The role of historical and contextual knowledge in enterprise search

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Published in:
Journal of Documentation

DOI (link to publication from Publisher):
10.1108/JD-08-2021-0170

Publication date:
2022

Document Version
Accepted author manuscript, peer reviewed version

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Purpose – The purpose of the study is to examine enterprise searching practices across different work areas and work tasks in an enterprise search system in an international biotechnology company.

Design/methodology/approach – A mixed-method approach studying employees' authentic search activities during a 4-months period by log data, questionnaire survey, and interviews. The log data analysed the entire active searcher group, whereas the questionnaire and interviews focused on frequent searchers.

Findings – The three studies provided insight into the searching activities and an understanding of the way searchers used the enterprise search system to search for information as part of their work tasks. The data identified three searcher groups, each with specific search characteristics. Four work task types were identified, and for all four types the searchers applied a tracing searching technique with use of contextual and historical relationships as paths.

Practical implications – The findings point to the importance of knowledge on historical and contextual relations in enterprise search.

Originality/value – The work sheds new light on enterprise searchers' information search practices. A significant contribution is the identification of a tracing search method used in relation to four essential work task types. Another contribution is the importance of historical and contextual knowledge to support the tracing search and decide what paths to follow.

Keywords - Enterprise search, Workplace searchers, Information practice, Search techniques

Paper type - Research paper

Introduction

Enterprise search refers to managed search environments in the workplace that allows federated search and makes content from multiple sources, such as intranets, document management systems, e-mail, and social media, searchable to a defined audience within an organization (Kruschwitz and Hull, 2017). Related research is found under terminologies such as "workplace search systems" (Freund *et al*., 2005, p. 441) and "enterprise document search" (Schymik *et al*., 2015, p. 1049). Common feature to all is that enterprise search uses search technologies to facilitate information retrieval, sharing and re-use of organizational information supporting development, decision-making, and the creation of new knowledge. Structured as well as unstructured data are searchable.

Many enterprise searchers express a low degree of satisfaction with the enterprise search due to contextual and technical factors (Stocker *et al*., 2015; Freund, 2015; Stenmark *et al*., 2015; Cleverley and Burnett, 2019a). Several researchers report a widespread sentiment among workplace searchers that enterprise search does not deliver on its promises (Phillips *et al*., 2019). Even if it is difficult to exactly determine the amount of time spent on looking for information, most people intuitively acknowledge it as a time-consuming task. Knowledge workers spend a lot of time to find information of which as much as 10 to 20 percent is spent on unsuccessful search (Schymik *et al*., 2015). In addition to time losses, time-consuming searching for relatively simple work tasks also causes negative feelings, i.e., frustration (Borlund *et al*., 2012).

Cleverley and Burnett (2019b) found that a major part of user dissatisfaction depends on other than technological factors and highlight the need to learn more about socio-cognitive aspects. The existing studies tend only to cover specific occupations (i.e., Du *et al*., 2013; Freund, 2015), specific issues such as barriers (Stocker *et al*., 2015), or specific types of information systems (Stenmark, 2010; Joseph *et al*., 2013). The aim of this exploratory study is to examine authentic enterprise searching across different organizational work areas. We conducted three separate studies of employees' search activities in an operational system: log data analysis, questionnaire survey, and interviews. The purpose was to extend our knowledge about enterprise search and provide insights for development of enterprise information systems.

The first research question addressed the background of the enterprise searchers:

RQ1. What characterizes the enterprise searchers as regard organizational affiliation, search topics, and search frequency?

The next three research questions focused on the most frequent searchers:

RQ2. What work tasks prompt the frequent searchers' enterprise search?

RQ3. What searching techniques do the frequent enterprise searchers use in their searching?

RQ4. What challenges do the frequent enterprise searchers meet, and how do they deal with them?

Previous research

Although people have used the internet for information searching for both private and work-related purposes, and some practices are transferable to enterprise search, there are also many essential differences (Jansen and Pooch, 2001). Fagin *et al*., 2003, p.366) found that "the determination of a "good answer" for intranet search is quite different than on the Internet". Similarly, there are differences between professional and nonprofessional searchers at

workplaces. Surveys on professional enterprise searchers reveal that they appreciate Boolean operators to formulate precise search queries (Joho *et al*., 2010; Russell-Rose *et al*., 2018). Contrarily, the nonprofessional searchers seldom utilize formal search logic (Stenmark, 2010). This paper focuses on nonprofessional searchers who search for information as a supporting activity in work tasks rather than as a core activity of the task. In the following sections we will review what we know about nonprofessional enterprise searchers' practices.

Work tasks

Work roles and associated work tasks are important contextual factors shaping how people seek information (Byström and Järvelin, 1995; Vakkari, 2005; Ingwersen and Järvelin, 2005). While most workplace studies have focused on how work tasks shape information-seeking behaviour, only few empirical studies have studied how different work tasks affect a user's interactions with information systems.

In an evaluation study on an operational news archive of a newspaper, Blomgren et al. (2004) found that the system performed "better" in user perspective than in system perspective. The study setting was authentic in the sense that professional journalists carried out one simulated work task and one real work task in their everyday work setting. The journalists seemed to actively compensate for the system's low performance through their expertise on the content and their experiences of the system. Their findings show that the system was an important source of background material for the journalists in their daily work, whereas people sources were considered the most useful.

In a study of marketing professionals Du *et al*. (2013) analysed 101 work tasks that demanded information seeking. They developed a taxonomy consisting of eleven concrete work tasks reflecting the specific work setting. The study further showed how the marketing professionals' information seeking behaviour and relevance criteria were contingent upon the different work tasks. The work tasks prompted specific searches and triggered a purposive information seeking behaviour.

In a study of software engineers' source selection Freund (2015) similarly identified a set of work task categories that were closely related to the work environment. She further identified five information tasks that may arise during the information seeking. The use of people as information sources was an accepted practice supported institutionally through conference calls, team databases, and listservs. The use of colleagues as sources is costly, in terms of social capital and revenue for the organisation, and the choice of channel was associated with the existence of personal relationships, an awareness of people's expertise, and trust. The paper concluded that support tools could be developed for novice nonprofessional searchers.

Searching activities and techniques

Stenmark (2010) found that nonprofessional searchers used navigation on an intranet, rather than the enterprise search engine, despite the fact that they may be heavy users of search engines in the public internet. His finding supports the results of Teevan *et al*. (2004) who found that keywords were used only seldom, even for looking up a known item, and that employees preferred to locate the information by moving stepwise and relying on their knowledge of context. One reason for preferring navigation strategies over searching may be that the nonprofessional searchers do not trust the enterprise search engines, whereas browsing folder structures allows more control over the contents (e.g. Stocker *et al*., 2015, p. 483).

Joseph *et al*. (2013) identified three main search techniques: metadata search, search from shortcuts, or navigation by classification schemes. The searchers used their contextual work task related knowledge and the nature of the search task to choose a search strategy. Key reasons for search difficulty were that the sought information: was not meaningfully titled; had inadequate or inaccurate metadata; was classified into folders users would not consider searching; was not accessible by them; and/or was not registered into the system and therefore did not exist in the system. Li *et al*. (2019) found that complexity, familiarity, and goal were the most important task attributes that directly shaped the information seeking of strategic planners.

Already in the 1960s studies introduced a colleague as a best source for answering any type of questions arising at work (Allen, 1969). A review by Hertzum (2014) confirmed the importance of people as information sources, in particular for more complex tasks. Employees search for documents to find people, for people to get documents, and interact socially to get information without engaging in explicit searches. They do so to obtain information in effective ways.

