



Dimensions of tasks: influences on information-seeking and retrieving process

Information-seeking and retrieving

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Abstract

Purpose – Previous research has demonstrated that task is the driving force for information retrieval (IR). However, few studies investigate how people engaged in work and search tasks define their decisions and behaviors in the IR process. The purpose of this paper is to investigate how dimensions of tasks affect the information-seeking and retrieving process.

Design/methodology/approach – In total, 40 participants are recruited for the two studies conducted in a corporate setting as well as an academic setting. Multiple methods are applied to collect data related to participants' tasks and the information-seeking and retrieving process: web surveys, questionnaires, diaries, and telephone interviews. Both qualitative and quantitative data are analyzed.

Findings – This paper identifies nature (routine, typical, and unusual), stages (pre-focus, formation, and post-focus), and timeframe (extremely urgent, urgent, and non-urgent) as dimensions of work tasks as well as origination (self-generated and assigned), types (updating information, looking for specific information, looking for items with common characteristics, and looking for known items), and flexibility (very flexible, flexible, and inflexible) as dimensions of search tasks. Moreover, the relationships between dimensions of work and search tasks and the information-seeking process – in particular, the extent of planning, the application of different types of information-seeking strategies, and shifts in search-task-related goals – are explored.

Originality/value – This paper fills in a gap in current research – the impact of dimensions of task on the information-seeking and -retrieving process.

Keywords Data collection, Information retrieval

Paper type Research paper

Introduction

Goal and task are the leading factors for individuals to search for information. Even though researchers have used different terminologies to represent goal and task, they agree that goal and task are the most important components that affect users' information seeking strategies (Belkin *et al.*, 1990; Byström and Järvelin, 1995; Hert, 1996; Vakkari, 2001). Attfield *et al.* (2003, p. 430) eloquently stated, "Information seeking does not occur in a vacuum but invariably is motivated by some wider task." Leide *et al.* (2007) stated that task defines the entire information-search activity. In order to understand the nature of information seeking and retrieving, researchers have to first characterize goal and task.

Before we can explore the influences of goal and task, we must first define these key terms. Xie (2000) developed a goal structure to represent levels of goals based on Daniels' (1986) classification of goals:



- Long-term goal refers to a user's personal goal that they will pursue for a long time, such as professional achievement (e.g. doctorate degree).
- Leading search goal refers to a user's current task-related goal that leads to a search (e.g. writing a paper).
- Current search goal refers to the specific search results a user intends to obtain (e.g. find relevant literature on task).
- Interactive intentions refer to sub-goals that a user must achieve to accomplish their current search goal. Task and goal are inseparable in the information-seeking and -retrieving process.

Task is defined as “what someone does to achieve a goal” (Hackos and Redish, 1998, p. 56). Vakkari (2003) pointed out that defining the task and subtasks depends on the circumstances. To connect levels of goals with tasks, a leading search goal (e.g. writing a thesis) could be a subtask for someone to achieve their long-term goal (e.g. earning a master's degree); at the same time, it also could be a task for someone to work on their current search goal (e.g. finding relevant literature about an interactive information retrieval – IR model). Task can be classified into two levels: work and search tasks. While a work task represents a task that leads to information searching, a search task represents a task that determines what a user is searching for (Borlund and Ingwersen, 1997; Ingwersen, 1996; Ingwersen and Järvelin, 2005; Vakkari, 2003). Under the context of information seeking and retrieving, leading searching goals are comparable as work tasks while current search goals can be regarded as search tasks. Higher levels of goals and tasks impact on lower levels in terms of the types of goals and tasks they have to achieve and how they intend to fulfill these goals and tasks.

Goals and tasks not only lead users to look for information, but also affect how they seek information. Previous research has demonstrated the impact of goal and task from the complexity of tasks to the stages of tasks on the application of information-seeking strategies. A detailed discussion is presented in the “Literature review” section. Even though some researchers have recognized the important role that tasks play in how users seek and retrieve information, little attention has been placed on the relationship between task and information-seeking and -retrieving. Vakkari (2003) emphasized that it is essential to take into account task in order to understand information searching and to design systems for effective IR.

Literature review

Levels of goals and tasks

Both goals and tasks are considered important components of interactive IR in a variety of digital environments. Researchers have used different terminologies to represent goal and task including user goal, intention, task, work task, and search task. By applying the author's goal/task structure discussed in the “Introduction” section, different uses of goal and task can be clarified. In many studies, interactive intentions were labeled as either goal or sub-goals. For example, Belkin *et al.* (1990) and Chang (1995) refer to goal as one dimension of information-seeking strategies; in their studies, “goal” was actually referred to as “intention.” In the web environment, Broder (2002) and Rose and Levinson (2004) explored a series of sub-goals, such as informational, transactional, and navigational searches – directed and undirected – to get advice, to locate information, or to obtain a list. These sub-goals are comparable to interactive intentions.

In empirical studies, most researchers concentrate on current search goals and their relationships to information-seeking behavior or strategies. For example, Hert's (1996, 1997) user goal definition – what a user attempts during the interaction – is more comparable to current search goal. She focused on whether users' goals were changed and how their' goals affect their interactions with online public access catalogue (OPAC) systems. In Slone's (2002) investigation of the influence of goals on search patterns in web interaction, users who sought broad and/or situational goals, such as job-related, educational, recreational, or personal-use information, are related to leading search goals; specific current search goals consist of searching for historical or background information, known persons or organizations, or current information. As part of current search goals, users also set format goals for the necessary information, such as detailed text, brief text, non-textual data, and e-mail.

As with goals, task can be broken down into levels. Byström and Hansen (2005) developed a conceptual framework in which information seeking is a subtask to a work task and information searching is a subtask of information seeking. Work tasks are the main focus in studies on tasks, even though researchers did not specifically label task as "work tasks." Derived from empirical studies, Kuhlthau's (1991) information-seeking model associated phases in task performance with the feelings, thoughts, and behaviors involved. Pennanen and Vakkari (2003), Vakkari (2000a, b, 2001), Vakkari and Hakala (2000) and Vakkari *et al.* (2003) conducted a series of studies to examine the task performance of writing a research proposal for a master's thesis. Byström and Järvelin (1995) explored the complexity of work tasks and its impact on information seeking and use. Applying cognitive analysis, Fidel *et al.* (2004) – in their study of collaborative IR – analyzed a work task, such as the design of navigation functionality. Kim and Allen (2002) probed the effect of two work tasks (writing a term paper versus writing an article for the student newspaper) on participants' search behavior. Freund *et al.* (2005) further conducted correspondence analysis to identify relationships between work task and document genre in different dimensions.

In addition to work tasks, search tasks are frequently studied variables, such as Shiri and Revie's (2003) topic complexity; Sutcliffe *et al.*'s (2000) ambiguous statement of search tasks; Kim and Allen's (2002) known-item and subject-search tasks; and D'Alessandro and Kingsley's (2002) common-pediatric problems. In search-task studies, users conduct assigned tasks in experimental settings. For example, Bilal (2002) compared children's behavior and success in three types of tasks: assigned fact-finding, assigned research-oriented, and self-generated tasks. In Text REtrieval Conference (TREC) studies, tasks are assigned for different teams to compare search performance. For example, in TREC-10, researchers found that the types of assigned tasks on shopping, medicine, travel, and research topics affect searchers' perception and behavior (Toms *et al.*, 2002; Hersh *et al.*, 2002).

Dimensions of work task

Echoing Vakkari's (2001) suggestion, Berryman (2006) emphasized the need to develop a task structure because task not only associates with how users seek information, but also more importantly, it is the basis for users' assessment of whether or not they have found enough information. Researchers have identified different aspects of tasks and their impact on the information-seeking and -retrieving processes. These aspects can

be labeled as dimensions of tasks. Dimensions of work tasks can be characterized as: nature, stages, and timeframe of the tasks.

