Understanding Human–Work Domain Interaction: Implications for the Design of a Corporate Digital Library

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The author applies the cognitive work analysis (CWA) approach to investigate human–work interaction in a corporate setting. This study reports the analysis of data collected from a Web survey, diaries, and telephone interviews. The results present characterizations of actors and the work domain; three dimensions for each of the four interactive activities involved in the human–work interaction and their relationships are identified. An enhanced model and its implications for the development of a corporate digital library are discussed.

Introduction

There is a growing recognition that the traditional corporate library model largely based on printed resources no longer works effectively in business. The information needs of corporate employees are changing, and information services in the corporate environment need to change as well. Corporate libraries and information services should address new needs and expectations in the area of content medium and deployment, along with the new economic situation of the publishing world. Many companies have started to build digital libraries that are accessible to all employees via the corporate intranet (Alsmeyer & Smith, 1997; Crandall, 1998; Gulliford, 1998; Harmsen, 1998; Hoffman, O'Gorman, Story, Arnold, & MacDonald, 1993; Pack, 2000). According to Stratigos and Strouse (2001), two thirds of the respondents in Qutsell's 2000 Corporate Information Professional Study reported that they were moving toward fully or nearly digital libraries. Over the past several years, there has been a tremendous increase in research on digital libraries, much of it focused on how to convert printed material into an electronic format, organize different types of resources, and design system structure. Although there are a variety of digital library user studies in different settings (Baldonado, 2000; Bishop et al, 2000; Marchionini, 2002), there has been scant research on how to design digital libraries to satisfy the needs of specific user groups in corporate settings. Therefore, there is a need to understand people's information seeking behaviors within a larger context of this working environment.

End users of corporate libraries have their own unique characteristics, and they are in a typical "information rich" environment in which people are exposed to, and make use of a variety of information resources in support of their daily work (Auster & Choo, 1993; Cool & Xie, 2000). In an early study, corporate respondents reported spending about 16 hours per week on scientific and technical information activities (Mick, Lindsey, & Callahan, 1980). A more recent study yielded similar results with participants spending approximately 68% of their workweek on information-related activities (Hirsh, 2000). However, regardless of many technological advances, people merely have *more* information, not necessarily *better* information (Broady-Preston & Hayward, 2000). Information seeking is never an easy task, especially for people who work in a corporate environment. Their work tasks require support for unique information seeking strategies (Crandall, 1998; Smith, 1999).

Many factors make the corporate setting a complex environment which requires the design of corporate digital libraries to support and enhance employees' work productivity. For example, how to implement the corporate culture into the digital library is one of the challenges in creating corporate digital libraries (DiMattia & Blumenstein, 1999). Cognitive work analysis (CWA) is one of several analytic approaches to cognitive engineering that addresses this problem (Sanderson, 2003). The CWA approach (Rasmussen, Pejtersen, & Goodstein, 1994; Vicente, 1999), which focuses on the human activities and work context in which an information system is used, can offer guidance on the design of a digital library by analyzing the actors, the work domain, and the interactions between them.

To design digital libraries to understand and support users' information use in corporate environments, it is important to characterize patterns of information use and the factors affecting use in particular work domains. Specifically, this study addresses the question: What are the

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characteristics of the actors, the work domain and the dimensions of interactions between the actors and the work domain that are important to understand to best design corporate digital libraries?

Previous Research and Theoretical Framework

The cognitive work analysis approach analyzes the complex interaction between activities of work domains and end users' cognitive activities, social activities, and their subject preferences (Rasmussen, Pejtersen, & Goodstein, 1994; Vicente, 2000). Cognitive work analysis is commonly viewed as the analysis, modeling, design, and evaluation of complex sociotechnical systems (Sanderson, 2003). It is generally done by field studies that involve systematical investigation of work domains, actors, and their interactions. It is a powerful approach to analyzing the complexity of interactions instead of just describing them by facilitating an in-depth examination of the dimensions of a context (Fidel & Pejtersen, 2004).

The CWA approach has been widely applied to the design, development, and evaluation of a variety of information systems. Book House, one of the first interactive multimedia online public access catalogues (OPACs) was designed based on the CWA approach (Pejtersen, 1992). Following the same approach, the Design Explorer project, a supplement to the Book House project, used specified requirements for an information system that enabled design team members to interact more effectively in the design process. This framework is the basis for the specification of a digital library system supporting access to a wide network of heterogeneous databases and resources (Pejtersen, Sonnenwald, Buur, Govindaraj & Vicente, 1997; Pejtersen, 1998). It has been also applied to the analysis and design of a healthcare information system in a case study by Effken (2002) and a large-scale, first-of-a kind system for U.S. Navy surface combatant. (Bisantz et al., 2003). In addition, the CWA approach has been shown to be a powerful tool for the evaluation of system designs (Naikar & Sanderson, 2001).

The CWA approach has also been used to study information use and system use for existing system improvement or potential system design. Sonnenwald and Pejtersen (1994) developed a conceptual representation of the information space based on field studies of relationships in cognitive work dimensions and communication networks for the design of information retrieval systems. The CWA approach was also applied to study high school students' problems in Web searching; design recommendations were developed (Fidel et al., 1999; Pejtersen & Fidel, 1998). The cognitive work analysis framework was used to guide the field study to investigate situations where members of a work team are seeking and using information collaboratively to further design systems to support collaborative information retrieval (Fidel et al., 2000). It was also applied to analyze how to design systems to support engineers' searching for people in addition to searching for documents because they rely on people as sources of information (Cool & Xie, 2000; Hertzum & Pejtersen, 2000). Recently, its use was introduced to facilitate the potential development of a European film archive, a distributed multimedia film collaboration that supports the preservation, analysis, indexing, and retrieval of films (Hertzum, Pejtersen, Cleal, & Albrechtsen, 2002).

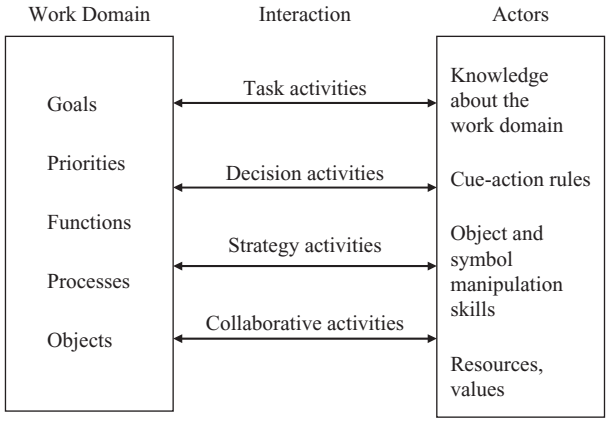

FIG. 1. Model of human–work interaction (1998). From "Human-work interaction on the web" by A.M. Pejtersen and R. Fidel, 1998. Unpublished manuscript. Reprinted with permission of the authors.