Challenges in searching

Cleverley *et al*. (2017) found that search success varied heavily among the experienced nonprofessional searchers. The best performing participants in their controlled experiment retrieved 75 percent of the highly relevant items, others were not able to find any, with an average of 27 percent of retrieved highly relevant items. Further, they found a tendency for many participants to overestimate their search expertise. Cleverley and Burnett (2019a) concluded that inadequate search literacy and "Google Habitus" lead to unrealistic expectations causing major hindrances to carry out successful searches in work settings.

Later, Cleverley and Burnett (2019b) found that whereas the technological issues such as ranking, syntax handling, and reliability of search tools and systems, were the single most often referred factor of dissatisfaction (38%), the information factors, i.e. completeness of items, accuracy of best bets, and semantics handling were nearly as frequent (36%), with literacy issues i.e. challenges in selecting query terms and channels, as the third frequently referred factor (26%). Moreover, of all complaints studied, 55% were made after one single search with no reformulations, indicating that the searchers were lacking skills to search. The findings made the

authors conclude that there is a need to increase search literacy. For some search queries, enterprise searchers will simply need to be more search literate, aware, persistent, and creative when using enterprise search tools.

Stocker *et al*.'s (2015) identified barriers that nonprofessional enterprise searchers have to overcome when using enterprise search to find project-relevant documents. The identified barriers related to keyword selection, query formulation, availability and adequacy of metadata, relevance judging, search strategies, and overall perception of enterprise search. Freund (2015) identified six types of barriers from a study of software engineers: awareness of information, findability of information, abundance of information available, level of cooperation between experts sharing information, permissions with respect to access-controlled information, and amount of time available to seek and use information.

Stenmark *et al*. (2015) investigated whether findability and satisfaction are affected by the way organisations are governing enterprise search. Their study showed that employees in large organisations have a harder time finding the information needed and tend to be less satisfied with search tools than employees in smaller organisations. Further, the study indicated that having an outlined enterprise search strategy has a positive influence on the perceived level of satisfaction. White (2015) introduced twelve critical factors for enterprise search. He highlighted a clear understanding of user needs and integrating the search tool into information management strategy as the most important factors for success. Failure is rarely a result of poor technology. Problems are related primarily to content quality and to an inadequate level of skilled support for the application.

Search frequency

In a study of software engineers Freund *et al*. (2005) estimated that technical professionals spend about 25% of their time at work on searching. Allard *et al*. (2009) made observations of engineers in six high-tech companies and found that the time spent for activities involved in the search for knowledge ranged from 18.4% to 42.2 % of the observed time, with an average of 25.6% of the time observed. Stenmark (2010) reported that around 30-35% of the employees searched the corporate intranet daily. Stocker *et al*. (2015) found that the searchers in a R&D organization on average used between 10 - 30 minutes per day to search.

To sum up, there has only been little research about enterprise search practices in authentic workplace environments and only a few studies reported findings specifically about enterprise search systems (e.g., Stenmark, 2010; Cleverley and Burnett, 2019a). Earlier research most often distinguished between intranet and internet searching and between professional and nonprofessional searchers. Additionally, previous research has focused on a sample or specific group of searchers and do not provide insight into the entire user group (e.g., Blomgren *et al*., 2004; Freund and Toms, 2005; 2005; Allard, 2009; Freund, 2015; Stocker et al., 2015).

Search success has varied among searchers, and a large set of barriers related to searching have been identified as personal, contextual as well as technical (e.g., Stocker et al., 2015; Freund, 2015; Cleverley and Burnett, 2019b). Many searchers seem to overestimate their search expertise (Cleverley and Burnett, 2019ab). Problems are rarely technological but related to content quality and inadequate level of support for the enterprise search application (White, 2015). Contextual factors, specifically work and information tasks, and personal factors influence the way people search, and facilitating diversity in search by either recommender systems or instructions may be a key factor in enterprise searching. The present study seeks to extend our knowledge about enterprise search practice based on an authentic study of an entire group of workplace searchers with focus on the relationship between work tasks, searching techniques and challenges in the searching.

Conceptual framework

Methodologically we approach the research topic from a task-based conceptual framework where an information search task is seen as a part of information seeking task that further is placed in a context of work task, and where connections to both individual attributes as well as workplace practices are acknowledged at all task levels. In this framework tasks are central; it is their – or to them fixed – characteristics that are under study. In line with Byström and Järvelin (1995), Byström and Hansen (2005) and Byström and Kumpulainen (2020), we see all tasks to consist of the phases of initiation, actual performance, and conclusion, and that all three phases may lead to a need to look for information. This indicates that any work task can include multiple information needs that lead to consulting of several information sources, which are required to be collated to complete the work task itself.

Information search task concentrates on a consultation episode, in which one or several sources are used simultaneously. Traditionally this has consisted of querying an information retrieval system that access data from one or more databases, including iterations and loops in the process (e.g., Marchionini, 1995). However, similar mechanisms are adequate when posing a question to a person or stating it to several persons simultaneously. When the information looked for in the information search tasks are different, but thematically connected to each other, they form an information seeking task. The difference between the two is in their scope; the information searching task narrows down to consulting one source, whereas the information seeking tasks comprises a broader set of sources used in concert (Byström and Hansen, 2005). The scope mirrors the information needs addressed; whereas consulting one source (information search task) target specified intentions that build on more or less accurate expectations on what may be possible to retrieve from the source, consultation of combination of sources (information seeking task) reflects a more nuanced understanding of what is needed to progress in the task at hand (Byström and Kumpulainen, 2020). Furthermore, the information gathered in these tasks becomes evaluated and used towards the goal of a work task, rather than being valued on its

own, or in relation to information searching/seeking tasks (Byström and Järvelin, 1995; Savolainen, 2017; Byström and Kumpulainen, 2020).

In his seminal work, Marchionini (2006) differentiates between exploratory search tasks that are connected to the aims of learning and discovering, and lookup searches that are, for example, factual searches or searching for known items or other well-structured or well-known objects. Exploratory search tasks can be considered as complex search tasks (White and Roth, 2009). Wildemuth and Freund (2012) state that explorativeness is formed of several factors, such as multi-faceted, dynamic searching that occurs over time. Such an explorative, semi-navigational strategy is presented by Bates' (1989) berrypicking model that illustrates how the searcher moves from one source to another harvesting the interesting information along the way and moving forward based on interim results until reaching a satisfactory outcome. In addition to documented information other types of sources could also be included into the model.

Li and Belkin (2008) differentiate between tasks based on a faceted classification aiming to offer a holistic view that involves multiple aspects of both work and search tasks. Common task attributes identified were connected either objectively to tasks themselves or subjectively to their performers' perceptions. Generic categories consisted of source of task, task doer, time, action, product, and goal. By combining the facets and their subcategories the authors create a comprehensive matrix of tasks. Li and Belkin (2010) found that different work-task types significantly affect users' interactive information searching behaviour.

Not only tasks, but also information sought after may be of different types and looked for from different sources. Facts and details that consist of known specifics form one type of information, another type is explanatory and regulative information that consists of general principles and descriptions within a given field; yet another type is instructive information that constructs the methods and procedures to be applied. These types of information are available from many kinds of sources. Sometimes sources are separated from channels that guide towards the source that *de facto* contains the information sought after; other times both are called sources (Byström and Järvelin, 1995). Most often studied are the information sources for documented information, such as records, databases, information retrieval systems etc. within the level of information search tasks. People and situations, in addition to sources for documented information, are included in studies with broader focus on information seeking tasks.