Nature of the task. The nature of the task defines the task itself. One of the key dimensions of tasks is complexity. Based on a priori determinability or structuredness of task, Byström and Järvelin (1995) classified tasks into the following categories: automatic information-processing, normal information-processing, normal decision, known, and genuine decision tasks. They concluded that task complexity has systematical relationships with the types of information, information channels, and sources needed. Byström (2002) further identified the relationship between task complexity and information-seeking activities, focusing on task uncertainty and analyzability. The results of the study indicated that the higher the level of task complexity, the more types of information and sources are needed. de Alwis *et al.* (2006) analyzed managers' information-seeking behavior in the literature and found that work-related variables, including the nature and complexity of the tasks, determine managers' choice of information sources, in addition to situational variables related to organizations-, personal- and social-cultural and informational variables associated with information resources themselves. Based on the situations of the tasks, Slone's (2002) broad or situational goals, such as educational, recreational, job-related, and personal-use goals, are similar to work tasks that reflect different types of situations. The findings showed that children and adults older than 45 presented similar search approaches. One possible explanation for this is that recreational goals were identified more by children while personal goals were highly related to older adults, and both of these goals were found less motivating than educational or job-related goals.

Leide *et al.* (2007) identified task structure as the essential nature of the task – in particular, different essay types. They further tested whether a task-focused visualization device can effectively assist students in their task performance even though the result is inconclusive. Kim and Allen (2002) revealed that task has significant effect on precision. The term-paper writing task showed higher precision than the newspaper-article writing task. Interacting with search engines and cognitive abilities, the type of task was also found to influence how users searched the web. In one word, tasks of a different nature require different strategies, and the search performances might also be different.

Stages of the task. Not all searches can be done within one step. In many cases, users have to go through different stages in order to achieve their work tasks. Kuhlthau (1991) identified six information-seeking stages: initiation, selection, exploration, formulation, collection, and presentation. She also specified physical actions, cognitive thoughts, and affective feelings that are related to these stages. Pennanen and Vakkari (2003), Vakkari (2000a, b, 2001), Vakkari and Hakala (2000), Vakkari *et al.* (2003) identified three stages in task performance: pre-focus, formulation, and post-focus. While the pre-focus stage corresponds to Kuhlthau's initiation and selection, the post-focus stage associates with collection and presentation. Vakkari (2000a) and Vakkari *et al.* (2003) also investigated how changes in users' problem stages were associated with changes in search tactics and term choices. The more focused users' understanding of their tasks is, the more specified search terms, additional operators, and additional tactics were used. Vakkari (2000b) and Pennanen and Vakkari (2003) focused on the research of relationship between the changes in users' problem stages and types of information sought. They found in the pre-focus stages that users were searching for background information, as well as theories and models, for the

research proposal. In the focus phase, they still sought what they were looking for in the first stage, but also acquired methods and focused information. In the final stage, users looked for specific information; methods and empirical research results were also useful to them. Vakkari and Hakala (2000) explored how changes in problem stages affected changes in relevance criteria during the task-performance process. They identified a relationship between a changing understanding of task and how users judged the relevance of documents.

Timeframe of the task. Timeframe is an important dimension in defining tasks. In time-sensitive environments such as hospitals or corporate settings, the ways users search for information are limited by their availability. According to McKnight (2007), critical care nurses gain information mainly from interacting with charts and patients. Lack of time prevents them from access to published information even though libraries and computer systems are available. Pharo (2004) developed the search situation and transition model; he defined attributes of work task as goal, complexity, size, and stage based on both theoretical and empirical studies. These attributes correspond to the dimensions identified above. Size of the task is determined by the number of working hours assigned to it, which associates with timeframe of the task.

Dimensions of search task

Different types of searches represent another dimension of search tasks. Researchers have examined common types of search tasks: fact-based, known-item, and subject- or research-based searchings. Schacter *et al.* (1998) discovered that children were better at performing ill-defined than well-defined tasks that are similar to research- and fact-based tasks. The children had to apply more analytical strategies in order to complete well-defined/fact-finding tasks. Bilal (2002) reaffirmed the Schacter *et al.*'s (1998) findings. Kim and Allen (2002) reported the significant effects of subject search versus known-item search on precision and recall, search time, the number of pages viewed, the number of embedded links used, and jump tools used as well as the number of keyword searches completed. Slone (2000) explored and identified information-seeking strategies associated with three types of searches: unknown-item, area, and known-item searches. The results showed that term generation is the driving force for unknown-item searches, where the basic strategy is to formulate a query, evaluate the results, and reformulate the query if necessary. For area searches, users quickly look for a few records from OPAC and complete their searches by browsing the shelves. Query-matching is more related to known-item searches because accuracy and simplicity are most important for this type of search.

Bilal (2000, 2001) reported on children's (seventh grade students) cognitive, physical, and affective behavior in using the Yahoo!igans! search engine on fact-based and research tasks. For fact-based tasks, more children adopted the keyword searching approach (64 percent) than the browsing approach (36 percent). The children who used the keyword approach were nonconforming and certain about the keywords, while the children who applied the browsing approach were systematic and orderly. For research tasks, children browsed more than they searched by keyword. Only one child used natural language queries. The results indicated that the children browsed and searched by keyword more in fact-based tasks than in research tasks. Simultaneously, they made more moves and took more time to accomplish fact-based tasks than research tasks. The findings of this study uncovered the problems of the design of Yahoo!igans!

Complexity of task is not only a dimension of work tasks but also a dimension of search tasks. After comparing children's behavior and success on self-generated tasks with fact-finding and research-oriented tasks, Bilal (2002) discovered that children browsed more and made more moves on the self-generated tasks than the other two types of tasks, and they were more successful on the self-generated tasks. While their motivation to pursue their topics of interest and their ability to modify topics contributed to the success, the simplicity of the self-generated task is also a main reason for the success on such tasks. Ford *et al.* (2002) investigated the relationships between tasks and system performance. The selected two tasks represented different levels of difficulty. The findings showed that simpler tasks correlated significantly with higher relevance scores. The complexity of tasks can also be affected by the description of tasks if they are assigned. After investigating end-user information-searching of the MEDLINE database, Sutcliffe *et al.* (2000) found that the ambiguous statement of search tasks might contribute to the poor performance of these tasks.

Domain of the task refers to the field of the content of the task. The most popularly searched domain tasks for web search – shopping, medicine, travel, and research topics – were selected as the search tasks for TREC-10. Hersh *et al.* (2002) found that domain of the task affected the searchers' behavior and efficiency; in particular searchers took the most time and the most page views for shopping tasks among all the tasks. Toms *et al.* (2002) discovered that the perception of search task difficulty and satisfaction with results is associated with the domain of the task. In these studies, the shopping tasks were more difficult to accomplish and less satisfying than the other tasks. However, there is no theoretical basis to account for this phenomenon.

Considering the limitation of the previous classification schemes for work or search task, Li and Belkin (2008) developed a faceted classification scheme of tasks which is able to characterize both work and search tasks. Based on the analysis of previous research, they identified generic facets of tasks consisting of source of task, task doer, time action, product and goal as well as attributes of task including task characteristics and user's perception of task. In addition, they also defined the associated sub-facets and values. Li (2008) further validated the classification scheme in a university community. It would be helpful if the key dimensions for work and search tasks can be identified from empirical studies from different settings.

Limitation of previous research

Researchers have theoretically and practically identified task as one of the key factors that affect users' information-seeking and -searching processes. Some researchers further identify dimensions of work and search tasks that affect the IR process. However, previous research on task has its limitations:

- There are more theoretical discussions and less-empirical studies on relationships between task and the IR process. While there are more works on task in general, there is less research on dimensions of task and their influences.
- While some of the studies have unveiled the impact of dimensions of task on the IR process, they mostly focus on the impact of only one or two dimensions on one issue of the IR process.
- In testing the impact of dimensions of task, existing research only examines one type of task in a specific environment, such as an academic or corporate setting.

