Web 2.0 applications and services are not necessarily those you would expect to be, thus defying commonly accepted stereotypes, according to Procter et al. (2010a). The authors found that high usage of Web 2.0 applications and services was positively associated with researchers from the older age groups and in more senior positions. In contrast, in their survey of 2,000 researchers, Rowlands et al. (2011) found that social media use could not be linked to a specific age group, their findings showing that age a 'poor predictor' of social media use.

Moreover, Procter et al. (2010a) identified a gender bias in the use of Web 2.0 services and applications, with two-thirds of frequent users being men. They also identified a possible discipline effect, noting that researchers in medical and veterinary sciences were less likely to use Web 2.0 tools than those in computer science, for example. By contrast, Thelwall and Kousha (2014) claim that the literature shows that there exists a faculty and female advantage in the use of social networking sites. Looking at Academia.edu, the authors definitely found a female effect in some disciplines, but not in philosophy, law and computer science. The authors also reported a faculty effect, in that Academia.edu received more staff profile views than student views. In a large study (over 1,200 researchers) exploring Catalan researchers' behaviours on Academia.edu, Nández and Borrego (2013) found that the majority of profiles were from faculty (over 50%); doctoral students accounted for just under a third of the profiles (29%); and only 6% for post-docs. Almost half of the profiles of those Catalan researchers were from the social sciences; the rest of survey respondents were split between arts and humanities (22%), exact and natural sciences (12%), engineering (11%), and health sciences (4%). The authors found that 61% of the researchers studied were less than 40 years of age. The large proportion of PhD profiles (one third of the total population studied) is in line with previous studies, in particular Procter et al. (2010b) which found that there exists an age

group effect in the use of Web 2.0 or social networking sites: more junior researchers tend to be more active on social networks while their more senior peers are more likely to use other Web 2.0 tools, i.e. not specifically social networking sites. Likewise, in the case of Mendeley, doctoral students, postgraduate students and post-docs primarily form the user base of the site (Mohammadi et al. 2015), at least in social sciences, physics, chemistry, engineering and technology, which were the disciplines surveyed; thus confirming the good fit between this application and the emerging research practices reported earlier.

There is an indication that overall researchers do not regard those Web 2.0 tools as particularly important, although some variations can be found at the discipline level (Procter et al. 2010a). Differences can indeed be found in the 'occasional users' groups, whereby researchers in the humanities, social sciences and natural sciences tend to use generic resources such as Google Scholar or Facebook while researchers in medicine/veterinary sciences and biological sciences, would rather use discipline-specific Web 2.0 tools such as PubMed (61% and 59%, respectively) (Procter et al. 2010b). Furthermore, although physical sciences researchers are often presented as leading the way in terms of adopting new forms of communications or novel methods, Meyer et al. (2011) claim that researchers in that broad disciplinary group are not necessarily the prime users of Web 2.0 services and tools. The authors argue that face-to-face interactions in physical sciences (e.g. conferences or symposia) remain an important aspect contributing to the research process, and in particular getting as a source of new research information. On the other hand, mathematics students report more use of social networking sites to identify information sources than mathematics researchers, thus indicating a possible shift of the information-seeking paradigm in the discipline (Sapa et al. 2014).

5. Decision making with relevance and use

In their exploration of the information behaviours of researchers of tomorrow, the so-called generation Y students, Carpenter et al. (2012) identified that accessing relevant information sources was students' second biggest constraint (after time constraint). There again, Generation Y students expressed a strong preference for e-journals and reported that they would contentedly use the abstract if they could not access the full text of a journal article (Carpenter et al. 2012). The issue of how often students are not able to access the full-text materials they have identified for their research is not clearly discussed in the literature and satisfaction levels vary greatly. For instance, in their small-scale study of graduate students' use of electronic resources at a research university in Taiwan, Wu and Chen (2012) report that satisfaction levels vary between 70% and 95%.