Guided by the cognitive work analysis approach, Pejtersen & Fidel (1998) developed a model (Figure 1) that shows the invariant properties of human–work interaction in which technology is embedded to support work. These invariant properties highlight the stability and regularity of dynamic work environments, and they greatly help designers to characterize and further predict actors' information seeking behaviors. The authors did a case study of high school students searching the Web for their homework to illustrate the model and its application for the improvement of Web design. The following components and their properties are the essential parts of the model: (a) work domain, (b) actors, and (c) interaction activities. Work domain analysis is to identify the current and future means and ends of a working place, which includes the goals and constraints, priorities, general functions, work processes, and physical objects. Actor analysis focuses on the knowledge and preferences that are related to information seeking, which consist of knowledge about the work domain, cue-action rules, object and symbol manipulation skills and resources, and values. Interaction analysis examines interactions between work domain and actors. Task activities, decision activities, strategy activities, and collaborative activities are the main products. Adapting this model, the author examines the dimensions and relationships of these interaction activities to study people who work in a corporate setting with the purpose of developing a digital library design. To better understand the context of this study, see the discussion of these activities in the Results section.

Methodology

A large-scale international company, Case Corporation, located in Milwaukee, Wisconsin, which has already provided partial virtual library service, was selected as the model site. The company has provided the Case virtual library, which

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TABLE 1. Methodological matrix.

Research question	Sampling	Data collection	Data analysis
Work domain	20	Telephone interview Company report Company Website	Open coding
Actors	263	Web survey	Descriptive analysis
	20	Telephone interview	Open coding, taxonomy of types of knowledge structure
Dimensions of interactions	263	Web survey	Descriptive analysis
	10	Diary	Open coding, descriptive analysis
	20	Telephone interview	Open coding, taxonomy of dimensions of interaction activities, descriptive analysis (for the 10 subjects who did not submit their diaries, but described their search process in the interviews).

includes both internal and external information resources, to its employees via its intranet since 1998. The Case virtual library offered a NewsCenter, SearchCenter, Reference Desk, Research Department, Reading Room, and Special Focus Corner. Case Corporation merged with New Holland in 1999 and planned to establish its integrated CNH digital library. Case and New Holland manufacture the world's leading agricultural and construction equipment. To address the proposed research question, the author conducted naturalistic studies with people as they engaged in a variety of information seeking tasks, in their working environments one year after the merger. This methodological matrix (Table 1) combines Web surveys, a diary method, and open-ended telephone interviews.

At the beginning of the project, a Web-based survey was posted on the digital library page as well as the company homepage. The survey asked participants (a) for demographic information, (b) about their general patterns of information resource use, and (c) for an evaluation of current CNH Virtual Library. Two-hundred sixty-three employees filled in the survey. The average time the respondents worked in the company was 3–5 years. The majority were male (82.6%), and their average age was 41–50. Their average educational level was postgraduate with a majority preferring to use a digital library (68.2%) over a physical library (31.8%). Surprisingly, over half of them (53%) were not aware of the existence of the CNH virtual library.

Within the Web survey, one of the questions asked was whether the respondent was willing to be a participant in a further study. Twenty subjects representing a variety of departments were chosen from those who agreed to be part of the second-phase study. Participants were asked to keep an "information interaction diary" for two search tasks within a 2-week period. Participants were to use the diary to keep track of their information seeking interactions in the order in which they took place. They were required to record the following information in the diary: (a) search tasks, (b) time spent on each of the task, (c) information resources and systems used, (d) types of people consulted and databases or publications selected, (e) queries asked or used in the search process, (f) the outcome of using each information resource, and (g) factors leading to the success or failure of each of the resources or systems used. The diary data provided a record of activities related to two search tasks a participant engaged in over a 2-week period. Ten subjects returned their diaries before the interviews, and another 10 subjects kept their notes for telephone interviews.

After they finished their diaries, telephone interviews were conducted with the participants who were located in different parts of the world. The interviews focused on general information related to (a) typical work-related tasks and goals that precipitate information seeking behavior, (b) typical information interactions associated with these tasks and goals, (c) reasons for interacting with specific information resources or items, (d) typical information-seeking problems encountered, and (e) typical ways of solving the problems. These interviews were also initiated in an attempt to verify and enrich the diary content; more importantly, to probe for more information related to participants' information seeking process when searching for the two specific tasks. For the 10 subjects 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.

Quantitative as well as qualitative methods were employed for this study. The quantitative methods concentrated on a descriptive data analysis of the data. For this study, the qualitative analysis started with content analysis (open coding) and the development of taxonomies of dimensions of interaction activities. Table 1 presents the data collection and analysis of each part of the research question. To avoid repetition, the discussion of the open coding and the development of taxonomies are presented in the Results section.

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Results

The results of this study were summarized to answer the research question proposed in the first section: What are the characteristics of the actors, the work domain and the dimensions of interactions between the actors and the work domain that are important to understand to design corporate digital libraries?

Dimensions of the Work Domain

Before the discussion of the dimensions of interactions between actors and the work domain, we need to examine the work domain and characteristics of actors. The work domain of CNH is summarized based on interviews with 20 subjects from different departments, and information gathered from company reports and the company Web site (Table 2).

Based on the analysis of the CNH work domain, the results show that the merger of Case and New Holland had largely impacted the interactions between the actors and the work domain; to be more specific, it greatly affected people's information seeking strategies, especially their use of information resources. For example, the main problem is that there are no authorized and complete internal databases for all the internal information. One subject described the situation in detail,

> The problem we have is there have been a lot of changes, and there is still change going on. So sometimes it's very hard to find the owner of a standard. There should be one repository for all the standards. I've got one of those situations now. I want to find some standards with the company, and actually I found multiple owners which isn't a good thing because only one person should be from the intranet.

Another subject complained, "When I prepare a report to find employees of a certain race, I have to search two databases (New Holland and Case), and they have different fields, different designs, and different ways to organize things."

Company philosophy and business cycles also affected employees' choices of information seeking strategies. One subject discussed his strategy, "I may choose to focus on certain pieces of the results that become more or less important depending on the business climate or depending on my company philosophy. We're shifting our focus a little bit this year to reward and recognize improvement in loyalty." Another one clarified why she discontinued using some of the resources, "It's just a very cyclical of the business [sic] when there's money to be spent, but then all of sudden, there is no money in using some of the paid information resources."