Very few studies have investigated different types of tasks in different environments. This study intends to fill in the gap of the current research – the impact of dimensions of task on the information-seeking and -retrieving process in different settings.

Research problem and questions

Previous research has demonstrated that tasks do influence the information-seeking and retrieving process. Different aspects of tasks affect information seeking and retrieving in different ways. However, few studies investigate how tasks, in particular the dimensions of tasks influence user decisions and behaviors in the IR process. Moreover, existing studies in general only focus on one dimension of task. There is a need for researchers to identify dimensions of tasks and further explore the relationships between dimensions of tasks and the information-seeking and -retrieving process. In this research, the author continues her previous research on task as one type of interaction activity between actors and work domain (Xie, 2006).

This paper addresses two research questions:

RQ1. What are the types of dimensions of tasks?

RQ2. How do dimensions of tasks affect users’ information-seeking and -retrieving processes? In particular, to what extent did participants plan for the searching and retrieving process? What were the different types of information-seeking strategies that participants applied in the searching and retrieving process? Did participants change their search-task-related goals? If so, how?

Methodology

In order to have a more comprehensive representation of tasks, the author conducted studies in two different settings: corporate and academic. One of the major objectives of these two studies is to explore how tasks affect their information-seeking and -retrieving processes (Table I).

The first study was conducted in a large international corporation in Milwaukee. Multiple methods were applied to collect data: web-based survey, information

Research questions	No. of participants	Data collection	Data analysis
<i>RQ1.</i> What are the types of dimensions of tasks?	20	Web survey	Taxonomies of dimensions of tasks and descriptive analysis
	21	Pre-questionnaire	
	30	Information interaction diary	
	20	Telephone interview	
	20	Post-questionnaire	
<i>RQ2.</i> How do dimensions of tasks affect users’ information-seeking and -retrieving processes?	30	Information interaction diary	Relationships between dimensions of tasks and users’ plans, strategies, and changes of goals; descriptive analysis
	20	Telephone interview	
	20	Post-questionnaire	

Table I. Data collection and data analysis plan

interaction diary, and telephone interview. A web-based survey was posted on the company homepage and its digital library site. The survey asked participants for:

- demographic information;
- the typical types of tasks they normally have to accomplish; and
- general patterns of information resource uses.

A total of 263 employees filled in the survey. In total, 20 participants representing a variety of job titles were chosen from those who agreed to be part of the second-phase study, and these participants' surveys were analyzed.

These 20 participants were asked to keep an "information interaction diary" for two search tasks within a two-week timeframe, and to use the diary to keep track of their information-seeking interactions in the order in which they took place. Participants were required to record the following information in the diary:

- work task;
- search tasks;
- time spent on each of the tasks;
- information resources/systems used;
- types of people consulted and databases/publications selected;
- queries used and search process carried out;
- outcomes of using each information resource; and
- factors leading to the success or failure of each of the resources or systems used.

The diary provides a record of activities related to two search tasks a participant engaged in over a two-week period. Ten participants returned their diaries before the telephone interviews, and another ten participants kept their diaries as their notes for interviews.

After they finished their diaries, telephone interviews were conducted with participants because they were located in different parts of the country. The interviews focused on general information:

- typical work-related tasks and goals which precipitate information seeking behavior;
- typical information interactions associated with these tasks and goals;
- reasons for interacting with specific information resources or items;
- typical information-seeking problems encountered; and
- typical ways of solving the problems.

These interviews attempted to verify and enrich the diary content. More importantly, they probed for more information related to participants' information-seeking processes when searching for the two specific tasks. For the ten participants who did not return their diaries, the interviewer asked questions about the two search tasks and related information as stated in the diaries. All interviews were tape recorded and transcribed.

The second study was conducted in an academic setting. The 21 participants were students who were recruited from a large state university in Milwaukee.

These participants were enrolled in a class in which they were required to write a research proposal as a final project. The data collection process lasted a semester (about three months), and the data were collected by using a pre-questionnaire, information interaction diary, and post-questionnaire:

- (1) The participants were instructed to fill out a pre-questionnaire that requested their demographic information, the typical tasks that normally lead them to search for information and associated information-seeking behaviors, past experiences in information seeking and retrieving, their plans to accomplish their research proposal writing tasks, and other information. The majority of the participants are female (66.7 percent) and between 21 and 30 years of age (76.2 percent).
- (2) The participants were instructed to keep an information interaction diary of their information-seeking and -retrieving processes for writing their research proposals. Each subject recorded the following information: research proposal topic, search topic, the time spent on each of the information resources, types of interactions with each information resource, types of problems encountered, how they solved the problems, results of their interactions, their next steps, and other information. In total, 20 participants returned their diaries.
- (3) After the participants were done with information seeking and retrieving, they were instructed to fill in the post-questionnaire, which asked for changes in their search tasks and associated reasons; their assessment of each information resource in terms of accessibility, frequency of use, and satisfaction level; and the types of problems they encountered and how they solved the problems. Most importantly, they were asked to provide information related to their interactions with information resources and associated reasons for writing their research proposals.

Both qualitative and quantitative data collected from the multiple methods were analyzed. Qualitative data were analyzed by using open coding (Strauss and Corbin, 1990), which is the process of breaking down, examining, comparing, conceptualizing, and categorizing. Quantitative data were tallied and analyzed for descriptive analysis. For these two studies, every work task was recorded and analyzed with its corresponding search task, user's plan and associated reasons, user's strategies and associated reasons, problems encountered and how they were solved, as well as whether or not search task related goals had changed. The relationships between dimensions of task and a user's plan, application of search strategies, and change of search task related goals were analyzed based on the reasons associated with plans, strategies, and change of goals. Table II presents the coding sheet. The examples of each category and their relationships are analyzed and presented in the "Results" section because of space limitations.

Work task	Search task	Plan developed and associated reasons	Strategies applied and associated reasons	Problems encountered and how they were solved	Change of search-task-related goals and associated reasons

Table II.
Coding sheet

Results

The findings of these two studies focus on answering the two research questions proposed above. The results present:

- the types of dimensions of work and search tasks; and
- how dimensions of tasks influence users' information-seeking and -retrieving processes, in particular the extent to which participants planned for the searching and retrieving process, the types of information-seeking strategies that they applied in the searching and retrieving process, as well as whether and how participants changed their search-task-related goals.

Types of dimensions of work tasks

Three types of dimensions of work tasks emerged from the data:

- (1) nature of task;
- (2) stages of task; and
- (3) timeframe of task.

One interesting finding is that not all dimensions of work tasks are equal. Some dimensions can be applied to more work tasks than other dimensions. Table III presents the frequency and percentage for dimensions of work tasks.

The nature of task refers to participants' familiarity with the task. In these two studies, the nature of task can be represented by three types of tasks: routine, typical, and unusual. Here, routine tasks refer to those regular tasks that participants have to perform repeatedly. Typical tasks refer to the types of tasks that participants are used to performing, but they have not preformed the exact same task before. Unusual tasks refer to those tasks that participants have not encountered before.