Perhaps most telling is the fact that Generation Y students' reliance on Web search engines or library interfaces (Carpenter et al. 2012; Niu et al. 2010) tends to render them oblivious of the wider publishing environment, such as publisher name, publication title etc., which also adds confusion to the existing and widespread lack of understanding of new publishing models such as open access (Carpenter et al. 2012; Fry et al 2009 ; Tenopir 2015b). One may wonder whether students' anxiety to find (enough) material influences their judgement

about relevance and use at the expense of quality, as embodied in journal reputation, for instance. Furthermore, previous studies had already claimed, with regard to Web search engines searches in particular, that students from the Google generation did not spend enough time reading the information they had retrieved (at best, just a quick glance – they are said to be ‘viewers’ more than ‘readers’), and therefore had trouble evaluating the information, which resulted in downloading or printing off most of what they had retrieved without being sure that the material was relevant to their needs – a behaviour the authors referred to as ‘squirelling behaviour’ whereby the content is stored for later use (Rowlands et al. 2008). The same authors claimed that wide-spread access to technology had definitely not helped improve students’ information literacy skills (Rowlands et al. 2008); they may master the technology and retrieve a significant volume of information, it does not mean they can assess properly that information – in cases, it may also lead directly to information overload owing to the lack of analytical skills in filtering out what is relevant. Interestingly, Korobili (2011)’s small-scale study of graduate students’s information behaviours shows that students are more often satisfied with the relevance of the information when the information is retrieved via Web search engines (43%) than via library-supported electronic journals or databases (23%). Looking at the information skills of mathematics students and researchers, Sapa et al. (2014) found that although both groups use Google a lot – they particularly like the varied and quick response they get – students did not evaluate the information retrieved based on author name, affiliation, journal and publisher, like researchers commonly do in that discipline. Indeed, the traditional evaluation criteria for trustworthiness and quality are said to encompass all disciplines and age groups (Tenopir et al. 2015b). The authors found that peer review is the most important criteria, followed by content soundness and journal reputation or ranking. For researchers, content remains the determinant factor in decision making about relevance, and as reported in Tenopir et al. (2015, p.12), *“availability does not trump content when looking at trustworthiness of information source”*. There remain some concerns that doctoral students have not yet reached that level of understanding about what criteria should come first in their decision making process.

With regard to the evaluation of the information retrieved via user-generated content website such as blogs or wikis, researchers’ opinions are clearly divided, with the non-users justifying their choice by claiming that those platforms are untrustworthy and so searching for information on there is simply a waste of time; but, overall, wikis and blogs attract the lowest use and are perceived as less important than other user-generated platforms (Procter et al. 2010a). In Gu and Widén-Wulff (2011)’s small case study, only 6.3% of faculty and doctoral students reported finding Web 2.0 information sources reliable and trustworthy – concerns included copyrights and means to assess quality. This echoes Tenopir et al. (2015b)’s claim that researchers still did not fully trust social media and open access sources. The more users use those Web 2.0 services the better they may get at assessing this type of information, according to Kim et al. (2013). In their survey of undergraduate and graduate students, the authors found that frequent users of social media for academic purposes were reported to assess the information obtained through social media more than those who used it less frequently.

6. Supporting doctoral students in their information seeking

The academic lifecycle of doctoral students and researchers tends to follow some general patterns that can be identified through research trails. Looking at the case of matter physicists, Horlings and Gurney (2013) have identified a certain number of strategic positioning along the academic lifecycle. With regard to PhD students, the authors argue that, contrary to more senior researchers who work on multiple well-defined research areas, doctoral students often conduct research in one single research area, although that research domain may evolve and change substantially during the course of their doctoral studies, and have no connections to the multiple research areas they may work in later on in their professional career. Furthermore, Horlings and Gurney (2013) describe the research environment in condensed matter physics as a very hierarchical environment with tasks generally assigned according to the seniority: for example, the authors reports that professors are often regarded as the ones who lead on multiple research domains, providing the research framework and leadership while doctoral students are the primary researchers doing the day-to-day project work and postdocs gravitate around the two groups and other communities of peers in search of new directions and niches, and opportunities for collaboration and network building.