Actor's Knowledge Structure

Another component of the human–work domain interaction is actors. The demographics of actors were discussed in the Methodology section generated from the Web survey. In this section, the author focuses on the analysis of the actor's knowledge structure based on the telephone interviews. In addition to personalities, people's knowledge of the domain, system and information seeking skills play a critical role in determining their choices of information seeking strategies. Here is an example of a subject who discussed her strategies when she did not have enough topic knowledge:

> When I'm not successful in finding information, it's usually because of insufficient knowledge about a topic. If I'm having trouble understanding the topic, I'll go back to the person who made the request and get more background information on it. Then I'll go to the Web search engine and look up more information on this topic. If that doesn't work, I will call and set up an appointment with an analyst. I always get information when I talk to an analyst.

TABLE 2. Dimensions of work domain.

Dimensions	Descriptions
Goals/constraints	Become the number one manufacturer of agricultural tractors and combines in the world; become the top maker of construction of equipment; own the industry's largest equipment finance operations/different levels of regulations; copyright laws; financial limits; merger problems.
Priority	Consolidate the standards and resources from Case and New Holland and establish unified databases since CNH was created in November 1999 through the merger of Case Corporation and New Holland N.V.; Target technology and people development as a key corporate strategy.
General function	Design and manufacture agricultural and construction equipments; provide financial services; market and sell CNH products; develop/purchase technology; manage employees and their benefits.
Work process	Identify search task, look for information from external or internal information resources; evaluate/validate information; apply relevant information to achieve working tasks.
Physical resources	Colleagues; experts; computers; Internet; Intranet; printed materials.

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In terms of system knowledge, participants tended to use the information retrieval systems that they were familiar with. Here is an example, "I use either MSN search engine or the one many others like—Google. Typically you use whatever you're best [sic], you're most comfortable with. It's the things that I'm just familiar with." One subject talked about his information seeking skills and related search problems, "When I'm not successful it's due to not narrowing my search query enough. My own rating is a 2.5 [on a 1–5 scale] for information seeking skills. I believe the information I need is out there, I just don't always know how to narrow my query." Finally, personality comes to play a role, "I generally don't spend much time, maybe it's short attention span. If I haven't come up with what I'm looking for in the first half hour, I'll stop and say we need to reevaluate and start over again," explained one subject. The impact of actor's knowledge structure on converting their information needs to an expression or a query is further discussed in *The Dimension of Decision Activities* subsection.

Types of Interactions

Types of interactions were defined by dimensions of interactions. Three dimensions of each of the four types of interactions emerged from the data. Table 3 presents the dimensions for the four types of interactions in the corporate setting: task activities, decision activities, collaborative activities, and strategy activities. The results of descriptive data analysis presented in Tables 4–7 are based on diary analyses (for the 10 participants who submitted their diaries) and telephone interviews (for the 10 participants who did not submitted their diaries but described their search process for specific tasks in the telephone interviews) of the specific search tasks that participants performed. The examples provided for dimensions of interactions and their relationships were derived from telephone interviews because the interviewer probed for more description and discussion of the search process recorded in diaries.

Dimensions of task activities. This study concentrated on information seeking tasks. Three dimensions of task activities emerged from the data:

1. The nature of the task—Whether the task was routine, typical, or new. Here routine tasks referred to those tasks that people had to perform repeatedly. Typical tasks referred to the types of tasks that users were used to performing, but they had not performed the exact same task before. New tasks referred to those tasks that people encountered for the first time.

TABLE 3. Dimensions of human–work domain interaction.

Types of interactions	Dimension I	Dimension II	Dimension III
Task activities	Nature of task: Routine Typical New	Types of tasks: Update information Look for specific information Look for items with common characteristics Look for known items	Time frame: Extremely urgent Urgent Non-urgent
Decision activities	What to do: Need support for domain knowledge Need support for system knowledge Need support for information seeking skills	How to do: Plan oriented Situation oriented Plan-situation oriented	When to stop: Obtain complete information Enough information Partial information
Collaborative activities	Types of collaborators: Clients People within the project team/department Experts within the company Experts outside the company Vendors/Consultants	Types of interactions: Gain background knowledge Acquire guidance Verify information Obtain direct answer	Types of channels: Face to face Phone E-mail/fax
Strategy activities	Types of behaviors: Scan Search Acquire Compare Consult Link Learn Select Read	Types of resources: Human Electronic Printed	Types of shifts: Shift resources Reformulate queries (narrow down/broaden up/try synonymous/change format) Shift behavior

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TABLE 4. Frequency and percentage for dimensions of task activities.

Dimensions of task activities		Frequency	%
Dimension I	Routine	6	15
Nature of task	Typical	31	77.5
	New	3	7.5
	Subtotal	40	100
Dimension II	Update information	5	12.5
Types of tasks	Look for specific information	16	40
	Look for items with common characteristics	16	40
	Look for known items	3	7.5
	Subtotal	40	100
Dimensions III	Extremely urgent	6	15
Time frame	Urgent	16	40
	Non-urgent	18	45
	Subtotal	40	100

2. The type of task—Whether it was to update information (e.g., keep track of information about new agricultural equipment), look for specific information (e.g., look for a syntax), a known item (e.g., look for an item for which a user knows the title), or items with common characteristics (e.g., look for items on the same subject).
3. The time requirement of the task—Whether the task was extremely urgent, urgent, or nonurgent. Here extremely urgent, urgent, and nonurgent referred to these tasks that had to be accomplished within half an hour, 24 hours, and more than 24 hours, respectively.

These dimensions greatly affect the decision, collaboration, and strategy activities. Table 4 presents the frequency and percentage of dimension of task activities based on the analysis of 40 cases of search activities from diaries and interviews of 20 participants. It is essential to know whether the task is routine, typical, or new; this was identified by MacMullin and Taylor (1984) as one of the problem dimensions. They found in their study that the majority of the tasks the participants had worked on were typical ones (77.5%). In corporate settings, people normally work on similar tasks, and they develop certain information seeking strategies for each type of typical task. Moreover, these information seeking strategies become part of their plans in decision activities. The following is an example of a subject's plan and information seeking strategies, which include information resources selected and behaviors presented for different types of typical tasks:

> 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.