The multi-level view on tasks highlights the connections between different information-related activities at work. Lloyd's (2010) conceptualisation of information landscapes illustrates the interrelationships between information modalities of textual, social, and corporeal, which together form a basis for information practices at work. We interpret this so that none of the modalities are independent of the other two, but the three of them form a backdrop for any kind of information activity. This means that information searching from one source for a work task is embedded in the collectively maintained assembly of surrounding information sources in that

particular work setting, which information seekers have technical access to and have contextual knowledge of in different degrees (cf. Byström and Kumpulainen, 2020).

There is an overall agreement of the fruitfulness of task-based approach for understanding information searching as such, and as part activities in which searching is prompted. In the present study we concentrate on information search tasks and the utilization of an operative enterprise search system. However, throughout the study, from the data collection to the analysis, we situate the information searching into its broader context, connecting both to work tasks as an activity and to work practice as mutually enacted constructions. We consider this approach to facilitate understanding the conditions and goals of searching in real-life settings.

Methods

The empirical study took place in an international biotechnology company that conducted research, development and production of industrial biotechnological products and biopharmaceutical ingredients. It employed approximately 7,500 people and was organized into seven core organisational areas, each with a specific management group. The core areas were Top management, Administration, Research & Development (R&D), Production, and three Business Areas, each focusing on a specific product application area.

From the start in the 1920ies the company focused on research and built up research related information systems. The first digital research archive was developed in the 1980ies. The present enterprise search system that is based on a Sharepoint solution was introduced in 2016 as a common interface to the core corporate information systems. The enterprise system includes the intranet, people directory, news, quality documentation database, research archive, laboratory system, and social media. The interface allows the user to search across all systems and to specify the search to a selected system. The search interface facilitates command-based keyword searching and filtering by metadata, e.g., document format, author, date. Search support is available in the form of information boxes and links to guidelines.

We used a convergent parallel mixed methods design (Bryman, 2016) to study the use of the enterprise search system. Our data came from three separate studies: search log analysis, questionnaire survey, and interviews. The purpose was to obtain different, but complementary data. Table 1 provides an overview of the research data.

Search log analysis · 5,854 active users · Data: user ID, data and time, source, search string, organizational affiliation, job title Questionnaire survey · Sent to 226 most active users during the last three days, response rate 43.4% (98 users) · Data: Search frequency, time spent on searching, satisfaction, sources, information types, reformulation strategies Interviews · 8 frequent users from frequent organizational areas, except general management that was not available for the study · Demonstrations of 19 search tasks

Table 1: The research data

The search log analysis covered a 4-months period in the autumn 2016. During the period 5,854 employees carried out 288,363 search queries. For each query submitted in the search box the log provided the following data: date and time, user ID, source, search string, user's organizational affiliation, and user's job title. The search strings were automatically categorized into a defined set of 30 top-subject categories and 221 sub-subject categories. The Sharepoint Categorization feature that builds on FAST and Autonomy IDOL technologies was used for the automatic categorization of search strings (Microsoft, n.d.). The categorization was taxonomy and vocabulary based (Krushwitz and Hull, 2017). Both the taxonomy and the categorization rules were developed manually and continuously updated by the corporate information specialists as the log file developed. The log file and the search string categorization were used to track the usage of the enterprise system as part of the ongoing monitoring and updating of the enterprise search system.

The questionnaire survey was carried out in the spring 2017, giving the respondents two weeks to complete the survey. The questionnaire was sent out to a sample of 226 most frequent users during the last three days. The sample consisted of employees from the seven core organizational areas. The questionnaire included twelve closed questions and one open question about the users' function, main language, and time spent looking for information, satisfaction with search results, sources used, type of information, and reformulation strategies. The questionnaire survey was completed by 98 users (response rate:43.4%).

Eight frequent users were interviewed during the spring 2018. The interviewees were sampled so that they represented frequent searchers and the organizational areas that used the enterprise search system most frequently (for specification see Table 2). The interviews were conducted in meeting rooms at the head office. In four interviews the interviewee participated by video conference from regional offices. The interviews were inspired by the principles from Contextual Inquiry, developed by Holtzblatt and Beyer (2016). During the interviews the users were asked to give examples of typical search tasks and furthermore to repeat two or three recently performed searches. They used the enterprise search system to show and explain their search activities. They explained what work task motivated the search task, aims and relevance criteria, time frame, sources used, choice of search terms, filters used, colleagues involved, location. The interviews closed by an open discussion about general search routines, challenges, and emotions related to search. The interviewees were encouraged to relate their searching to their work tasks, work role and organizational affiliation. The interviews were audio-recorded, and the search activities were documented by video-recording.

Informant	Core organisational areas	Work role	Location
1	Research and Development (R&D)	Senior scientist	India
2	Business Area I	Accounting manager	Switzerland
3	Administration	Finance manager	Switzerland
4	Administration	Senior manager	Denmark
5	Business Area II	Senior manager	Denmark
6	Research and Development (R&D)	Science manager	Denmark
7	Business Area III	Scientist	US

8	Research and Development (R&D)	Information specialist	Denmark

Table 2: The interview informants.

Data from the three studies were firstly analysed separately to get an overview. Data from the log analysis were assembled in Excel, one column for each individual data type: user ID, source, search string, user's organizational affiliation, user's job title, and categorization of search strings at top- and sub-subject level. The log data analysis started with univariate analyzes of the number of searches per user ID, source, organizational area, and top-subject category to get an overview of the data. As the standard deviation of number of searches was high, we made a variability analysis by use of a boxplot to provide an indication of the dispersion of the data and to identify outliers. The boxplot revealed that the data set had a lower quartile, a median, an upper quartile of respectively 7, 21 and 63 searches per active searcher, and an end lower and upper whisker of respectively 1 and 147 searches. The boxplot distribution meant that the group of active searchers could be divided into three searcher groups of, respectively, of highly frequent searchers (outliers), frequent searchers (upper whiskers), and infrequent searchers (all other searcher searchers). After the boxplot analysis, bivariate analyzes were performed to explore relationships between the three boxplot searcher groups and the five organizational areas and the two variables top-subject category and source.

Data from the closed questions in the questionnaire survey were analysed through univariate analysis. The analysis focused on examining the distribution of respondents' organizational affiliation, time spent on searching per week, sources used, administrative and professional tasks, information types, and reformulation strategies.

The interview data were processed by the two interviewers. They transcribed the tape recordings and looked through the related screen videos to recall the interviews and generate a first list of emerging themes for each interview. The interviewers separately conducted the thematic coding as an open, inductive analysis (Bryman, 2016). In the next step each interviewer prepared summaries of each interview. Finally, the researchers compared and discussed the summaries and coding results across the eight interviews to determine recurrent themes, paying particular attention to commonalities and differences. In the last step of the data analysis the researchers used the concepts from the conceptual framework to structure the findings and identify practices in the use of the enterprise search system.

Findings

We will start the presentation of findings by presenting what we learnt from the log analysis about the entire group of enterprise searchers. Primarily based on the questionnaire study and the

contextual inquiry interviews, we will hereafter zoom in on the frequent searchers and present what we learnt about their search practices.

Organizational affiliation and search frequency

From the log analysis we know that 77.2% of the corporate workforce carried out 288,363 search queries, on average 2,363.6 queries per workday and on average 49.3 per individual active searcher. As shown in table 3, almost all employees from the three business areas and R&D used the enterprise search system during the study period. In top management, production, and administration around three quarters of the employees used the system.

Organisational area	Number of employees	Number of active employees	%
Business Areas	1,355	1,282	94.6
R&D	1,981	1,768	89.2
Top management	11	8	72.7
Production	2,868	1,931	67.3
Administration	1,365	865	63.4
In total	7,580	5,854	77.2

Table 3: Number and percentage of active searchers per organizational area.