In the study at the corporate setting, employees mostly worked on routine and typical tasks. Among the 40 cases recorded, 77.5 percent of them are typical tasks. Routine and unusual tasks only account for 15 and 7.5 percent, respectively. For example, typical tasks include looking for the syntax of a command or information regarding a competitor's products. While routine tasks involve updating agricultural information everyday, unusual tasks consist of looking for tax information in a foreign country. In the study

Dimensions of task activities	Corporate study (n = 40)		Academic study (n = 20)	
	Frequency	%	Frequency	%
<i>Dimension 1: nature of task</i>				
Routine	6	15	0	0
Typical	31	77.5	13	65
Unusual	3	7.5	7	35
<i>Dimension 2: stages of task</i>				
Pre-focus	4	10	21	100
Formation	40	100	21	100
Post-focus	6	15	21	100
<i>Dimension 3: timeframe of task</i>				
Extremely urgent	6	15	0	0
Urgent	16	40	0	0
Non-urgent	18	45	21	100

Table III. Frequency and percentage for dimensions of work tasks

conducted in the academic setting, participants also had different types of routine and typical tasks. In this study, the research focuses on their research proposal writing task. For participants, the nature of this task was different. About 65 percent had written a thesis or research paper before; this task became a typical task for them. For those who had not written a thesis or paper before (35 percent), this is an unusual task for them.

Stage is the second dimension of work task. Kuhlthau (1991) identified six information-seeking stages: initiation, selection, exploration, formulation, collection, and presentation. In order to write their research proposals, participants of the academic study went through several stages, which can be characterized as pre-focus, formulation, and post-focus, as identified by Pennanen and Vakkari (2003), Vakkari (2000a, b, 2001), Vakkari and Hakala (2000) and Vakkari *et al.* (2003). The pre-focus stage refers to the stage when participants explore ideas for the task. The formation stage refers to the stage when participants define the idea for the task. The post-focus stage refers to the stage when participants add an extra aspect for the task.

In the academic study, all the participants went through the three stages for writing their research proposals. At the pre-focus stage, they started conducting literature searches or talking to faculty members or librarians for ideas. At the formation stage, they searched for a more focused idea. At the post-focus stage, they looked for some aspects of the topic that have been found or checked with instructors or libraries for more information. However, not all work tasks contain multiple stages. If a task is very straightforward, then participants would only go directly to the formulation stage. In the corporate study, those unusual tasks involved multiple stages. In addition, a knowledge specialist who searched for her client also went through multiple stages. While all the participants worked on the formation stage for their work tasks, about 15 percent of these tasks also required people to engage in a post-focus stage to acquire more information.

Timeframe is another important dimension of work task. Timeframe refers to how much time a person has to fulfill the task. In these two studies, the timeframe varies for different tasks. In the corporate study, the timeframe of participants' tasks can be defined as extremely urgent, urgent, or non-urgent. Here, extremely urgent, urgent, and non-urgent refer to these tasks that have to be accomplished within half-an-hour, 24 hours, and more than 24 hours, respectively. Extremely, urgent and urgent tasks take account for more than half (55 percent) of the tasks. For the study conducted in the academic setting, each participant had the same timeframe – about three months. In that sense, they all worked on the non-urgent task. However, not everyone had the same starting date. Some of them started early, and some of them began their search process later.

Types of dimensions of search tasks

As work tasks, there are three types of dimensions for search tasks that emerged from the data. Dimensions of search tasks can be characterized as:

- (1) origination of the task;
- (2) types of the task; and
- (3) flexibility of the task.

Table IV presents the frequency and percentage for dimensions of search tasks.

The first dimension of the search task is origination of the task. Two types of origination of tasks emerged from the data: self-generated and assigned tasks. Self-generated tasks refer to these tasks that participants come up with themselves.

Table IV.
Frequency and
percentage for
dimensions of search
tasks

Dimensions of task activities	Corporate study (n = 47)		Academic study (n = 57)	
	Frequency	%	Frequency	%
<i>Dimension 1: origination of task</i>				
Self-generated	39	83	52	91.2
Assigned	8	17	5	8.8
<i>Dimension 2: types of task</i>				
Update information	5	10.6	0	0
Look for specific information	16	34	4	7
Look for items with common characteristics	23	48.9	44	77.2
Look for known items	3	6.4	9	15.8
<i>Dimension 3: flexibility of task</i>				
Very flexible	8	17	49	86
Flexible	13	27.7	8	14
Inflexible	26	55.3	0	0

Assigned tasks refer to tasks that are delegated or suggested by people other than participants themselves, such as clients, colleagues, instructors, or librarians. In the corporate study, the majority (83 percent) of search tasks are self-generated; about 17 percent of their search tasks are assigned by their clients or supervisors. As part of their class assignment, each participant in the academic study had to write a research proposal. In order to accomplish this work task, some of the participants contacted their instructors and consulted librarians. The instructors and librarians sometimes suggested different search tasks (8.8 percent) for them to work on.

The second dimension of the search task is the types of task. The types of task can be classified into the following categories:

- update information (e.g. keep track of information about new agricultural equipments);
- look for specific information (e.g. look for a syntax);
- look for a known item (e.g. look for an item for which a user knows the title); and
- look for items with common characteristics (e.g. look for items on the same subject).

The data from the corporate study showed that looking for specific information tasks (34 percent) and looking for information with common characteristics tasks (48.9 percent) accounted for more search tasks than updating (10.6 percent) and looking for known item tasks (6.4 percent). The results of the academic study presented different ratios for the types of search tasks conducted by participants because of the same work task. Looking for items with common characteristics (77.2 percent) accounted for the majority of the search tasks. At the same time, participants also looked for known items (15.8 percent) based on their own materials, suggestions from instructors and librarians, as well as retrieved results. Very few search tasks were related to looking for specific information (7 percent). None of the search tasks involved updating information.

The third dimension of the search task is the flexibility of the task. The flexibility of search task determines whether a participant can change, modify, or stick to the task.

The results of the two studies indicated that three levels can be used to define the flexibility of search tasks: very flexible, flexible, and inflexible. Very flexible refers to tasks that can be changed, yet participants are still able to fulfill their work tasks. Flexible tasks are those that can be modified in the process of achieving work tasks. Inflexible tasks are those tasks that cannot be changed or modified. The flexibility of search tasks largely depends on dimensions of their work tasks. The results show that writing a research proposal work task allowed more flexibility for participants because they could choose any topics for the research proposal. Therefore, the majority of the search tasks are very flexible (86 percent) or flexible (14 percent). In the corporate study, more than half of the search tasks are inflexible (55.3 percent) because of their more specific work tasks. For example, a subject was looking for a syntax in order to run a program; as a result, he could not change or modify the search task.

The identification of dimensions of work and search tasks corresponds to the classification scheme developed and tested by Li (2008) and Li and Belkin (2008). For example, the nature of work task can be associated with both objective and subjective task complexity, and stages and timeframe of work task can correspond to time of task. The origination of search task is similar to the source of task; the only difference is that collaboration is considered part of assigned search task instead of a separate value in this research. In addition, this research also identified types and flexibility of search tasks that were not in the classification scheme developed by Li and Belkin (2008).

Influence of dimensions of tasks

There is no doubt that tasks, in particular the dimensions of tasks, affect people's application of information-seeking strategies. The question is how dimensions of tasks influence their information-seeking and -retrieving processes. Based on the results of the data, the findings of these studies intend to answer the following questions regarding the influence of the dimensions of tasks:

- RQ2a. To what extent did participants plan for the searching and retrieving process?
- RQ2b. What were the different types of information-seeking strategies that participants applied in the searching and retrieving process?
- RQ2c. Did participants change their search-task-related goals? If so, how?

Extent of planning. Among the work tasks, the decision regarding the extent to which participants planned for their searches is mainly determined by the nature of tasks. Interestingly, these two studies yielded different responses for planning. The majority of the participants in the corporate study said they did not plan for their searches. Almost everyone in the academic study responded that they did plan for their searches.