Approximately 15% of the tasks are routine ones. Participants normally did not have to plan for that, and they just used the same information strategies. To be more specific, they went to the same resource and displayed the same behavior. For example, here is an example of how a subject worked on routine information seeking 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 new tasks (7.5%) that were not familiar to them. These types of tasks take more planning and need more participants' involvement in collaboration with clients or experts. Here is an example of a new task:

> I rarely had problems in finding information. The other day I was looking for tax information on Japan and I didn't have success finding it because it's a new country to us. We never had a foreign service for it. Normally I start with our intranet, but there won't be much information out there because this is a new country. I did a search on Google, and did not find the useful information. Then I talked to the senior consultant from Arthur Anderson and found the information with her help.

Updating information, looking for specific information, known items, and items with common characteristics are the common types of tasks. Eighty percent of the search tasks are looking for specific information and looking for items with common characteristics; they are the most popularly engaged search tasks. These tasks require different levels of planning. Here is an example:

> 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.

Updating information accounts for about 12.5% of the search tasks, and it normally takes different information

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seeking strategies. Scanning and reading electronic and printed information are the typical information seeking behaviors applied for this type of task. In addition, they are normally driven by plans not situations. 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.

Types of tasks and their related information seeking strategies are associated with strategies for information retrieval proposed by Rasmussen, Pejtersen, and Goodstein (1994). For example, updating information corresponds to a "browsing strategy" that a user scans to find a match with his or her information need. Looking for specific information is associated with an "analytical search" that a user analyzes his or her needs and compares with relevant aspects of information resources. Looking for items with common characteristics is correlated to an "analytical search" and "search by analogy" in which a user finds items that are similar to a known item. Looking for known items is related to a "bibliographical search" in which a user knows some information of an item, such as author, title, etc.

Based on the data, time ranges from extremely urgent, urgent, to nonurgent. The timing of a task also influences people's decision, collaboration, and strategy activities. More than half (55%) of the tasks the people perform have to be fulfilled within 24 hours. Therefore, people have to have alternative plans; therefore, changing resources are normally part of their planned information seeking strategies. Here is an example of a subject's alternative plan for information that is not available within the required period:

> 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 24 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 2 weeks because the archivist was on vacation. I tried to get information within 5–10 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.

Dimensions of decision activities. Decision activities focus on (a) what to do, (b) how to do it, and (c) when to stop. "What to do" is related to the analysis of information needs: that is how to convert information needs to something that can be expressed or presented to the human or information retrieval (IR) systems. "How to do" is more related to whether information seeking behavior is plan-oriented, situation-oriented, or both. "When to stop" is related to users' decisions about whether they obtain complete information, enough information, or partial information before they quit their retrieval process.

Table 5 presents the frequency and percentage of dimensions of decision activities. In terms of what to do, many of the participants had problems in converting their information needs to queries. A lack of domain knowledge, system knowledge, and information seeking skills contribute to the problem. Here domain knowledge, system knowledge, and information seeking knowledge refer to the subject of the search topic, the current IR system in use, and information search techniques, respectively. A majority (65%) needed support for information seeking skills. One subject gave her version of the problem when she was asked what the reason might be when she could not find information, "that's because I don't know how to ask for it, how to phrase the term." Another subject discussed her insufficient system knowledge, "I am knowledgeable [sic] what I am trying to find. I would say semantics. The wording I'm using to inquire versus how it's really filed is the problem." Sometimes, the problem is caused by lacking of all three types of knowledge. One subject further illustrated his problem,

TABLE 5. Frequency and percentage for dimensions of decision activities.

Dimensions of decision activities		Frequency	%
Dimension I	Need support for domain knowledge	8	20
What to do	Need support for system knowledge	6	15
	Need support for information seeking skills	26	65
	Subtotal	40	100
Dimension II	Plan oriented	6	15
How to do	Situation oriented	0	0
	Plan and situation oriented	34	85
	Subtotal	40	100
Dimensions III	Obtain complete information	18	45
When to stop	Obtain enough information	19	47.5
	Obtain partial information	3	7.5
	Subtotal	40	100

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"The query was structured incorrectly. My difficulties are in the way you pose the queries to the search engine. I'm having trouble doing this. But oftentimes you know when someone else maybe comes up with an answer and you finally see it, you see how it was obtained, you go yes, that makes sense except for when you ask the question, you don't phrase it that way." A lack of the knowledge also leads to a change of information seeking strategies. Here is an example about how lacking of domain knowledge changed a subject's information seeking strategies: "My title is Business Analyst, and I always use electronic resources first. There is no other person with the same job title so there is no one else to turn to. But on this task I rank myself as a "1"—very little knowledge. I had to go back to the person who made the request and get more background information on it."

After deciding what to do, participants normally work on how to do it. If subjects follow their predetermined plans about resource use and strategy application in their information seeking process, they are plan-oriented; if subjects make decisions about resource use and strategy application only based on the situations they encounter, they are situation oriented; If subjects start with their plans, and then change their plans according to the situations, they are plan-situation oriented. Most of the participants thought they did not plan before they started to search. Even those who claimed that they did not plan were neither situation-oriented nor plan-oriented. Instead, they were plan-situation oriented. They did plan in a certain way or to some extent, especially at the beginning of the search process, to determine which resource to use first, what strategy to apply, etc. After that, they made their decisions based on situations encountered. While 15% of the searches were completely plan-oriented, the majority of them (85%) were plan-situation oriented. Surprisingly, no searches were completely situation-oriented. Most of the participants who are plan-situation oriented have a high level of plans. The typical plan includes resource selection, especially the first resource to use. Here is an example, "I tend to be a shoot from the hip kind of guy. I generally don't plan it out very much at all. I just start and let the tool kind of guide my thoughts. You tend to form a normal strategy that you would employ. So always do this first, if don't find anything, go to the next one." These high-level plans can be represented by a procedure, especially for routine or typical tasks, and here is an example of following the known procedure, "I don't plan, but I always have a certain kind of known procedure I normally do, either go for MSN, or for Excite, or talk to people. By doing the same thing over and over again, you know, I basically have a process." One subject explained his plan, "It's very ad hoc. But I do follow a set pattern—go to team members, then the Internet. I tend to use AltaVista unless I know the URL or specific Web site I want. But if I don't have luck with AltaVista, I'll go to Yahoo. When I don't get any results I try to modify my search—either broaden the search or use alternative terms or synonyms." Some of them have more detailed plans, for example, "I plan the topic to search and then some search terms, as well as resources to use. I also think about what to do for a backup plan, for example, different resources and different search terms." Some of them clearly recognized that their information seeking behaviors were driven by both plans and situations. One subject considered the information seeking process as a problem solving process, "I generally have a game plan in mind but not very detailed, because depending on what I find it may change what I do next. Like any problem-solving process, it builds on the results of the last step—you know where you want to end up but you may have to take some turns along the way." "How to do" is affected by "type of tasks" as discussed in *Dimensions of Task Activities* subsection. In almost every case of routine or updating information, participants were plan oriented; while in other types of task activities, participants were plan-situation oriented.