The variation in number of searches was high, with a standard deviation of 72.9. The number of searches per active employee varied from 1 search (344 employees) to 878 searches (1 employee). The boxplot analysis revealed that the searcher group consisted of three searcher group; of highly frequent searchers, that had a noticeable higher number of average searches per active searcher (240.3), compared to both the frequent searchers (95.8) and the main group of active searchers (18.3), as shown in table 4.

	Number of searches (% total number)	Number of active employees (% all active)	Lowest to highest searches per employee	Average searches per employee	Standard deviation
Highly frequent	115,112 (39.9)	479 (8.2)	148-878	240.3	108.2
Frequent	92,624 (32.1)	967 (16.5)	64-147	95.8	22.7

Infrequent	80,627 (28.0)	4408 (75.3)	1-63	18.3	16.6
All active employees	288,363 (100.0)	5,854 (100.0)	1-878	49.3	72.9

Table 4: Active searchers divided by number of searches.

The searchers from top management and administration were the most frequent searches per active employee, followed by R&D and the three business areas. Searchers from production carried out the lowest average number of searches per active employee. Thus, top management performed on average most searches per searcher, but they accounted for only 0.1% of all the active searchers. At group level most searchers were affiliated to production, followed by R&D, the three business areas, and administration.

	Highly frequent n=479		Frequent N=967		Infrequent n=4408		All active employees n=5854	
	Active searchers (%)	Average searches	Active searchers	Average searches	Active searchers	Average searches	Active searchers	Average searches
Top management	1 (0.2)	302.0	2 (0.2)	115.0	5 (0.1)	22.6	8 (0.1)	80.6
R&D	182 (38.0)	242.9	348 (36.0)	95.3	1,238 (28.1)	20.9	1,768 (30.2)	58.4
Production	68 (14.2)	235.5	205 (21.2)	94.8	1,658 (37.6)	14.3	1,931 (33.0)	30.6
Business areas	77 (16.1)	216.5	225 (23.3)	95.3	980 (22.2)	21.2	1,282 (21.9)	45.9
Administration	151 (31.5)	251.1	187 (19.3)	98.2	527 (12.0)	19.4	865 (14.8)	76.9
All active searchers	479	240.3	967	95.8	4,408	18.3	5,854	49.3

Table 5: Searcher groups divided by organizational area.

The infrequent searcher group had a similar distribution to the entire searcher group. Also, the frequent searcher group followed to a large degree the entire group, with a small increase in percentage of employees from R&D and administration. This increase, on the other hand, was

clearer when we look at the highly frequent searchers. In total, R&D and administration together made up 69.5% of the highly frequent searchers as opposed to 45.0% when we look at the entire group, 40.1% for the infrequent group, and 55.3% for the frequent group.

Search topics

The most frequent subject category was People search, covering 59.5% of the search queries. In the People search category the searchers searched with search terms such as initials, names, department, phone number, email, job description. Search with initials accounted for 83.7% of People searches and search for names 11.6%, department 2.1% and phone numbers 1.9%. The other types of searches related to People searches were all below 1%, i.e., job title, job description, or email. The second most frequent search topics of much less frequency included categories such as: Quality, IT, HR, Products, Finance, Facility Service, Sourcing, and Intranet. In Quality the searchers searched for i.e., quality standard names, GLP, in the subject category IT they searched for database names, IT concepts, security, in the HR category for benefits, insurance, employee handbook, in Product for product names and product codes, in Finance for payroll, credit card, SAP, VAT, and in Sourcing for vendor and supplier names. The rest group of very infrequent subject categories consisting of 21 categories included i.e., Location, Communications, Sales. The set of non-categorized queries was the second largest group.

Top category (%)	Highly frequent (n=479)	Frequent (n=967)	Infrequent (n=4,408)	All active employees (n=5,854)
People Search	63.4	61.7	51.3	59.5
Quality	4.4	4.5	6.3	5.0
IT	2.6	3.4	6.7	4.0
HR	2.2	2.5	3.9	2.8
Product	1.9	1.6	1.6	1.7
Finance	1.1	1.5	2.2	1.5
Facility Services	1.0	1.0	1.2	1.1
Sourcing	1.3	0.9	0.8	1.1

Intranet	0.8	0.9	1.4	1.0
No top category	17.2	17.1	18.9	17.7

Tabel 6: Percentage of subject categories divided by searcher groups. The difference between the searcher groups is significant with $p<0.001$.

The distribution of subject categories changed slightly when we look at the three searcher groups. The People category was slightly higher for the highly frequent and frequent groups and slightly lower for the infrequent searchers. The main difference was that the highly frequent searchers used slightly more product-related search terms, just as their share of administrative-related IT, HR and Finance subject searches was smaller. The large infrequent searcher group stood out by having more IT, HR, quality and finance searches than both the entire group and the other two searcher groups.

When we look at organisational affiliation, the share of People searches was highest for top management (74.4%), administration (70.0%), followed by production (57.0%), the business areas (56.8%), and R&D (55.5%). Similarly, the percentage of product and quality searches was higher for the business areas and R&D compared to the other organizational areas. The share of HR and IT was largely the same for the five organizational areas.

Sources and timeline of searching

Most of the searches (73.4%) were carried out in the All index allowing the searcher to search all internal sources at the same time, i.e. lab data from the laboratory system, reports from the research archive, news from the intranet. When the searchers limited the search to a specific source the people directory was the most used search filter (20.0%), followed by the intranet (2.5%), the quality system (1.9%), the research archive (1.6%), the news (0.4%), the social media (0.1%), and the laboratory system (0.1%). The infrequent searchers used the ability to search in a specific source to a greater extent than the other two searcher groups. They used the ability to delimit search to the intranet and the people directory. The highly frequent searchers limited to a greater extent to the quality system and to a lesser extent to the intranet and the people directory.

Concerning sources, the questionnaire study showed that the respondents used most search time (36.7%) in the enterprise search system, while they used 28.5% of their search time in own archives, e.g., email, personal file systems, 22.3% of their time in external search sources such as Google and library catalogues and asked a colleague in 12.5% of the time used.

The questionnaire study further showed that 90.8 of the respondents searched daily. 5.1% respondents answered that they spend more than 10 hours per week, 18.4% between 5 to 10

hours per week, 40.8% of the respondents answered that they spend 1 to 4 hours per week looking for information, and 35.7% spend less than an hour per week.

Work tasks behind the searching activities
The log and survey data provided insight into the entire group of active searchers. In the following we will focus on the eight frequent searchers that were selected for the interviews.

In all, the eight searchers presented nineteen work tasks during the interviews. Their descriptions allowed us to categorize the work tasks into four types whether the overall work task was to (1) find new *application* areas for existing products, (2) *research* new products or technologies, (3) *support* the operation of existing products, or (4) *administration* of employees' maternal leaves, a customer's payment, travel expense, organization of meetings etc. Table 7 provides an overview of the work tasks and related search tasks.

The findings from the interviews matched the log and questionnaire findings showing that most search time (71.2%) was used in relation to professional tasks such as product research and development (work task category 1 and 2) and customer support (work task category 3) with the rest of the search time (28.8%) used on administrative tasks (work task category 4).