While many of the participants of the corporate study claimed that they did not plan for the searches, they did, however, at least identify the information resource that they were going to use first. People in general work on the same types of work tasks. Therefore, they consciously and unconsciously develop specific information-seeking strategies for each type of routine and typical task. These strategies are part of their plans, whether they realized it or not. Here, is an example of a participant's typical task:

If I'm looking for technical information on COBOL, I usually go out to the Internet to a specific site and look up books. If I'm looking for information from a particular vendor, I'll go out to the vendor site and search for a particular product. If I'm looking for business information, then I usually establish or set up a meeting with our clients to discuss how they are doing a project, or doing the process.

For routine tasks, participants did not need to plan because the strategies applied in achieving these tasks became part of their tasks. For example, a participant gave an example of how he worked on routine tasks:

The majority of what I would look for I already have found some information and bookmarked those sites. I would just go back there for additional information. I have categories for different topics and then underneath that I have specific sites.

Rarely did participants have to work on unusual tasks that were not familiar to them. However, unusual tasks require more planning since their strategies for typical tasks might not work. Here, is an example of how a participant dealt with an unusual task:

I planned the topic to search and then some search terms, as well as resources to use. I also thought about what to do for a back-up plan for different resources and different search terms.

While routine, typical and new tasks affect participants of the corporate study in terms of whether or not they plan, or what to plan, participants of the academic study's planning are more affected by academic tasks than personal tasks. Nine of the participants stated they did not plan for general situations, but all the participants planned for their information-seeking and -retrieving process for their research proposals. One participant put it well:

This typically depends on the type of information I am searching for. If my search is academic, I am more likely to plan, at least mentally, the databases or resources I intend to search. I also have an idea of the terms or limiters I may wish to use. Often with personal searches, it is more in-the-moment searches that are unplanned or unexpected queries that I search.

Academic searches are more complicated and require more cognitive process than personal searches.

Different stages of tasks require different planning. At the pre-focus stage, participants needed to clarify their information need and convert their information need from visceral to compromised need as stated by Taylor (1968); therefore, their planning focused on exploring different topics and searching for general information. At the formation stage, they planned more for the specific topic or specific item as well specific IR systems for searching. At the post-focus stage, they planned for more specific queries and searching tactics. Unlike participants in the corporate study, participants in the academic study went through stages of their research proposal writing. Here, is an example of a participant's plan at different stages. In the pre-focus stage, she planned for the specific online database (ERIC) and several topic ideas and general terms. At the formation stage, she planned a specific online database (ERIC) and several specific terms on a determined topic. At the post-focus stage, she selected Google Scholar and planned to browse it for more information on the topic.

Obviously, the timeframe of tasks influences whether or not participants planned for their searches. Participants had more time to plan for their searches in

non-urgent situations. Under extreme urgent situations, they were more directed by their situations. That is why more participants in the academic study had more specific plans for their searches than did participants in the corporate study; they had more time to work on searching for information related to research proposals than on searching for information for work-related tasks in corporate settings. Just as one participant stated, “For this task, I have to finish within five minutes because the client is waiting at the end of the phone. I do not have time to plan.”

Among dimensions of search tasks, different types of tasks require different planning. Updating information, looking for specific information, known items, and items with common characteristics are the common types of search tasks. In the corporate study, looking for specific information and looking for items with common characteristics are the most popular search tasks. These tasks require different levels of planning. For example, one participant stated:

It doesn't really require a real lot of planning when I look for the syntax (specific information) because I've already narrowed down what I'm looking for to a pretty specific area. If I look for technical information (items with common characteristics), I will do a little more background check and be ready for that call because that is person-to-person usually. I want to list all the questions I want to ask.

In the academic study, looking for items with common characteristics are the most engaged search tasks. For that purpose, their planning involves the following: the information resources that they would access, the order of the information resources that they are going to use, strategies they might apply, and a potential change to their original topic. Here, is an example of the order of resources that a participant planned to go through: online research, databases; catalog search and shelf browsing; reading; asking people (informants) questions; information synthesis, new facets/questions/ideas to research, and back to A.” Another example from a participant illustrates her plan: “My plan is to use as many information-seeking strategies as possible. Start with the ones that I know and then branch out. Seek help when necessary.” Interestingly, none of the participants planned when to stop searching.

Updating information is a routine task, and participants normally do not plan for this type of task. However, they always apply the same strategies to fulfill the same task. These strategies are their unspecified plan. Scanning and reading electronic and printed information represent the typical information-seeking behaviors applied for this type of task. One subject illustrated his strategies for updating information:

Part of my job is to update agriculture information. I signed up for the types of information I'm interested in and I receive daily updates. I look at these updates every day. I scan the first paragraph of an article to confirm whether it's relevant to me. If it is, I'll print out a hard copy that I can read at my leisure. Most of the information I need is in rural locations and can be difficult to find because it isn't “front page” information. I have to really drill down.

The flexibility of task has less impact on planning when compared with other dimensions of search task. It mainly affects whether an individual's plan involves a change of topic. Search tasks in the academic study are more flexible than in the corporate study. Therefore, some of the participants in the academic study had plans for changing topics. For example, in describing his plan, one participant said:

I'm going to look into a topic I'm interested in, first looking on the open Web and then for databases and libraries. After a lot of this, I'll change my topic at the last minute.

Assigned or self-generated search tasks determine whether participants planned themselves or collaborated with other people to plan their search tasks together. If participants work on self-generated tasks, they plan themselves. However, if they work on an assigned task, then they normally work with people who assigned or suggested the search task to them. In the corporate study, participants either worked on their own search tasks or were assigned tasks by their internal or external clients. Here, is an example of how a client helped a participant to plan for the assigned task:

The person in charge of the project asked me to find the topic: three to five vendors developing “dashboard” software. He gave me three companies involved in this. The names were [...]

In the academic study, participants either worked on their self-generated tasks or on assigned tasks suggested by an instructor or librarians. Here, is an example of how a participant planned the search with the instructor: “I expressed my ideas, and the professor expressed her ideas. Together we formulated a few useful hypotheses for the paper and information-seeking strategies.”

Application of different types of information-seeking strategies

Limited by what participants recorded in their diaries, their application of information-seeking strategies mainly focus on the types of information resources they chose, the number of resources they accessed, exploration and query formulation strategies, and validation/pearl-growing strategies.

Among the dimensions of work tasks, the stages of tasks play a major role in influencing users' application of information-seeking strategies. Here, the author used the example of the academic study to illustrate its influence, since the majority of participants in the corporate study did not go through stages of information seeking and retrieving. In the pre-focus stage, 26 percent of the participants tried to identify some information to get started by consulting the instructors of their classes and librarians. In addition, they browsed the internet and libraries to look for information for potential topics. A subject, in describing her experience, said, “I browsed the Internet for two days, found irrelevant information.” Another subject specifically browsed ERIC and Google Scholar. Some participants chose to browse in the library. For example, one participant “went to public library and browsed in ‘Reading’ sections, and selected three books.” About 68 percent of participants also changed search topics to make sure they could find enough useful information as well as cognitively engage in these topics for their research proposals.

At the formation stage, participants were fairly settled with the topics of their research proposals. Accordingly, they searched and browsed their selected search topics mainly from online databases (e.g. Academic Search Elite, ABI/Inform database and ERIC), web search engines (e.g. Google and Google Scholar) and OPACs based on their preferences. While they focused on exploring different topics at the pre-focus stage, at the formation stage, they focused more on how to formulate the query to represent their topics. All of them had to reformulate their queries; on average, participants reformulated three queries. Here, is an example of a participant's queries: “self-check machines, libraries-automation, radio frequency identification systems and libraries and libraries, radio frequency identification systems, and library automation.” Moreover, in order to find information on a topic, participants used the same terms in different

online databases. In the example above, the participant applied the same terms in both ABI/Inform and the Library Literature and Information Science databases.