Participants made their own decisions about when to stop. According to the data, participants quit their searches when they obtained enough information (47.5%), or complete information (45%), or partial information (7.5%). Here complete, enough and partial information is related to whether they obtain all the information or just enough information to achieve their tasks or only part of information that they can only somewhat achieve their tasks. As discussed in the *Dimensions of Task Activities*, when to stop is mainly determined by the type of task and the time required of the task. Generally, looking for specific information equates to obtaining complete information, otherwise the search task is not done yet. For example, when looking for a syntax, the syntax has to be found to achieve the task. At the same time, most of the participants decided that it was time to stop when they got enough to achieve their tasks, especially if it was urgent to get the task done. One subject said, "Time always matters. Like if I'm searching software for instance, I would stop searching after I think that's going to give me a good analysis [sic]."

Dimensions of collaborative activities. Three dimensions of collaborative activities emerged from the data:

1. Types of collaborators—Clients, people within the project team or department, experts within the company, experts outside company, vendors and consultants affiliated with the company.
2. Types of interactions—Gain background information, acquire guidance, verify, obtain direct information. Types of interactions are the focus of the communication when the collaboration takes place. Here gaining background information refers to getting more contextual information about the search task that normally only clients know about. Acquiring guidance refers to directing people or offering clues to find the appropriate information. Verifying refers to confirming the accuracy of the information. Obtaining direct information refers to getting the answers to achieve the search task.
3. Types of channels (face-to-face, phone, e-mail, and fax).

Table 6 presents the frequency and percentage of dimensions of collaborative activities. In this study, participants

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TABLE 6. Frequency and percentage for dimensions of collaborative activities.

Dimensions of collaborative activities		Frequency	%
Dimension I	Clients	6	15.8
Types of collaborators	People within the project team/department	10	26.3
	Experts in the company	9	23.7
	Experts outside the company	4	10.5
	Vendors/consultants	9	23.7
	Subtotal	38	100
Dimension II	Gain background knowledge	3	7.9
Types of interactions	Acquire guidance	8	21.1
	Verify information	4	10.5
	Obtain direct information	23	60.5
	Subtotal	38	100
Dimensions III	Face-to-face	15	39.5
Types of channels	Phone	17	44.7
	E-mail	5	13.2
	Fax	1	2.6
	Subtotal	38	100

collaborated 38 times to find information. Some of the participants collaborated more than once in one search episode while some of them did not collaborate even once. Several interesting findings were derived from this study in terms of collaboration. First, although clients only accounted for about 15.8% of the collaborations, they were the important collaborators because some of the search tasks were conducted per clients' requests. The type of interaction with clients generally involved gaining background knowledge; this made up about 7.9% of the interactions. Here is an example of talking to clients to gain background information, "I think the biggest thing we do here is trying to talk with people that we're trying to support, because I don't know all of their current processes as well as what they do or what they would like to see or what their real business requirements are to date. So the first thing to do always has to be talking with those people." Second, while it was convenient to collaborate with people within the project team or department (26.3%) or experts in the company (23.7%), it was a very effective approach to consult experts (10.5%), who were working in the same area in another company, to acquire guidance or to obtain a direct answer. The following is an example of how one subject consulted experts outside the company to get guidance in finding relevant information, "I do have a number of colleagues working for other firms that are very nearby, and certainly when something unusual happens, you can use them as a resource. Oftentimes it just gives you a different perspective. So, even though the person may not have had an answer, they provide different ways of looking at the problem and can help you use the electronic source effectively. Like when we were talking about point of view before, in terms of structuring your query." Third, participants needed to collaborate to obtain direct information (60.5%) or acquire guidance (21.1%), and they also needed to collaborate to verify information (10.5%). Here is an example of talking to people within the company to verify information,

> We have a female employee and her name is Jane Johnson, so I made the presumption that female is correct. But she is listed in the database as Hispanic and I know the individual. So you know basically what I did is rather than call the individual directly I asked around to find out whether her background is Hispanic.

Fourth, participants preferred to use a synchronous rather than an asynchronous channel for their collaborations. Surprisingly, e-mails (13.2%) were not frequently used. Telephone (44.7%) and face-to-face (39.5%) meetings were the major channels that participants used for collaboration because the majority of the tasks were urgent or extremely urgent and the synchronous channels allowed them the immediacy to interact more efficiently. "There are a couple of people in my group and there's another DBA group in the company and I have friends and buddies at other companies. When I have a problem, I chat with them since I can ask, 'Have you ever run into this problem?; It is fast," as one participant explained his reason for using face-to-face and telephone channels.

Fidel, Pejterson, Cleal, and Albrechtsen (2004) defined collaborative IR to be when the actors involved are colleagues and they are engaged in the same work processes. Because this study focused on information searching tasks that people performed, the objective of collaboration was the same as the objective of information seeking tasks. In this study, collaboration was defined in a much broader sense. The dimensions of collaborations have impact on the dimensions of strategy activities. To some extent, dimensions of collaborations are part of dimensions of information seeking strategies. The analysis of types of collaborators provided detailed information about types of human resources uses. Different types of collaborators were the main human resources that participants accessed when they needed information. Simultaneously, the discussion of types of interactions defined and enhanced the discussion of information seeking behavior "consulting."

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Dimensions of information seeking strategies. Three dimensions of strategies emerged from the data:

1. Types of behaviors—Scan, search, select, acquire, compare, consult, link, read, and learn.
2. Types of information resources—Electronic, human, and printed.
3. Types of shifts—Change resources, reformulate queries, and change behaviors.

Here information seeking behaviors refer to the micro level of actions that users take in information seeking process, and the behaviors identified in this study are pretty much same as the ones identified from another study in the library setting done by the author (Xie, 2000, 2002). However, there are other information seeking behaviors, such as "link" and "compare" emerged from the data. In addition, "consult" was further enhanced by type of interactions in collaborative activities. Types of shifts refer to how users change their strategies in order to find relevant information. Participants shifted their information seeking strategies by changing resources, changing behaviors and reformulating their queries. Information resources refer to the sources of information that are used. Table 7 presents definitions of strategies activities in detail.