Work tasks	**Search tasks**	**Search task type**	**Needed information**
1 Applying products	Find new application areas	Exploratory	Non-specific
	Find new application areas	Exploratory	Non-specific
	Find out how a potential application area is technically carried out, and what problems characterize the area	Exploratory	Non-specific
	Find existing application areas for specific products	Exploratory	Non-specific
	Find new applications areas for specific processes	Exploratory	Non-specific
2 Researching products and technologies	Find info validating a specific technology	Exploratory	Non-specific
	Find characteristics of specific product	Exploratory	Non-specific
	Find background lab data for a specific sample	Exploratory	Non-specific
	Find project information about previous research projects	Exploratory	Non-specific

3 Supporting operations around products	Find documentation for patent disputes	Exploratory	Non-specific
	Find documentation for trademark usage	Exploratory	Non-specific
	Find names of internal and external trademarks	Exploratory	Non-specific
	Find the master list of quality standards	Lookup	Specific
	Find specific article	Lookup	Specific
	Find the sales report for a product	Lookup	Specific
4 Administrating e.g. staff, customers, economy	Find the regulations for maternity leave	Lookup	Specific
	Find the order information for a customer	Lookup	Specific
	Find the payments information for a customer	Lookup	Specific
	Find the contact information for a customer	Lookup	Specific

Table 7: Overview of the interview search tasks.

The searchers distinguished between specific and non-specific search tasks. They described the specific search task as a task where they looked for particular information, e.g. background lab data for a specific test sample or a specific social media policy. They referred to the non-specific search as a search task where they looked for information without looking for or knowing in advance any specific piece of information, e.g. find out what problems characterize a certain application area.

One searcher described the difference between specific and non-specific as:

" One is when one follows a topic of interest in the search, the other one is when I need to use this information for my work now and here" (Science manager, R&D).

He continued about the non-specific search:

"I follow some specific product and search their name ... it can be both internally and externally, what is the latest that has emerged there ... it's part of the job ... I have to keep up with what's going on, and with some intervals I do this kind of searches" (Science manager, R&D).

He also used the terms interest search for the non-specific search and problem-solving search for the specific search. He explained how the interest search was a core task of his R&D job looking on a regular basis for new relations and opportunities to invest further. He independently decided what topics to investigate and in what timeframe. This task was ongoing over time without no clear start or end.

In the non-specific search the searcher knew well the topic of interest, often he had been following the area for several years. It meant that the searcher knew what type of information he was looking for, but he did not know what concrete information might accomplish the search. The non-specific tasks were open-ended, monitoring tasks where the searcher looked for new knowledge, news and developments, about a known, well-defined topic area. Most of the research and application-oriented search tasks were open-ended, non-specific searches whereas the support and administration-oriented searches were specific searches seeking for known documents, persons, or data.

Concerning search outcome, the interviewees did not have expectations that it would be possible to retrieve the full set of relevant information. For them it was important to get a sense of how much has been found, rather than to get maximum recall.

Searching techniques

In most cases the eight frequent searchers started out the search by querying the enterprise system with one or few search terms, then they browsed the hit list and document displays, opened and scanned interesting documents, continued by searching e.g., interesting subject terms, project names, or person names that popped up among the retrieved documents. In this way, the searchers pieced together the needed information by switching between searching, reading, and browsing.

The searchers used this exploratory approach for both the non-specific and specific searches. One searcher showed how he put together the search result for a non-specific search task by different information sources such as product sheets, colleagues, and how he switched between searching for a subject term, reading documents, looking up and calling a colleague, and again searching for a product number. During the searching activities he used contextual information to guide his searching steps and decisions about what to pursue in the browsing of results and information:

"…. Then you get a long list where 'X' appears, the name of a product that I work with, and then you get all these things… it means that I might want to open the documents and see what it is... I just want to see what it is … here is a person that has worked with 'X' … we can also contact him … here is a product sheet of a product that apparently has been developed lately … Here I can see a product that somebody has produced … it could be interesting … what it is used for, and who did it … it means that I might open it and see what it is… right now I will continue with this product number …" (Science manager, R&D).

Other searchers described similar sets of activities for specific search tasks where they equally pieced together the search result by using a combination of subject searching, looking up project documentation, identifying and contacting colleagues:

"*I want information that validates a certain method. Topic terms will lead me to information about the method, but not necessarily lead me to the needed information … I need to connect to the persons that may have worked with the method … thus I search some relevant persons, then I look at the different projects that the persons have made, and based on the hits I contact the person or go through the project*" (Senior scientist, R&D).

In several cases the searchers needed to go back in time to get an adequate answer to their problem. Over time products have been tried out in relation to different business areas and considering new opportunities the scientist needed to go back to former projects and people who at an earlier time worked with the topic of interest to profit from their findings or avoid replication of i.e., test work.

"There are really many of these application areas that the company has looked at before… 15 years ago… we often see this … that many things we have invented 10 years ago when the market was not clear… many of the projects run in such cycles" (Senior manager, Business Area II).

"If a project is in its initial phase and we are looking for different screening methods or different assays or different application methods ... we should connect to those who have done this before ... e.g., I have a project now that also ran in 2002 by a person in Denmark and she has made a closure report so it was a good place for me to start from where it ended ... and that was where I started in the Research Database with the name and project number, and then I contacted the person and got access to look at the documents" (Senior scientist, R&D).

In another case a searcher needed to reconstruct the course of a specific lab sample to fully understand the context around the sample and results, e.g., how it was previously used:

"…they [lab samples] typically have some kind of prehistory … some have generated them and given them a name … sometimes it can be useful to find out … it is limited what you can write on etiquette … sometimes the whole history is not there … you need to search for it" (Science manager, R&D).

Also, the persons who had previously worked with a product, process or market were significant sources in the exploratory search. The interviewees explained how they after having started the search by use of a single subject term continued the search either by looking up a colleague in the People directory that could guide them to relevant information or persons or by an author search to find documents or information authored by the person.

"Typically when you start digging in things ... a large part of the search is also identifying the network internally ... and then someone is saying ... a colleague worked with this in 97, and then I either get him to send some links or I go into the Research Database to see what I can find looking up my colleague ... and if you are lucky you find something" (Senior manager, Business Area II).

Asked how the searcher searched for a particular person, he elaborated his explanation:

"...I often search for persons… I search up here (in the All search box) … I know that I am searching in all content … but it is to search the phone book" (Senior manager, Business Area II)
"Ok, you do not search persons to find a particular project that a person is affiliated to or a document that he has written?" (Interviewer)
"It could be … I search persons to get their phone numbers to call or write to them for information that takes me further" (Senior manager, Business Area II).

Breakdowns and challenges

Generally, the interviewees consciously addressed their breakdowns, and addressed both how they saw the problem and how they handled them. We will start by the breakdowns caused by vocabulary variation. One interviewee explained how it is difficult to find appropriate search terms when you move into a new application area that use a different vocabulary:

"Our tasks are more exploratory. We are moving in areas that are not known ... where there are not necessarily subject terms to use to express products ... it may well be that there are professional terms in the applications ... but it is someone we do not know so well ... because we have not worked with it for many years ..." (Senior manager, Business Area II).

He continued by mentioning two other vocabulary problems. First, he talked about vocabulary changes over time. Then he mentioned differences across geographical locations and between regional offices of a company, e.g., between British and US offices:

"….. why it may be if I search for something with medical equipment and I know we worked on it in 2007 so it may well be that they have used some other words at that time ... because there were other people who had some other contacts ... sometimes they use a little different word in Europe than in the US (Senior manager, Business Area II).

An interviewee mentioned the vocabulary challenges in relation to changes over time of product names, e.g., because a product at a later stage in its life cycle may be applied into another industry:

"I work with commercial products and our company will recycle a lot of the same products… we just re-brand them in a new way… and one of the problems is that I might find an internal report dealing with the specific product that I am interested in … but it is renamed and put into another industry" (Scientist, Business Area III).

Another challenge that was mentioned by several interviewees was data quality. Here the interviewees referred to both simple spelling errors and inconsistency in the assignment of metadata, e.g., document type metadata.

"… then we have these classical errors where people have written I instead of L in the document … and people have spelled wrongly … it causes problems" (Science manager, R&D).