At the post-focus stage, participants either checked whether they missed anything or tried to add one aspect of the search topic. During this stage, they applied the following strategies to validate or enhance their searches. First, 16 percent of them checked with human resources about their search results from the formation stage including instructors, staff, librarians, and fellow students. For example, one participant checked the ALA web site, as suggested by another student. Second, they used the pearl-growing strategies. More than 80 percent of participants went through their retrieved results and looked for documents like the relevant one based either on citations of these items or on subject areas mentioned in these articles. Some of them browsed the subject heading of the relevant items. Third, 21 percent of the participants searched for different formats of documents, from online databases to OPACs for books, and from online databases to web pages for web site information (e.g. American Library Association site and Wisconsin Education Association Council).

The timeframe of the search task mainly affects the types and numbers of resources people choose to use. More than half (55 percent) of the tasks participants performed had to be fulfilled within 24 hours. Under urgent situations, participants need to find information as effectively as possible. One participant described their information-seeking strategy under urgent situations:

I work in the Technical Service Group and I take phone calls from external dealers who have concerns about equipments sold by CNH. Most of the questions that I get from the dealers are related to problems that need to be resolved within twenty-four hours or maybe sooner, so I can't really say I'll have the information in a week or two from now because the person who manages the archives is gone. The existing archives are paper-based and managed by a retired employee who works part-time. I needed information from the archives and was told I'd have to wait two weeks because the archivist was on vacation. I tried to get information within five to ten minutes while the dealer was on the phone. Therefore, I turned to people who've been here for quite some time and know the older equipments.

In the academic study, the average participant spent about 278 minutes searching for information; searches ranged from 40 to 690 minutes. It is interesting to note that the two participants who spent the least time (40 and 50 minutes) started one month before the deadline, and the participant who spent the most time (690 minutes) started three months before. Comparatively speaking, the participant who started early also accessed more information resources/IR systems than the two participants who started later. More detailed analysis could not be conducted because some of the participants failed to record the starting date in their diaries.

Comparatively speaking, the impact of the nature of work task on search strategies is less. Just as discussed in section on the nature of work task on planning, participants, in particular those in the corporate study, have their own strategies for their routine, typical, and unusual tasks. In routine tasks, they mostly went to the sites they bookmarked and scanned new information because their routine tasks are related to updating information. For example, a participant, in describing his routine task, stated:

The type of information I look for is business information – mostly agricultural-related such as crops, conditions, or prices. I look for this information daily by going to the bookmarked site and scanning related information.

In typical tasks, their strategies were highly associated with the information resources they would use. For example, a participant always went to a person or to the Oracle site for information related to bugs within the Oracle system. According to her:

I am an Oracle developer and I needed to figure out some bugs. I was looking for information to help me debug. I did not ask a human first because no one was around when I needed this information. I know the Oracle URL, and I've used the site frequently, so I typed the URL and went directly to the site.

For unusual tasks, they applied strategies depending on different situations.

The types of search tasks are the most important dimensions that affect individuals' application of information-seeking strategies. Each type of search task has its own associated information-seeking strategies. Participants normally specified information of a known item to look for that item, such as title or author. For example, a participant searched for an article by a specific title based on references of an article by specifying the title in an online database. Participants applied specifying and manipulating strategies to formulate and reformulate queries to look for items with common characteristics. In addition, they also browsed a location/category/special issue of the journal/site to find information with common characteristics. They also used the pearl-growing strategy to find articles that cited an author or one of the relevant or useful articles to find similar documents. For example, one participant tracked descriptors of retrieved items on library automation and checked to find similar documents. Another participant searched for articles that cited an author who did research on information searching. Looking for specific information requires the combination of creating search statements, modifying search statements, and evaluation. For example, one participant looked for specific information about a piece of equipment. She tried to search for the equipment by using the equipment number and other identifiers. Then she read through the document to find information she was looking for; scanning through electronic or printed information are the strategies applied for updating information.

Comparatively speaking, the origination of search tasks has less impact on participants' application of information-seeking strategies; however, if people who assigned the task made some suggestions about resources and terms to use, then the origination of search tasks has greater influence on the resources and terms used for queries. In the examples discussed in the planning section of this paper, for the corporate study, the participant received information about three vendors which helped her to make a decision to go to the three vendor sites first and then search the vendors' names in another IR system. For the academic study, as the participant worked with the professor to develop the hypotheses of the research proposal, he also used the terms in these hypotheses as his query terms.

The decision of shifting of search goals

In general, people do not change their work-task-related goals mainly because these are part of their job responsibility, or they are academic requirements for a degree. However, they do change their search-task-related goals either actively or passively. Some of the changes of search task goals are directed by a change in a subject's interest, and some of them are determined by problematic situations that they encountered. Dimensions of work and search tasks affect whether search task goals change, and how they can change. The academic study discovered the three types

of shifts in search task goals: planned, alternative, and opportunistic shifts, which were identified in the author's previous work (Xie, 2000). About 68 percent of the participants made changes to their original search task goals. Only 32 percent of them did not make changes to their search task goals during their information-seeking and -retrieving processes.

Even though their work tasks did not change, they did affect changes of the search task goals. Planned shifts, within the scope of the work tasks, occurred when participants did not actually shift their search tasks; instead, they modified their original search tasks. These shifts occurred as part of the plan. One type of planned shift is a shift that narrows down the original search task; it is part of the plan that participants have in mind. Participants normally started with a broad search task, and then narrowed it down in the search process. For example, one participant narrowed her topic from museums, to something with museums, and finally to how digital libraries of museums affect museum attendance, after consulting with the instructor and searching in online databases. Work tasks mainly define the range of alternative shifts in search task goals. When a participant could not find enough useful information regarding disabilities and library services, and how the Patriot Act affects library services, she had to make an alternative shift in search task to find information related to services for immigrants in public libraries. The new search task had to be related to library and information science as required for the research proposal. Opportunistic shifts occurred when participants found something interesting in the process of achieving their original search task goals. At that time, they encountered disruptive situations.

As to the dimension of work tasks, changes of search task goals in general occurred in their pre-focus stages when participants were still exploring the potential topics of the research proposal. The academic study showed that participants shifted more search-task-related goals in their pre-focus stage, when they were trying to identify their research proposal topics. One participant was initially interested in finding information regarding visually impaired users' use of OPACs. She searched several online databases and emailed librarians for more information. However, when she reviewed the retrieved documents and information provided by the librarians, she found that visually impaired users do not use OPACs. At the same time, she did find articles related to the information-seeking habits of visually impaired users quite interesting. Therefore, she shifted her original search task goals to information-seeking strategies of visually impaired users. This is a combination of opportunistic and alternative shift, because the retrieved results simultaneously forced the subject to change and offered her an opportunity for the new search task. At the formation stage, participants only modified their topics as needed. At the post-focus stage, they did not change or modify their search goals.

Changes of search task goals are also related to the timeframe of the work task. The participants in this study had about three months to prepare for their research proposals, and most of them started their search for information in early March and April. With an average of 278 minutes spent on finding useful information, they had more time to survey different topics of the search task. Their academic-oriented task determined that they needed to collect scholarly articles, which made it difficult for them to obtain useful information. That also led to more alternative shifts in search task goals.

Among the dimensions of search tasks, the origination of a task influences whether a participant could change their search tasks. In general, self-generated tasks allowed

participants to modify or change their search task goals mainly because they had some control of the task. Participants in the academic study had the freedom to change or modify their search task goals as long as they fell within the scope of the research proposal. On the contrary, assigned search tasks normally limit individuals in shifting their current search goals. Many of the search tasks in the corporate study were assigned by their clients or supervisors based on their work tasks. Therefore, participants in the corporate study showed fewer shifts of search task goals than participants in the academic study. For example, one participant needed information regarding descriptions of about 25 SAE technical committees and their members. He tried human resources, but the administration assistant was not able to provide him relevant information. Then he tried the SAE site, but only found some committees without membership lists. He could not modify or change the search task because it was assigned; finally, he contacted SAE staff several times for the complete information.