Table 8 presents the frequency and percentage of dimensions of information seeking strategies. Dimensions of information seeking strategies have been mentioned in the discussions of task activities, decision activities, and collaborative activities. With all the behaviors, scanning and searching took the leading roles, and they accounted for 16.3% and 12.7%, respectively. Participants not only scanned to find information, but also scanned to evaluate the search results. Participants selected (25.2%) the relevant ones, read (18.1%) some of them, and acquired (13.3%) the most relevant ones. Consulting (7.6%), the behavior exhibited for accessing human resources, especially in collaboration processes can be further classified or considered as gaining background information, acquiring guidance, verifying information, and obtaining direct information. The emergence of the Internet and hyperlinks made it easy for participants to link (4.4%) to different information; bookmarks became a useful tool for them to link to those sites that they visited before, especially for routine tasks as discussed in the dimensions of task activities. Sometimes, they also had to compare (2%) either different results, or the results with what information they already had. Because the majority of the tasks were extremely urgent or urgent, learning only took about 0.4% of the behaviors. If they could not find information, they just shifted strategies. Just as one

TABLE 7. Definitions of strategy activities.

	Dimensions of strategy activities		Definitions
Dimension I Types of behaviors	Scan		Glance through an item or a series of items
	Search		Examine a database(s) and identify items/information that match certain criteria
	Select		Pick up an item among a series of items
	Acquire		Write down or copy or print out specific or meta information, etc.
	Compare		Identify some information from different items and making a comparison
	Consult		Direct questions to human resources
	Link		Follow the hyperlink to get to another location or specific information
	Learn		Figure out something, especially system functions or system structure
	Read		Examine an item
Dimensions II Types of resources	Human		Consist of mainly the collaborators that are mentioned in dimensions of collaboration
	Electronic		Include both intranet and Internet online resources
	Printed		Contain periodicals, manuals, standards, etc. in print form
Dimension III Types of shifts	Change resources		Shift resources within one type of resource or among different types of resources
	Reformulate queries	Narrow down	Specify the meaning of the query
		Broaden up	Generalize the meaning of the query
		Try synonyms	Use terms with the same meaning
		Change format	Use different forms of terms or correct errors
	Change behavior		Shift from one type of direct seeking behavior to another

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TABLE 8. Frequency and percentage for dimensions of information seeking strategies.

Dimensions of strategy activities			Frequency	%
Dimension I	Scan		63	12.7
Types of behaviors	Search		81	16.3
	Select		125	25.2
	Acquire		66	13.3
	Compare		10	2
	Consult		38	7.6
	Link		22	4.4
	Learn		2	0.4
	Read		90	18.1
	Subtotal		497	100
Dimensions II	Human		38	28.8
Types of resources	Electronic		92	69.7
	Printed		2	1.5
	Subtotal		132	100
Dimension III	Change resources		32	50.8
Types of shifts	Reformulate queries	Narrow down	8	12.7
		Broaden up	5	7.9
		Try synonyms	4	6.3
		Change format	4	6.3
	Change behavior		10	15.9
	Subtotal		63	99.9

subject argued, "I don't have time to learn how to use some of the features or figure out what went wrong, and the system only displays an error message." The example of consulting people within the company to verify information about an employee's race is discussed in the collaborative activities. "Link" is a popular behavior in using electronic resources, especially on the Internet. Here is a typical example of "linking," "I do a ton of bookmarking of search results pages, and I go back to where I was by clicking and linking when I search for the same topic again."

Electronic (69.7%) and human resources (28.8%) were the most frequently used resources for participants while printed materials (1.5%) were rarely used. Four reasons were identified from the analysis of interview data in terms of why electronic resources were used, especially why they were the first choice: search capability, convenience, familiarity, and to avoid overloading colleagues. Here are some of the reasons that participants discussed when asked about which information resource they use first and why: "I always use the electronic one first because of the search capability [search capability]." "Because it's right here. My PC never says to me I can't talk to you or I have a meeting, never gives me a busy signal usually [convenience]." "I always use electronic resources first because it's what I feel most comfortable with. I have more familiarity with them [familiarity]." "If I have a utility issue, I would take it to him next. He is also overloaded so I don't use him as the first resource. I always go for myself first unless it's something that I'm absolutely certain they know right off the top of their head [to avoid overloading colleagues]."

Human resources were used first for best results. One participant said, "If I can think of someone who has experience with the specific application I'm working with, I turn to the human resource first. It normally gives me the best return." Time is another consideration. "I tend to use human resources first because it's the quickest way to get information from a time standpoint—my search skills aren't that good," explained one subject. The third reason is to avoid repeated work. One subject claimed, "I talk to humans first because I don't want to waste time looking for something if someone else has already done that." Fourth, credibility and expertise are the major issues. According to one participant, "I am concerned about the credibility and expertise issues and that's why I turn to human sources first—experts, team leaders." Finally, it is the human interaction. "I like the interactive nature of human-to-human information gathering. Humans can also help with search terms to use," emphasized one subject.

Printed resources were less used because the same material was also available online and the printed version normally was out of date. One participant explained, "Well, last resort is looking at the manual, but I consider that online because I know Cybase and I'm 99% sure Oracle on their Web sites, they have the manuals published." In addition, "I don't use printed material because I'd have to get up and leave my desk and go find them." However, some of the participants did use them under some circumstances. For example, one subject claimed, "I do use specialty textbooks about Oracle, Java, etc. for technical expertise." Another one said, "I'll take trade publications with me when I travel."

In corporate settings, employees have to accomplish a variety of tasks on time. Therefore, they do not have much time to figure out what goes wrong if their initial information seeking strategies do not work. In general, they change their information seeking strategies by changing resources, reformulating queries, or changing behaviors. In this study,

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changing resources (50.8%) accounted for about half of the shifts. Changing resources was considered as a quick and effective strategy in finding relevant information, especially for people who lacked the information seeking skills or system knowledge. Here is an example of changing resources, "I don't have enough knowledge about the system, and I don't have time to learn. The easiest way for me is to use another resource." Another gave specific conditions for changing resources, "If it is a normal typical problem, if I don't get what I want in the first 10, 15 minutes, I'm going to give up and go to a different source." Changing resources normally was part of their backup plans. It was also a common practice for people to reformulate their queries (33.2%) if they could not find enough information. Narrowing down (12.7%) was used the most as a query reformulation strategy because many of them liked to start with a general concept to find some information first. At the same time, broadening up (7.9%), trying synonyms (6.3%), and changing formats (6.3%) were also applied. The following is an example of narrowing down the search, "I started with 'privacy,' then got too many hits, and retried as 'customer privacy.'" The participants also changed their behavior (15.9%) to find relevant information. Among all the behaviors, "scan," "search," "consult," and "link" are the information seeking behaviors that can directly lead to potentially relevant information while "select," "acquire," "compare," "learn," and "read" are the indirect seeking behaviors which assist information searching and evaluation. In this study, the calculation of changing behaviors includes shifts among direct seeking behaviors except consulting because it is also part of the changing resource. Here is an example of changing behaviors, "I went to the supplier site and browsed different product information, but could not find the part I looked for; then I searched for the part name and found it." Here is another example of changing behaviors, "I searched on document/file sharing system and got too many hits, and nothing seemed relevant. Then I saw a familiar software company name, I linked to the company site and found the system information." A subject well summarized his information seeking experience, "You get clues where you can trace things down. It's kind of like a private detective, take leads, and go with them."