Of importance here is also the fact that doctoral students rarely choose their own doctoral research topic (Horlings and Gurney 2013) and are often inhibited by their lack of confidence in their research work (Carpenter et al. 2012); this may have significant implications in doctoral students' engagement and information-seeking behaviours in the first stages of their doctoral studies. This is echoed in Madden (2014) who reported that most students in the humanities had changed their research topic in the first months of their doctoral studies, thus making the information-seeking process even more challenging. Not only their research topic is evolving in the first year but they also need to identify the range of resources that may become useful to their research. For instance, 35% of doctoral students in Madden (2014)'s study were not aware of the resources they will use later on in their doctoral research. Supervisors and fellow doctoral students appear to play an important supportive role in overcoming the feeling of being overwhelmed by the task at hand in the early stages of doctoral studies.

6.1 Doctoral mentoring

The relationships doctoral students establish with their supervisors are arguably paramount to the success of their doctoral journey. Supervisors have an undeniable influence on doctoral students' success and completion rate (Fleming-May and Yuro 2009). It is, however, unclear whether doctoral students consult their own supervisor or other faculty members to seek help and guidance on conducting research information searches, particularly where or how to start (Catalano 2013; Larivière et al. 2013). Catalano's review (2013) suggests this is relatively common for doctoral students to do so, although the review also acknowledges that other studies points in the opposite direction. For instance, Jamali and Nicholas (2006) found that doctoral students tend to use word of mouth more than more senior researchers. On the other hand, Sloan and McPhee (2013) suggest that the physical and social structure of an academic department, as well as the overall structure of the campus, may influence the relationships doctoral students develop with their fellow doctoral students,

faculty and librarians. The authors found that graduate students were more likely to seek assistance from faculty or their supervisor for information about their research, while for any other type of information (like more general questions) they would consult their fellow graduate students; looking specifically at doctoral students within this group, it was found that they were less likely to seek assistance from both fellow students, faculty and librarians. Furthermore, Liao et al. (2007) suggest that international graduate students may be able to develop tighter and greater bond with faculty in their department than their fellow students.

While some studies claim that supervisors often presuppose that their students do not require any forms of training in this area, other studies shed a different light (Larivière et al. 2013). Recent research into the role of supervisors in doctoral students' acquisition of information literacy skills presents a very complex picture of supervisors' views on their mentoring role and students' expectations (RIN 2011). The authors' findings echo in part Catalano's claim that students do seek assistance and guidance from their supervisors. This renews the emphasis on the crucial role of supervisors in the development of students' skills and knowledge. Supervisors do generally accept this role as part of their duty towards their students; only a small fraction of supervisors do not seem to engage fully with this - only 5% to 15% of doctoral students feel their supervisors is not providing enough support and guidance (RIN 2011). The major issue pointed out in the RIN (2011) report lies in the fact that supervisors' support is not consistent across all elements of information literacy, e.g. from information search to critical analysis to reference management to ethics to reference management to publication etc. In fact, only a quarter of supervisors (n=382) feel 'very' or 'fairly' confident in their ability to help their students across all aspects of information literacy, according to RIN research (2011), leaving room for either the thorny issue of supervisor training or support coming from elsewhere, librarians for instance.

There also seem to be a gap between the role supervisors think they should have in students' learning of the research process and the actual skills students possess when they embark on their first year of doctoral studies. Indeed, Fleming-May and Yuro (2009) argue that supervisors provide very little support to doctoral students in helping them acquire the rudiments and basics required to start their information search journey at doctoral level. The authors claim that supervisors often assume that any newly-registered doctoral student already possesses the relevant information skills; on the other hand, students find it difficult to ask for assistance for fear of showing important gaps in their skills and knowledge and potentially risk losing their supervisors' trust and interest. Bøyum and Aabø (2015) add to this that doctoral students do not always feel faculty members – and sometimes even their own supervisors - can help, owing to the degree of specialization in their field of research; nor do they feel comfortable disturbing them by asking questions. Fleming-May and Yuro (2009) also found, in their US study, that the lack of confidence in asking assistance from faculty members was exacerbated for international doctoral students: they were even more reluctant to seek faculty assistance than their American fellows. Looking more closely at disciplines, Bøyum and Aabø (2015) reported that the literature showed that interactions with peers seemed to be greater in the sciences – particularly, doctoral students in sciences appeared more dependent

on recommendations from faculty and others - while at the same time other research showed that the smaller the disciplines the more its researchers depended on recommendations from others. The two claims are not necessarily irreconcilable if one thinks of the sciences as a series of very small, self-contained and specialised sub-disciplines.