As to how participants could change their search-task-related goals, the types of search tasks normally indicated the direction of shifts. A participant tried to look for information related to a specific engine oil cooler via consulting an expert and searching in an internal IR system, but could not find any information. He finally shifted from looking for the specific to small engine oil coolers. Therefore, he had to change from looking for a known item to looking for items with common characteristics. Of course, this type of shift has to associate with the dimensions of work tasks and the flexibility of search tasks. When participants looked for known items or specific information but could not find them, they might look for items with common characteristics as alternatives. Simultaneously, when participants looked for items with common characteristics, they might change their search topic when they saw something more interesting; this is more obvious in the academic study. In the example discussed above, the participant shifted her original topic from visually impaired users' use of OPACs to the information-seeking strategies of visually impaired users after reviewing the retrieved documents on the former topic.

Of course, the flexibility of search tasks determines more specifically whether and to what extent participants could shift their search-task-related goals. As discussed above, work tasks largely decide the flexibility of search tasks. Writing a research proposal allows participants to choose their own search tasks and change their search task goals. Therefore, their search tasks are flexible. For example, a participant changed his topic from computer use in public libraries, in particular monitoring techniques in relation to library size, to information related to benchmarks and ratings in strategic planning for libraries. Some work tasks limited participants' ability to even modify their search task goals. For example, one participant in the corporate study needed to use employment training software (Pro E). She tried to search for information in a web search engine by refining her searches several times without luck. However, she could not change her search task because that was an inflexible task. Finally, she found the information by consulting a human resource.

Discussion

Based on the results of these two studies, Figure 1 shows how dimensions of work and search tasks affect the information-seeking and -retrieval process, in particular the extent of planning, the application of information-seeking strategies, and shifts in

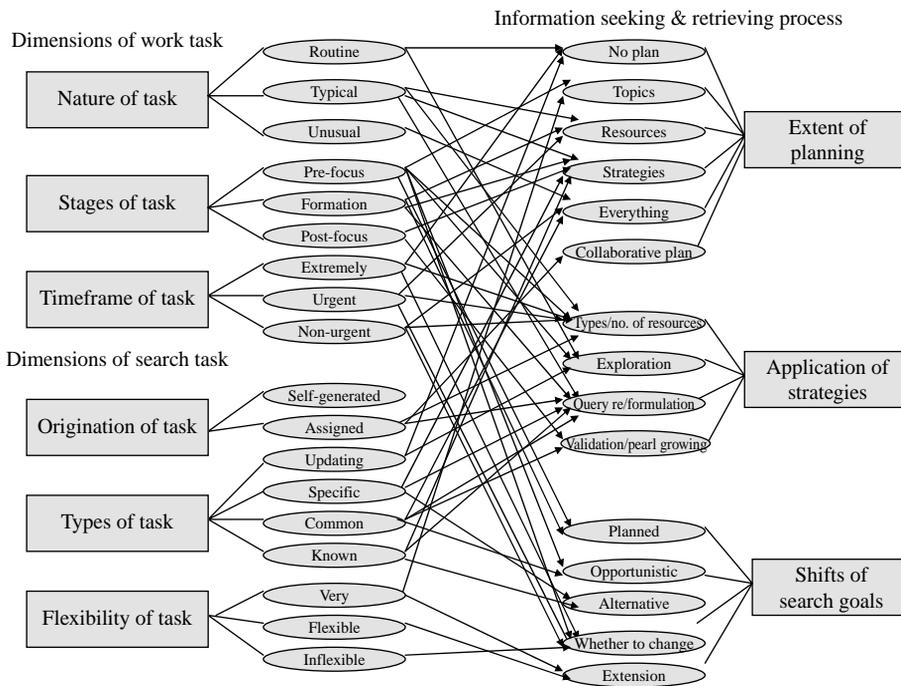


Figure 1. The dimensions of tasks' influences on information-seeking and -retrieving process

current search-task-related goals. Interestingly, not all the dimensions of tasks have the same influences. Some dimensions have more impact on planning, and others have more influence on applying strategies and shifts.

Information seeking and retrieving is a very complicated phenomenon. Task dimensions as well as other factors influence the information-seeking and -retrieving process. Byström and Hansen (2005) identified the individual, contextual, and situational attributes related to task and task performance. Individual attributes include people's knowledge, experience, and motivation, among other attributes. Contextual attributes are more related to the environment and domain that tasks are derived from. Situational attributes are associated with temporary conditions that emerge in task performance processes. Guided by these attributes, the author illustrates how the individual, contextual, and situational attributes are represented in dimensions of tasks and how they influence the information-seeking and -retrieving process.

The nature of task is highly associated with individual attributes as well as contextual attributes. On one side, participants' knowledge and experience defined their familiarity of these search tasks from routine, typical, and unusual tasks. On the other side, the nature of task was also in relation to their work environment or domain. For example, participants in corporate and academic settings had different types of routine, typical, and unusual tasks. The findings of the nature of task validate previous research on the complexity of task. First, familiarity with task procedure and requirements determines the classification of the nature of tasks. The three types of tasks – routine, typical, and unusual tasks – correspond to automatic, normal, and

decision tasks identified by Byström (2002) and Byström and Järvelin (1995). While routine, typical, and unusual tasks were classified based on participants' previous experience with tasks, automatic, normal, and decision tasks were based on the extent of required case-based consideration during task performance. Second, the results of this study echo Byström's (2002) and Byström and Järvelin's (1995) research, in terms of the relationship between the complexity of tasks and the number and types of information resources accessed. Typical/normal and unusual/decision tasks required that participants accessed more and different types of resources as well as that participants used people as information resources. More importantly, this study further investigated the search strategies applied in routine, typical, and unusual tasks, for example, the exploration strategy for routine tasks. Third, a main contribution of this research is it further explores the influence of the nature of task on planning and shifts in search-task-related goals.

The extent of planning can be classified into the following categories: no plan, plan for topics, plan for resources, plan for strategies, and plan for everything from topics to resources to strategies. Among the dimensions of tasks, the nature of task affected the extent of planning the most. Routine, typical, and unusual tasks led to different levels of planning, from no plan to plan everything, including backup plan, respectively, because of different levels of required cognitive engagement based on an individual's previous knowledge structure and experience. Different participants with different experiences and knowledge defined their nature of work tasks differently; thus, they required different levels of planning. A participant who had neither experience nor knowledge for an unusual task spent more time and effort to plan for resources, strategies, and even backup plans.

Participants also developed their unique resources and strategies for their routine and typical tasks. Among the nature of search task, exploration strategies involving scanning were mostly for routine tasks; types of resources and query formulation and reformulation strategies were for typical tasks. Even though there is no pattern for unusual tasks in terms of strategies applied, participants did use more human resources and multiple information resources than other types of tasks as found in Byström's (2002) work. The nature of task has less impact on shifts in search-task-related goals.

The stages of task are more affected by environmental attributes. Compared with corporate settings, the nature of academic work requires people to go through stages for their work tasks. In the academic study, the stages of task determined what participants planned for their searches from topics to resources to strategies. At the same time, the stages of task are situational. Participants moved from one stage to another depending on whether or not they finished the work for the current stage. Each stage has a situation that requires different types of information-seeking strategies. The application of types of information-seeking strategies can be summarized as the types of resources accessed, the number of resources accessed, the types of tactics applied, as well as the types of strategies applied.