Discussion: The Enhanced Model and Its Implication for Digital Library Design

This study examined human–work domain interaction in a corporate setting. Based on the results of the study, the model of human–work interaction developed by Pejtersen & Fidel (Figure 1) was enhanced. First, three dimensions for each of the interaction activities that are essential in people's information seeking process in a corporate environment were identified. Second, the relationships among the dimensions of these interactions, especially how strategy activities are affected by other interaction activities were illustrated. Third, characteristics of actors in three types of knowledge structure and personal preferences were highlightd. Figure 2

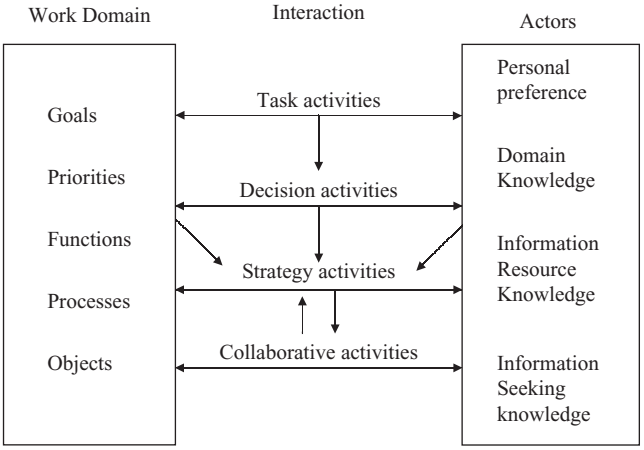

FIG. 2. Enhanced model human–work interaction.

presents the enhanced model derived from this study. The enhanced model echoes the "onion model" of CWA developed by Rasmusses and colleagues (1994, p. 25). The onion model focuses on the tasks actors perform, the work environment, analysis of the activities, the cognitive attributes of the people who typically conduct the task—each of whom is a dimension for analysis. This study further analyzes the three dimensions of each interaction activity and their relationships. Figure 3 illustrates the dimensions of human–work domain interaction and the relationships among them discussed in the Results section. The identification of the dimensions of human–work domain interaction and their relationships help us to understand the dynamics of information use in corporate settings.

The dimensions of interaction activities and their relationships clearly portray what and when users need support in their information seeking process; furthermore, how a digital library can best support them for effective information retrieval. Each work domain and its human–work domain interaction are unique; therefore, designers need to

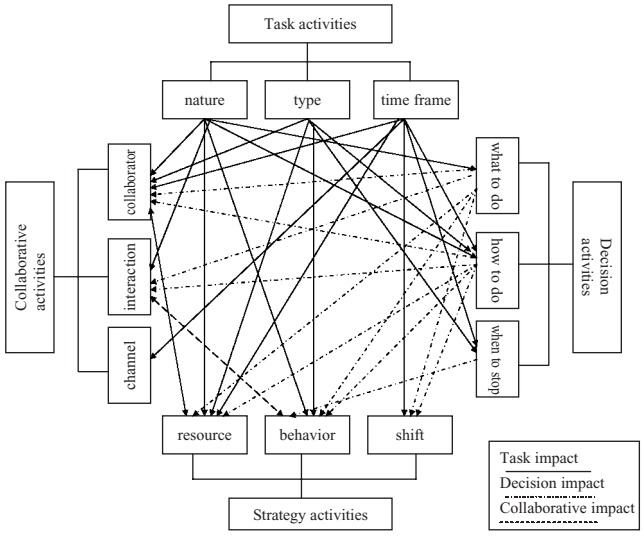

FIG. 3. Relationships among the dimensions of interaction activities.

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take multiple aspects of the context into consideration in the development of a corporate digital library. Four types of interactions form a hierarchy structure, and high-level activities have an impact on the low-level activities. Task activities, decision activities, and collaboration activities affect the selection of strategy activities. The unique contribution of this study is to discuss not only how to support users' information seeking strategies, but how to support dimensions of tasks, decisions, and collaboration activities that lead to different types of information seeking strategies. By supporting these dimensions and their relationships with dimensions of strategy activities, we can support the fundamental part of the information seeking process.

Research has demonstrated that tasks have an impact on information seeking behaviors (Algon, 1999; Bystrom & Jarvelin, 1995; Vakkari, 1999). This study further identifies the relationships between dimensions of tasks and dimensions of information seeking strategies. One interesting finding is the majority of the tasks that people in corporate settings perform are typical and routine ones. It is important for corporate digital libraries to support these typical tasks. This study shows that people normally have certain information seeking strategies in their plans for their routine tasks, which include information resources selected, possible actions, and even backup plans. One way to support these tasks is to create a personal portfolio for each of the employees, which consists of task categories with linked resources, queries used and search phrases, previous results presented, and alternative plans listed under each of the tasks. In addition, the time necessary for each task should also be considered in the backup plan, for example, for these extremely urgent and urgent tasks, if a certain information resource is not available temporarily, another one should be suggested. For new tasks, information seeking strategies can be recommended based on the types of tasks. One way to do that is to create templates for different types of tasks, such as updating information, looking for specific information, known items, and items with common characteristics. In one word, intelligent digital libraries need to be designed to provide users useful information as well as facilitate users finding relevant information efficiently.