"There seem to be 10-15 document types in the controlled vocabulary… but some of them are almost the same … people do not distinguish when they store documents … except when it is a minute which is very clear, or a highlight" (Senior scientist, Business Area III).

Lack of complete migration between systems was yet another challenge, because the searchers needed to go back in time:

"I have been in the company for 10 years - all the time in R&D ... mostly at the application side ... and I have seen quite a few different systems being used over the years ... sometimes we do not upgrade a system ... we replace it ... and some of my frustrations is that when we replace a system it is not everything that is migrated into the new system ..." (Scientist, Business Area III).

A related governance problem was the restricted access due to confidentiality. These documents are visible in the enterprise system, but to get access the searcher needs to consult the document owner:

"... we have these new IT policies that prevent access by default ... then most people do not have access to very many documents ... you have to ask for access to most of what you need ... it is less frustrating because you can still access ... but it was easier to share before ... now when writing monthly highlights, and I do every one month ... then I typically get 40-50 inquiries about allowing access to a document ... it's frustrating" (Scientist, Business Area III).

Other governance related problems were a lack of subject information and updated information in the people directory, and removal of person data from the people directory when an employee leaves the company.

"There we have a weakness that people disappear from our phone book ... so if you look for details about a person who wrote something, he might not be there because he has left the company" (Senior scientist, Business Area II).

Concerning responses to encountered breakdowns and failures to find the needed information, most questionnaire respondents tried to reformulate the search query (78.6%), ask a colleague (70.4%), or used their network to find the information (65.3%). They also consulted their private archives (44.9%), search support (21.4%), or the local department share (19.4%). One third (33.7%) reported that they sometimes give up.

Discussion

We now return to our research questions and the broader implications of the study. The findings revealed that almost three-quarters of the corporate workforce used the enterprise search system during the study period. The importance of the enterprise search system as a source was confirmed by the questionnaire study, where 90.8% of the respondents stated that they searched daily. In 36.7% of their searches, they used the enterprise search system alongside their personal file systems, external search databases and colleagues. The findings confirm AIIM and Findwise surveys that 75% of workplace respondents see access to information as very important to an organization (White, 2015).

The user group consisted of three groups with different search practices. A small outlier group of highly frequent searchers, 8.2% of all users that made 39.9% of all searches, a larger group of frequent searchers, 16.5% of the users making 32.1% of the searches, and a large group of infrequent users, 75.3% making 28.0% of the searches. Organizationally, most of the highly frequent users came from R&D and administration, while most of the frequent searchers came from production, R&D, and the business areas. The infrequent user group was more equally divided between the organizational areas. The results partly support Stenmark (2010) identifying specialists (technicians) and project leaders as more frequent users in comparison to managers and administrative staff. However, our findings alter the picture pointing to an outlier group of

highly frequent searchers that in addition to specialists (scientific and technical employees) also consist of administrative searchers. The highly frequent specialist searchers primarily performed search in connection with research and application of products, while the highly frequent administrative searchers performed searches in connection to supporting operations around products. Both groups of highly frequent searches carried out administrative tasks in relation to personnel management.

Regarding search topics, it characterized all three user groups that they did most people searches. The highly frequent and frequent searchers did on average 10% more people searches than the infrequent. For these two user groups, the administrative users primarily did people searches in addition to IT and HR subject searches, whereas the scientific, technical users in addition to the people searches made product related searches confirming two equally sized user groups each with a specific topical focus.

All administrative tasks and half of the supportive tasks were specific search task resembling what Marchionini (2006) called lookup searches where the searcher looks for specific facts, known items or answers to solve a specific problem, whereas the research and application-oriented tasks all were non-specific search tasks resembling the type of exploratory search that Marchionini (2006) described as investigative exploratory searches. Investigative searching may be done to discover gaps in knowledge and support planning and forecasting, which was also the case for present searchers that as part of their work tasks were looking for new opportunities for products and new methods and processes.

For the specific as well as the non-specific search tasks, the searchers applied a combination of an open, exploratory searching where the searcher submitted a tentative query to explore the search environment and navigate to relevant documents (White and Roth, 2009) and a focused, orienteering search, where the searcher reached a particular information through a series of small steps used to narrow in on the target and without specifying the information needed up front (Teevan *et al*., 2004). The search engine was used to transport the searchers to a part of the information space containing potentially relevant documents. Searchers then relied on their knowledge about the work environment and their recall and recognition skills to locate relevant information (White and Drucker, 2007). As opposed to the findings by Teevan *et al*. (2004) where the orienteering, stepping strategy was used to narrow in on the actual information target, the present searchers used the strategy to "dig" and "fish" and interactively put together a set of information that jointly provided the needed information. They both specified and broadened the search along the way. Each new piece of information the searchers encountered gave them new ideas and directions to follow. At each stage they identified useful information, documents, or persons that they could pursue. Often, they chose between different paths, and they explained how they would return and follow up previously identified paths. The exploratory searches were not satisfied by a single final retrieved set, but by a series of selections of documents and bits of

information at each path of the ever-modifying search. Their searching resembled Bates (1989) evolving berry-picking search. Bates (1989) distinguished between berry-picking where the search need evolves and changes during the searching and searches where the need remains unchanged. It characterized all the present search tasks that the task was stable, but that the answer had to be pieced together by relating information from textual and personal sources.

For both the specific and non-specific tasks, the searcher had to apply contextual knowledge to derive the requested information or answer. In relation to specifically the research, application and supporting work tasks, the searchers applied their knowledge of products, i.e., which projects over time had been around a product, colleagues who had been involved in the projects, and within which business areas the projects had been completed. They also used knowledge about sources and documents to find out paths to follow. Similarly, they used their knowledge about availability of metadata and vocabulary differences to choose new search terms. In relation to administrative tasks, they primarily used their knowledge about metadata and sources, i.e., migration of sources. Looking for people they also had to consider related colleagues, projects, products, and vocabulary changes during time. From their explanations, it became clear that this contextual and often historical knowledge about products, projects, people, business areas, documents, resources, and vocabulary variations was essential to dig up relevant information. Their explanations also showed that they did not always possess the necessary knowledge, and therefore often had to take a detour by consulting a colleague to find the necessary clues to be able to dive into the search system and find the desired information. As consequence, the searchers looked up colleagues as part of the tracing search to find contact information to phone or write to the colleague. There were no specific routes through the system. Sometimes it was relevant to start the search by searching for a product, other times it was relevant to start from a business area. Start and route could depend on both work tasks and searcher's prior knowledge. Like Du *et al*. (2013) and Freund (2015) there was a correlation between work tasks and search behaviour, but it was difficult to determine a specific route in advance. Retrieval and understanding of historic, contextual information were essential in their searching, to understand the retrieved information as well as decide which path to take.

The searchers were fully aware that they were using the enterprise search system in this meshed way. They were also conscious that it was a common search technique to dig out the needed information. The fact that the searches were at one time very focused with a clear picture of what kind of information (berries) they were looking for and at the same time carried out an open-minded as well as focused, explorative search, we consider the search technique as a variation and extension of Teevan *et al*. (2004) orienteering strategy and Bates (1989) berry-picking, why we choose to call the identified search technique for information tracing. The searchers consciously traced the sought information by digging around in the enterprise system. Sometimes they looked for specific information, sometimes they did not know the exact nature of information, or if it was available.