The stages of task are the major dimension that leads to the application of different strategies. The results of this study in regards to relationships between the stages of task and associated strategies are similar to the results of previous research. The research presented here not only agreed with Vakkari *et al.* (2003) findings (Vakkari, 2000a) that the more focused their tasks were, the more specified terms, more operators,

and more search tactics increased, but also revealed that participants explored more and accessed more resources, including human resources, in the pre-focus stage. At the formation stage, they formulated and re-formulated queries to find some useful documents. At the post-focus stage, they applied more validation or pearl-growing strategies to find documents like the one they selected. Compared with Vakkari's (2000b) and Pennanen and Vakkari's (2003) findings on users' searching for background information with theories and models at the pre-focus stage, for methods and focused information at the focus stage, and for specific information and empirical results for the post-focus stage, the results of the academic study of this paper indicate that participants explored different topics at the pre-focused stage, searched for documents related to the selected topic at the focus stage, and found more related documents at the post-focus stage. This research further validates Kulthau's (1991) information search process model in relation to actions associated with each stage, and it further enhances the model by showing how participants planned for their searches and how their search-task-related goals shifted at different stages.

These studies demonstrate that participants changed their current search-task-related goals in their information-seeking and -retrieving processes. The situation of each stage also delineates the types of shifts that have taken place. The majority of the shifts occurred at pre-focus stages when participants were not settled with their research proposal topics. While opportunistic, alternative, and planned shifts occurred at pre-focus stages, planned shifts also happened at the formation stage.

The timeframe of tasks reflects the integration of situational and environmental attributes. It defined the time participants had for planning under different situations and in different environments. In corporate settings, some situations required participants to fulfill work within five minutes; they had no time to plan in these extremely urgent situations. In academic settings, they had more than three months to accomplish their tasks and plan for everything. The timeframe of tasks played a major role in determining the types of resources and the number of resources that participants accessed as well. Sometimes, in order for participants to get information within five to ten minutes, they had to choose resources that they could effectively access and acquire useful information. At the same time, the more time participants had, the more resources they might try to access. The influence of the timeframe on shifts is defined by whether or not participants had the time to change if they wanted something better or they had to change their search goals because of the time limitation. However, that has to be related to the flexibility of the search task.

The types of tasks are the dimension that influences planning the most among the dimensions of search tasks. The types of tasks are the product of individual and situational attributes. It is derived from the work task, and participants decided the search tasks in order to achieve their work tasks, if they were self-generated. The types of information that participants looked for determined their cognitive involvement in the planning, from no plan for updating information, planning strategies for specific information and known item search, to planning everything for searching for items with common characteristics. The uncertainty of looking for items with common characteristics required participants to plan their searches more thoroughly. The types of search tasks play the major role in affecting applications of strategies among dimensions of search tasks. Participants had their own corresponding strategies for each type of search task. While scanning was more appropriate for updating information,

specifying and manipulating, as well as pearl-growing strategies, were more appropriate for looking for items with common characteristics. Of course, different situations might lead to the selection of different types of search tasks. Therefore, the types of search tasks led to how their search goals could be shifted. Participants changed from looking for a known item or specific information to items with common characteristics as alternative shifts. In addition, they also changed from looking for one type of item with common characteristics to another type as opportunistic shifts.

The origination of tasks represents environmental attributes – where the search task comes from – which strongly correlates to the environment or work domain to which the participants belong. In the corporate setting, clients, supervisors, and others assigned the tasks. In the academic setting, instructors and librarians assigned or suggested the tasks. The origination of task determines who plans for the search. Assigned tasks decided that participants had to collaborate with those people who assigned them the task. In assigned search tasks, resources selected and query terms used were to some extent suggested by the assignees of the tasks. The origination of task is more related to whether participants could change their search goals. The assigned search tasks made it difficult for people to make any changes without consent from the assignees. Of course, for the self-generated search tasks, individual knowledge and experience determined their selections of information-seeking strategies and how they would like to shift their search goals.

The flexibility of task is the product of individual, contextual, and situational attributes. Many factors affect the flexibility of a search task such as personal interest, a work domain's requirements, and the outcomes of user-system interactions. Undoubtedly, the flexibility of search tasks determines whether search goals can be changed, and if so, to what extent can they be changed. While very flexible and flexible search tasks defined the scope of shifts, inflexible search tasks determined their search goals could not be changed. Whether or not a search task goal can be changed has to be determined by whether or not that search task is necessary to fulfill the work task, whether or not a participant is willing to modify or change the topic, as well as whether or not there is sufficient retrieved information for the search task. The flexibility of search task has the least impact on planning. Very flexible tasks allow users to plan for changing their topics. There was no direct relationship between the flexibility of search tasks and the application of strategies identified from the study.

Conclusion

This paper not only validates previous research results which showed that task is the driving force for IR, but also identifies the nature, stages, and timeframe as dimensions of work tasks as well as origination, types, and flexibility as dimensions of search tasks that affect information-seeking and -retrieving processes. Most importantly, it further illustrates the relationships between dimensions of work, search tasks, and information-seeking and -retrieving processes, in particular, the extent of planning, the application of different types of information-seeking strategies, and shifts in search-task-related goals.

The extent of planning is mainly affected by the nature of work task and the types of search task. Stages of work task and types of search task are the major dimensions that lead to participants' application of different types of information-seeking strategies. The majority of shifts in search goals relates to the stages of work task, particularly at the pre-focus stage. At the same time, the flexibility of search task delineates the scope of the change of search goals. In addition, the analysis of the dimensions of work and search

tasks and their impact on information-seeking and -retrieval processes indicates that these dimensions are not isolated. Moreover, they are closely related to individual, contextual, and environmental attributes. The dimensions of work and search task, and the attributes at individual, contextual, and environmental levels, co-determine users' information-seeking and -retrieving processes.

The findings of these studies also have their implications for IR system design. Task-based IR systems can be developed to interact with users to diagnose their dimensions of work and search tasks. After analyzing and understanding the dimensions of their work and search tasks, task-based IR systems can prescribe to users what they need for effective IR. Based on the relationships between the dimensions of work and search tasks and the information-seeking and -retrieving processes, more explicit and implicit tools can be designed to guide users as they plan for their IR, apply appropriate information-seeking strategies, and facilitate their shifts in search-task-related goals.

At the same time, the findings of these studies also have their implications for service development. Different types of services in corporate and academic settings can be provided corresponding to their targeted users' routine, typical, and unusual tasks. Workshops and training sessions can be held to train users to understand the relationships between dimensions of tasks and their information-seeking and -retrieving processes and further help them to develop best strategies for their planning, strategy application, and shifts in search goals.

These two studies also have their limitations. First, participants in these studies only represent people who have to achieve tasks in either a corporate and academic setting, and they were only instructed to record their work-related or proposal-writing tasks. More participants with different demographic characteristics who engage in different types of work tasks in different settings need to be recruited. Second, while diaries are able to record the information-seeking process unobtrusively, not all participants offered detailed information. Some of them concentrated more on recording the strategies in relation to creating search statements and modifying search statements, and less on other types of strategies. Participants decided what information and how much information they would like to record, even though they were all given the same diary forms and instructions. Third, these studies fail to investigate whether or not the dimensions of task affect how people exit their IR process. Data related to participants' decisions to exit the searches were not fully collected in these two studies.

To avoid these problems, the author is currently working on a project for further research. The author has recruited more participants who represent general users with diverse demographic characteristics. More importantly, diaries are supplemented with think aloud and transaction logs to record the information-seeking and -retrieving activities related to the tasks that they have to achieve. By integrating diary, think aloud, and log data, we will be able to learn not just what actions people take but also why and how they adopt these strategies. Moreover, think aloud can offer insight into individuals' decisions to stop the search process. Therefore, we can have a better understanding of users' information-seeking and -retrieving processes. In addition, more structured and instructional diary forms will be sent to participants to guide them in recording more detailed information. Finally, as Freund *et al.* (2005) did in their study in relation to the identification of relationships between work task and document genre, more quantitative analysis can be conducted to discover patterns between dimensions of task and attributes of the information-seeking and -retrieving processes.

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