Decision activities need to be supported most; at the same time, they are the most difficult activities to be supported. In the process of supporting tasks, we need to discuss how to support decision activities in more detail. Most of the participants in this study expressed their concerns in query formulations. To help people to convert their visceral information needs to an expression (Taylor, 1968) that an information retrieval system or human resource can understand, the digital library needs to offer help in (a) domain knowledge, such as a description of a topic or synonyms for key terms in one area; (b) system knowledge, such as multidimensional help mechanisms, especially examples of different ways to form a query; and (c) information seeking knowledge, such as suggestions for different information seeking strategies. This study demonstrates that participants did plan to a certain extent even though they did not think they did. Simultaneously, situations greatly affected their information seeking strategies in the retrieval process. That corresponds with my previous research (Xie, 2000, 2002) that information seeking behaviors are the products of both plans and situations. This study suggests that the digital library needs to be flexible in supporting a person's plan, considering some of the frequently occurring situations, for example, unavailability of some of the information resources, unsuccessful search results, etc. Another way to support that is to characterize shifts of information seeking strategies and further support those shifts. Each individual has his or her own way of determination of when to stop looking for information. One way to support this dimension of decision activity is to support the evaluation activities; that is to assist people to evaluate their results effectively, so they can make a quick decision about whether they have enough information. For each of the routine and typical tasks, people are clear about what to look for in the results, if the system can present a summary and highlight the information to help them to make the decision.

While this research results echo previous research that people are the important resources of information (Hertzum & Pejtersen, 2000), it further analyzes the reasons for collaboration and types of interactions in collaboration. In terms of how to support collaborative activities, three approaches can be applied. First, based on the analysis it seems that although collaborative activities are essential in assisting the information retrieval process, some of the collaborative activities can be avoided or improved. One reason for the increase in collaborative activities is that most of the internal data are located in different places and owned by different people. One way to solve this problem is to construct integrated databases for varied internal data; furthermore, the digital library should also offer search capability to enable people to search for internal information. There are new federated search solutions that can integrate proprietary and subscription databases with Internet resources, as well as internal information sources. The availability of internal data in the digital library will greatly reduce some unnecessary collaborative activities and make necessary collaborative activities more efficient. Second, some of the interactions of collaborative activities focus on providing guidance in locating the right information. As an alternative way to support that, the most frequently asked questions could be incorporated as part of the help mechanism. Third, among all the collaborators, experts play an important role in guiding people in finding the relevant information. Simultaneously, it is not an easy task for an individual to name all the experts within and outside the company. The most effective way to support collaborative activities is to identify the contact information of experts within and outside the company; employees normally know their clients and consultants but don't have all the information about experts. Technologies, such as ActiveNet software developed by Tacit located in California, offer expert finding systems within organizations. This will provide a central point for connecting experts within the company. The availability of online chats,

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especially streaming video online chats will faciltate face-to-face and other synchronous interactions.

As discussed above, it is important to support interaction activities that lead to the strategy activities. There are still some important issues that need further research: (a) The identified information seeking behaviors reflect the normal information seeking process. One behavior that takes users' time but gets little attention from the existing IR systems is scanning to evaluate the relevancy of the results. One subject complained, "Like for example, today when I did customer relationship management, it says you are looking at one of the first 20 of 144,000 hits." Further research needs to examine what components users normally scan to evaluate and find a way to highlight these components in the display of results. (b) Because there is no way we can design a digital library that can adapt to every user, therefore, users, to some extent, have to adapt to the digital library. The problem is that employees in corporate settings do not have much time to learn. How can we design a corporate digital library that makes the learning process a minimum? One way is to develop an interactive help mechanism that enables users to interact with the digital library in terms of what they want and how they can proceed. (c) Because of the dynamics of information retrieval process, users have to change their resources, change their behavior, or reformulate queries to fulfill their search tasks. The most popular shift for the participants is to change resources. The best solution for the resource change is to integrate the three types of resources in a digital library. As suggested above, federated search solutions can be used to integrate different types of resources that might help reduce or eliminate some of the resource shifts. Converting printed material, especially internal documents into electronic format is also vital and possible. The difficult part is how to convert a human resource into an electronic format. One way is to record human knowledge into files, and another way is to incorporate the interactive components into the design of digital libraries. Of course, for the time being users still need help from human resources. The design of digital libraries needs to facilitate the identification and interaction with human resources by using synchronous multimedia technologies. (d) In terms of supporting shifts in behaviors and query reformulations, more options for users to search, browse, link, and consult need to be integrated, and the changes among them need to be facilitated. Different knowledge structures discussed above for effective query reformulation need to be built in. Employees in a corporate setting normally only need enough instead of complete information. As a result, the focus of the digital library design is how to increase precision not recall.

When we discuss how to design digital libraries to support dimensions of interaction activities, we need to pay special attention to the work domain and the actors involved in the process. The analysis of the work domain demonstrates that it plays a crucial role in affecting the four types of interactions, and it provides the context for the development of a digital library for the people in that work domain. In this study, the work domain analysis reveals that the merger between the two big corporations influences strategy activities, especially people's information resource uses. Hirsh and Dinkelacker (2003) found that the unstable environment resulting from a corporate merger affects people's information use and collaboration. Information seeking was dominated by use of the Internet and participants consulted with colleagues outside of the newly merged company because of culture change. This study further revealed that the merger had an impact on the availability, the organization, and the presentation of a variety of information resources. There was a lack of standardized, authorized, and organized information resources, especially internal information resources in this merged corporation. The existing digital library failed to serve as the center of information resources. Creating an integrated collection of different types of information resources with an integrated interface of a digital library is the fundamental part of the creation of this corporate digital library. Simultaneously, company philosophy, business cycles, goals of the company, priority, general function, work process, and resources available also need to be considered in the process of designing corporate digital libraries. Another vital component that needs to be considered is the actor's knowledge structure that has been discussed in detail in decision activities. In summary, a personalized and customized digital library is crucial for its effective use.

Conclusion

This study investigates human–work domain interaction in a corporate setting by using the cognitive work analysis approach, which allows a systematic analysis of the work domain, the actors, and the interactions between the two. Three important dimensions emerged from the data for task activities (nature of task, type of task, and time required), decision activities (what to do, how to do it, and when to stop), collaborative activities (types of collaborators, types of interactions, and types of channels), and strategy activities (types of behaviors, types of resources, and strategy shifts). The illustration of the relationships of the dimensions of four types of activities, especially how the dimensions of high level activities affect the dimensions of low level activities and finally influence the dimensions of information seeking strategies, highlights the most important user support needs in corporate digital library usage. It contributes to the essential knowledge required to design digital libraries that enable users to access effectively a variety of information resources in a corporate setting.

Further research needs to be done on how can we design a digital library to adapt to users and at the same time make it easy for users to adapt to the system as well as how to support the dynamics of the information retrieval process by taking into account the dynamics of the human–work domain interactions—people are the actors as well as the collaborators for human–work domain interaction. There is still the question of how to design digital libraries that facilitate people's collaboration and more important, to enable

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digital libraries to interact with users. Future research also needs to compare cognitive work analysis and other research approaches for studying interactive information retrieval and further develop an integrated model to illustrate the nature of information retrieval process.

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