6.2. Is there a role for librarians?

With regard to seeking help from a librarian, Catalano (2013)'s review reports an interesting point: distance learning doctoral students are likely to consult a librarian, while other doctoral students tend to avoid asking librarians for help. Malliari et al. (2013) found in their study at a Greek University that, overall, 11% of postgraduate students regarded 'consulting a librarian' as a common practice when starting a search; in practice, it appeared that 38% of the postgraduate respondents had actually never sought help from a librarian and only 25% had asked for help in the last six months of the period studied. Barriers that refrain doctoral students from asking help from librarians are manifold and varied. Sloan and McPhee (2013) refers to the need for instant help, uncertainty about what can be asked or late working hours. Chen and Brown (2012), on the other hand, identifies a series of reasons for which international students, and in particular Chinese students, may not want to seek help from a librarian. Those included a perceived ease of use of Web search engines (easier than library portals), a lack of critical evaluation of items retrieved, language abilities (students often think their reading skills are better than their speaking or listening skills), and cultural barriers. The latter, the authors claim, is particularly true in the case of Chinese students for whom asking for help can be perceived as a sign of weakness in their native culture. Lack of confidence in international students' own speaking skills and cultural barriers are also found in Liao et al. (2007), although the authors claim that this is becoming less of a problem.

In her review of literature, Catalano (2013) reported that consultation with librarians or peers (i.e. other students, not faculty) was ranked in third place by graduate students, after Web searching and consultation with supervisors or faculty members. In their case study of 18 graduate students at a research-intensive university in Taiwan, Wu and Chen (2012) reported that in general library courses were valued by graduate students; however, those same students indicated that by the time they come to use the library resources for their research project, they tended to have forgotten everything they had learnt. The authors also reported that science and technology students tend to learn from their peers, most likely in laboratories, whereas humanities and social sciences students are more likely to learn on their own (i.e. self-taught). In Blummer (2012)'s case study, most education graduate students reported limited comfort with the use of library resources, despite having attended library instruction programmes. This very last point on the (in-)effectiveness of library instruction programmes seems to be present throughout the literature without being articulated clearly. Why is it happening? The important issue of the timing of library interventions during the course of doctoral studies is certainly a major factor influencing success: understanding the information-seeking behaviours during the doctoral research lifecycle may help librarians time their interventions better. According to Madden (2014), who surveyed 1st year

humanities PhD students, it is in the first months of doctoral studies that information literacy instruction -including current awareness, information management, ethics or publication - should generally take place as it fits the information search process of the majority of students. However, the author emphasises the need for flexibility in the delivery as not all doctoral students go through the different stages of the doctoral research process at the same pace. For some, the initial stages, when they get to know an area of research and select a topic, may take some time and iterations before they can move on to the next 'exploration' stage where they can make full use of information literacy instruction.

Information literacy has become one of the cornerstones of librarians' activities, probably even more today than before owing to the critical need to be able to search the vast mass of digital resources available today, and evaluate it properly. The literature abounds of reports that a majority of today's students, including doctoral students, regard themselves as expert users in Web searching and proficient users of library-supported resources (Malliari et al. 2013). Paradoxically, the literature also emphasises students' struggle with searching library resources, particularly when it comes to developing efficient search strategies, as we reported earlier in the paper. Two points stand out in this respect: firstly, there is undeniably a need to constantly raise students' awareness of the services and resources their library offers (Catalano 2013); secondly, it is essential to focus on the development of sophisticated and effective search strategies (Malliari et al. 2013) for a great variety of search tools, including non-library-supported tools.

7. Discussion and conclusions

The literature review shows that the information-seeking behaviours of doctoral students follow a steady trend, with no major break-ups in recent years, but rather some subtle changes, particularly in the use of social media. Convenience, intuitive and user-friendly interface and full-text retrievals are the major selling points of Web searches for students and researchers, although there are definite signs that library e-resources, after a period of disenchantment, are definitely back on the radar and potent enough to compete for attention and rival Web searches. With regard to Web searches, high levels of use of Google are reported across disciplines, whereas use of Google Scholar appears more uneven, although the reasons for this difference are not properly discussed in the literature reviewed. The literature also shows that there seems to be a gap between doctoral students' own perceptions of their abilities to search for information effectively and their practice, with doctoral students often over-rating their ability to construct effective search strategies. The nature of the disciplines can affect doctoral students' information-seeking practices to a certain extent, but may not be the only influencer. There appears to be more similarities than differences across disciplines in the information-seeking behaviours of doctoral students. If anything, the humanities have probably witnessed the greatest changes in recent years, most likely as a consequence of the development of the digital humanities and transformative approach to research in the discipline, affecting the overall information behaviours of humanities scholars at large.