The searchers' explanations provided some explanation for the log data findings that the people category covered more than half of the searches, especially for the highly frequent and frequent searchers. This also contributes with some explanation for the mismatch that we saw between the log data and the questionnaire answers where the respondents that consisted of highly frequent and frequent searchers did not present person information as significant information. From the interview explanations we know that person searches in connection with tracing searches form a steppingstone, where names make a type of key word, to be able to continue the search rather than having a goal to find the persons themselves. The tracing searchers searched for person names to find contact data to contact related persons and documents as well as get clues to select the next path in the tracing search. These findings provide new insights into how persons sometimes are used in information search to mediate the search. In addition, they also confirm the importance of people as information sources for complex tasks (Hertzum, 2014).

Summing up, four main findings emerge from the study:

1. Tracing search tasks. In many search tasks search is conducted by tracing and tracking clues across business areas, information types, information sources and back in time. This applies to specific as well as non-specific search tasks and for research oriented, application oriented, supportive, as well as administrative work tasks.
2. Contextual and historical knowledge. To carry out the tracing search, searchers need contextual and historical knowledge about relationships between products, projects, people, business areas, sources, and vocabulary variations, across disciplines and over time.
3. People search. People search has two different purposes that sometimes coexist. Names are used to find specific persons, but also to mediate search as keywords to find other information and to decide paths to follow as part of the tracing search.
4. Two equally sized searcher groups from R&D and administration with same search techniques, but different search aims and topics.

The searchers' explanations corresponded to Cleverley and Burnett's (2015) findings regarding query expansion in enterprise search where clusters of related concepts are useful inspiration. In the present study, searchers expressed a need for reference to relationships between products, projects, people, business areas, documents, resources, and vocabulary variations The findings further support Cleverley and Burnett's (2015) finding that precision in referencing is more important than referencing for serendipity. The present searchers did not express a need for inspiration, they expressed a need for support to recall relationships that they knew about or had a presumption about but could remember.

The company has subsequently used these results to develop supportive contextual and historical semantic relations that they have built into the search interface as part of the display of retrieved documents. Through an intelligent text mining software and a set of inhouse and commercial biotech taxonomies, a set of related products, persons, projects, and patents were related to each document. The relationships appear as clickable metadata that information searchers can consider and use in the exploratory, 'tracing' search strategy. A click at the metadata refers the searcher to information and documents about the related subject category. The role of the relations is primarily to support the searcher in recalling contextual and historical relationships and clues to pursue in the tracing search. A new research project has been launched to investigate how searchers understand and use the derived relations. The study focuses on examining how the different types of relationships are used in search, whether searchers understand how to use the contextual and historical relations, and whether the relations improve the search experience. Another goal is to study whether such a query expansion tool should be used manually by the searcher as opposed to automatically by the computer (Efthimiadis, 2000). The study findings indicated that it requires contextual and historical knowledge to understand and apply the contextual and historical information and make decisions in the tracing search. This points to an interactive and manual application of the relations.

Conclusions

This study provides insight into enterprise searching practices across different organizational work areas in an international biotechnology company. The work task based conceptual framework has provided a fruitful basis to study search embedded in its broader context. Three separate studies of employees' authentic search activities were conducted: log data analysis, questionnaire survey and interviews. The log analysis provided insight into the entire user groups, whereas the questionnaire and interviews focused on frequent searchers. An important contribution is the insights into an entire user group in a 4-months period and the identification of a small outlier search group that stands for forty percent of the searchers. This group of high-frequency searchers turns out to consist of searchers from specialist work areas as well as administrative areas, which is surprising compared to previous studies.

Another important contribution is the identification of an extension of the explorative search, a tracing search, where searchers use the search engine to transport them to a part of the information space containing potentially relevant information. Searchers then rely on their knowledge about the work environment and their recall and recognition skills to locate relevant information. As opposed to previous findings the searchers used the strategy to trace and interactively put together a set of information that jointly provided the needed information. Another significant contribution is the importance of historical and contextual knowledge to decide the tracing path. A third significant contribution is how people are key sources and clues, to gain the necessary contextual and historical knowledge. The tracing search and importance of historical and contextual knowledge are essential for all four work task types identified,

professional as well as administrative. The study indicates that there is a need to develop semantic tools to support searchers with contextual and historical relationships to support the tracing search.

Acknowledgments

References

Allard S., Levine K.J. and Tenopir C. (2009), "Design engineers and technical professionals at work: Observing information usage in the workplace", *Journal of the American Society for Information Science and Technology*, Vol. 60 No. 3, pp.443-454, doi: 10.1002/asi.21004.

Allen, T.J. (1969), "Roles in Technical Communication Networks", working paper [#434-69], Sloan School of Management, MIT, Cambridge, MA, December.

Bates, M.J. (1989), "The design of browsing and berrypicking", *Online Review*, Vol. 13 No. 5, pp.407-424.

Blomgren, L., Vallo, H., & Byström, K. (2004). "Evaluation of an information system in an information seeking process", in Heery, R. and Lyon, L. (Ed.s) *Research and Advanced Technology for Digital Libraries, 8th European Conference, ECDL 2004, Bath, UK, September 12-17, 2004, Proceedings*. Lecture Notes in Computer Science 3232, pp.57-68. Springer, Berlin, Heidelberg.

Borlund P., Dreier S. and Byström K. (2012), "What does time spent on searching indicate?", in Kamps, J., Kraaij, W. and Fuhr, N. (Ed.s), *IIIX '12: Proceedings of the 4th Information Interaction in Context Symposium, Nijmegen, The Netherlands, August 21-24,* Association for Computing Machinery, New York, NY, pp.184-193, doi: 10.1145/2362724.2362756.

Bryman A. (2016), *Social research methods* (5. ed.), Oxford University Press, Oxford, UK.

Byström K. and Hansen P. (2005), "Conceptual framework for tasks in information studies", *Journal of the American Society for Information Science and Technology*, Vol. 56 No. 10, pp.1050-1061, doi: 10.1002/asi.20197.

Byström K. and Järvelin K. (1995), "Task complexity affects information seeking and use", *Information Processing & Management*, Vol. 31 No. 2, pp.191-213, doi: 10.1016/0306-4573(95)80035-R.

Byström K. and Kumpulainen S. (2020), "Vertical and horizontal relationships amongst task-based information needs", *Information Processing & Management*, Vol. 57 No. 2, pp.1-14, doi: 10.1016/j.ipm.2019.102065.

Cleverley P.H. and Burnett S. (2015), "The best of both worlds: highlighting the synergies of combining manual and automatic knowledge organization methods to improve information search and discovery", *Knowledge Organization*, Vol. 42 No. 6, pp.428-444, doi: 10.5771/0943-7444-2015-6-428.

Cleverley P.H. and Burnett S. (2019a), "Enterprise search: A state of the art", *Business Information Review*, Vol. 36 No. 2, pp.60-69, doi: 10.1177/0266382119851880.

Cleverley P.H. and Burnett S. (2019b), "Enterprise search and discovery capability: The factors and generative mechanisms for user satisfaction", *Journal of Information Science*, Vol. 45 No. 1, pp.29-52, doi: 10.1177/0165551518770969.

Cleverley P.H., Burnett S. and Muir L. (2017), "Exploratory information searching in the enterprise: A study of user satisfaction and task performance", *Journal of the Association for Information Science and Technology*, Vol. 68 No. 1, pp.77-96, doi: 10.1002/asi.23595.

Du, J.T., Liu, Y. H., Zhu, Q. H. and Chen, Y. J. (2013), "Modelling marketing professionals' information behaviour in the workplace: towards a holistic understanding", *Information Research*, Vol. 18 No. 1, paper 560.

Efthimiadis, E.N. (2000), "Interactive query expansion: A user-based evaluation in a relevance feedback environment", *Journal of the American Society for Information Science*, Vol. 51 No. 11, pp.989-1003, doi: 10.1002/1097-4571(2000)9999:9999<::AID-ASI1002>3.0.CO;2-B.