With regard to Web 2.0 applications, social media and networking sites, the picture is still very unclear. There is however an indication that those applications can be brought in to the doctoral research process if they can be easily riveted to current practices; but doctoral students are not necessarily the primary users, which may go against commonly accepted stereotypes for the current generation of doctoral students. Overall, scholars' information-seeking behaviours have not massively changed over the period considered, despite claims that Web 2.0 technologies, social media and networking sites have become ubiquitous in scholars' research workflow. If anything, those new technologies seem to have permeated other stages of the research lifecycle (e.g. collaboration, dissemination or researchers' profile); but for what concerns information seeking, change in behaviour, if any, is taking place at a relatively slow pace. Of importance to the information-seeking domain is the slowly growing use of Twitter and reference manager applications such as Mendeley by doctoral students, although levels of use remain patchy across the doctoral population and no definite trends can be clearly identified so far. Both applications seem to be found particularly useful in scanning the literature when the topic (often new to the information seeker) casts a wide net. There is an indication that Web 2.0 applications and social and networking sites may however be more used at a later stage in the research process (for instance, research management, collaboration, dissemination etc.).

The literature review highlighted the fact that one of the difficulties in studying the information-seeking behaviour of doctoral students lies in the fact that they represent a very heterogeneous group, sharing characteristics with both other students and researchers. Only a handful of studies actually looked at the sole group of doctoral students. Most of the studies reported here were looking at doctoral students as part of either the graduate students group or the researchers group. This is tell-tale to a certain extent of the difficulty to harness specific information-seeking behaviours inherent to this segment of the information-seekers population. The common mistake is to see them as a well-defined group, but, as Barrett (2005) suggested, it would be more accurate to regard this group as a 'unique series of stages'. It is therefore of primary importance to regard the doctoral research journey as a series of intermediate stages students go through, e.g. selection of topic, exploration etc. This is very much in line with Kuhlthau's six stages of the information search process (summarised in Kuhlthau 2008) which bring together feelings with thoughts and activities that take place during the search process.

When it comes to relevance and use, the information literacy skills of doctoral students may lack depth, particularly in relation to Web search results.

Traditional criteria for trustworthiness and quality, such as content soundness, author name, affiliation or journal title, are very little used for Web results, while views on social media and open access are divided.

The aforementioned findings have important implications on the way doctoral staff and librarians can best support the doctoral students population. For instance, the literature highlights an important disparity of attitudes from supervisors towards doctoral mentoring, which can only exacerbate the existing difficulties doctoral students are faced with when beginning their research project. Furthermore, there is an undeniable need for library support along all stages of the doctoral research process, and a greater understanding of the

doctoral research lifecycle can only help librarians and other support services understand better what doctoral students go through at a certain point in time in their studies, and provide a better understanding of what the optimal zones of interventions for libraries are. However, one needs to be aware that one size cannot fit all because all doctoral students do not start their studies with the same level of information literacy skills and knowledge, their progress on the doctoral study road may take place at different pace, and finally their 'way of doing things' may be the result of the culture inherent to their discipline. All those factors influence doctoral students' ability to benefit fully from library instruction programmes. It is therefore important to look into tailoring library instruction programmes as much as possible so that it fits the culture of their discipline and understand why some students actually fail to benefit from those programmes. Is it a timing issue? Is it because students are brought to use tools they are not comfortable with? Is it necessarily a bad thing to incorporate Google and Google Scholar into standard library instructions so that students who are already using those tools can actually get better results from them? Looking back at the information-seeking behaviours of doctoral students the key points for librarians is to be cognisant of the different stages that form the research process in order to try and time their interventions at different points along that journey.

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