Fagin, R., Kumar, R., McCurley, K.S., Novak, J., Sivakumar, D., Tomlin, J.A., and Williamson, D.P. (2003), "Searching the Workplace Web", in *WWW '03: Proceedings of the 12th international conference on World Wide Web, Budapest, Hungary, May 20-24*, Association for Computing Machinery, New York, NY, pp. 366-375, doi: 10.1145/775152.775204.

Freund L. (2015), "Contextualizing the information-seeking behavior of software engineers", *Journal of the Association for Information Science and Technology*, Vol. 66 No. 8, pp.1594-1605, doi: 10.1002/asi.23278.

Freund, L., Toms, E.G., Clarke, C.L.A. (2005), "Modeling task-genre relationships for IR in the workplace", in Marchionini, G., Moffat, A., Tait, J., Baeza-Yates, R. and Ziviani, N. (Ed.s), *SIGIR '05: Proceedings of the 28th annual international ACM SIGIR conference on Research and development in information retrieval, Salvador, Brazil, August 15-19*, Association for Computing Machinery, New York, NY, pp.441-448, doi: 10.1145/1076034.1076110.

Hertzum, M. (2014), "Expertise seeking: A review", *Information Processing & Management*, Vol. 50 No. 5, pp.775-795, doi: 10.1016/j.ipm.2014.04.003.

Holtzblatt K. and Beyer H. (2016), *Contextual design: design for life* (2. ed.), Elsevier, Cambridge, MA.

Ingwersen, P. and Järvelin, K. (2005), *The Turn - Integration of Information Seeking and Retrieval in Context*, Springer, Dordrecht, The Netherlands, doi: 10.1007/1-4020-3851-8.

Jansen, B.J. and Pooch, U. (2001), "A review of web searching studies and a framework for future research", *Journal of the Association for Information Science and Technology*, Vol. 52 No. 3, pp.235-246, doi: 10.1002/1097-4571(2000)9999:9999<::AID-ASI1607>3.0.CO;2-F.

Joho, H., Azzopardi, L.A. and Vanderbauwhede, W. (2010), "A survey of patent users: an analysis of tasks, behavior, search functionality and system requirements", in *IIiX '10: Proceedings of the third symposium on Information interaction in context, New Brunswick, NJ, August 18-21*, Association for Computing Machinery, New York, NY, pp.13-24, doi: 10.1145/1840784.1840789.

Joseph, P., Debowski, S. and Goldschmidt, P. (2013), "Search behaviour in electronic document and records management systems: an exploratory investigation and model", *Information Research*, Vol. 18 No. 1, paper 572.

Kruschwitz U. and Hull C. (2017), "Searching the Enterprise", *Foundations and Trends® in Information Retrieval*, Vol. 11 No. 1, pp.1-142, doi: 10.1561/1500000053.

Li, Y. and Belkin, N.J. (2008), "A faceted approach to conceptualizing tasks in information seeking", *Information Processing & Management*, Vol. 44 No. 6, pp.1822-1837, doi: 10.1016/j.ipm.2008.07.005.

Li, Y. and Belkin, N.J. (2010), "An exploration of the relationships between work task and interactive information search behavior", *Journal of the American Society for Information Science and Technology*, Vol. 61 No. 9, pp.1771-1789, doi: 10.1002/asi.21359.

Li, Y., Li, Y., Pan, Y. and Han, H. (2019), "Work-task types, stages, and information-seeking behavior of strategic planners", *Journal of Documentation*, Vol. 75 No. 1, pp.2-23, doi: 10.1108/JD-01-2018-0015.

Lloyd A. (2010), *Information literacy landscapes: information literacy in education, workplace and everyday contexts*, Chandos Publishing, Oxford, Cambridge, UK and New Delhi.

Marchionini G. (1995), *Information seeking in electronic environments*, Cambridge University Press, Cambridge, UK and New York, NY.

Marchionini G. (2006), "Exploratory Search: From Finding to Understanding", *Communications of the ACM*, Vol. 49 No. 4, pp.41-46, doi: 10.1145/1121949.1121979.

Microsoft (n.d.), "SharePoint", available at: https://www.microsoft.com/en-us/microsoft-365/sharepoint/collaboration (accessed 10 August 2021).

Phillips M., Fosmire M., Turner L., Petersheim K. and Lu J. (2019), "Comparing the Information Needs and Experiences of Undergraduate Students and Practicing Engineers", *The Journal of Academic Librarianship*, Vol. 45 No. 1, pp.39-49, doi: 10.1016/j.acalib.2018.12.004.

Russell-Rose T., Chamberlain J. and Azzopardi L. (2018), "Information retrieval in the workplace: a comparison of professional search practices", *Information Processing and Management*, Vol. 54 No. 6, pp.1042-1057, doi: 10.1016/j.ipm.2018.07.003.

Savolainen R. (2017), "Information need as trigger and driver of information seeking: a conceptual analysis", *Aslib Journal of Information Management*, Vol. 69 No. 1, pp.2-21, doi: 10.1108/AJIM-08-2016-0139.

Schymik G., Corral K., Schuff D. and St. Louis R. (2015), "The Benefits and Costs of Using Metadata to Improve Enterprise Document Search", *Decision Sciences*, Vol. 46 No. 6, pp.1049-1075, doi: 10.1111/deci.12154.

Stenmark D. (2010), "Information Seeking in Organisations: A Comparative Survey of Intranet Usage", in *Proceedings of the 16th Americas Conference on Information Systems (AMCIS), Lima, Peru, August 12-15*, Curran Associates, Red Hook, NY, pp.4782-4793.

Stenmark, D., Gårdelöv, F. and Larsson, V. (2015), "Why should Organisations Govern Enterprise Search?", in *Proceedings of Americas Conference on Information Systems, Puerto Rico, August 13-15*.

Stocker A., Richter A., Kaiser C. and Softic S. (2015), "Exploring barriers of enterprise search implementation: a qualitative user study", *Aslib Journal of Information Management*, Vol. 67 No. 5, pp.470-491, doi: 10.1108/AJIM-03-2015-0035.

Teevan J., Alvarado C., Ackerman M.S. and Karger D.R. (2004), "The Perfect Search Engine is Not Enough: A Study of Orienteering Behavior in Directed Search", in: *CHI '04: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Vienna, Austria, April 24-29*, Association for Computing Machinery, New York, NY, pp.415-422, doi: 10.1145/985692.985745.

Vakkari, P. (2005), "Task-based information searching", *Annual Review of Information Science and Technology*, Vol. 37 No. 1, pp.413-464, doi: 10.1002/aris.1440370110.

White M. (2015), "Critical success factors for enterprise search", *Business Information Review*, Vol. 32 No. 2, pp.110-118, doi: 10.1177/0266382115589482.

White R.W. and Drucker S.M. (2007), "Investigating behavioral variability in web search", in: *WWW '07: Proceedings of the 16th international conference on World Wide Web, Banff Alberta, Canada, May 8-12*, Association for Computing Machinery, New York, NY, pp.21-30, doi: 10.1145/1242572.1242576.

White R.W. and Roth R.A. (2009), *Synthesis Lectures on Information Concepts, Retrieval, and Services: Exploratory search: beyond the query-response paradigm*, Morgan & Claypool, San Rafael, CA.

Wildemuth, B.M. and Freund, L. (2012), "Assigning search tasks designed to elicit exploratory search behaviors", in *HCIR '12: Proceedings of the Symposium on Human-Computer Interaction and Information Retrieval, Cambridge, MA, 4 October*, Association for Computing Machinery, New York, NY, USA, pp.1-10, doi: 10.1145/2391224.2391228.