

# **Information-seeking behaviors of academic researchers in the Internet Age: A user study in the United States, China and Greece**

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This paper presents preliminary results of an ongoing study of academic researchers' information-seeking and communication behaviors (IS) in the Internet age. The study used a semi-structured interview method, and a hybrid quantitative and qualitative approach to observe research use of Internet-enabled information and communication technologies/resources (IICTs). A research framework is developed to comprise two dimensions: (A) IS behaviors pertaining to long-term research needs or corresponding to project lifecycle; (B) IICTs providing information or supporting communication. The IS dimension adopts Ellis's behavioral model with revision; the IICT dimension includes commonly used tools and resources such as the Web, email, digital library, online library catalog, e-journal, etc. This paper reports on part of the preliminary results of three datasets from two disciplines (computer science and engineering) in the U.S. (28 participants), Greece (19 participants), and China (35 participants). Converging and integrating information resources have caused terminological confusions. Overlapping in access to information resources also blurred the boundaries between different types of

information systems. The use and non-use of IICTs depend on many different factors. Our results also show that the major IS activities proposed by Ellis continue to play important roles in research, but these activities are now handled in both traditional and diverse new ways in the Internet environment. Managing information is a big challenge and effective tools are needed. Libraries and librarians are less recognized as information is becoming more accessible via the Internet. There is a need to shift from traditional service and user instruction roles to new roles.

## Introduction

Understanding communication and information behaviors of scientists for designing effective and efficient information systems and services has been an important research topic since the 1960s (There are few influential writings on scientific communication: Dervin & Nilan, 1986; Garvey, 1971; Ingwersen, 2001; Tenopir & King, 2004). Although a substantial body of literature exists reporting on empirical results of the studies of information seekers in various contexts, there is an enduring interest in observing information-seeking behaviors in our ever-changing information environments, and the need to ask and try to answer the question: how do scientists seek information in the Internet age?

This ongoing study investigates academic researchers' information-seeking and communication behaviors (IS) in the Internet age. We use a semi-structured interview method, and a hybrid quantitative and qualitative approach to observe researchers' uses of Internet-enabled information and communication technologies/resources (hereafter, IICTs). The purpose of the study is to understand how various IICTs are used to support IS in research and what are the similarities and differences across disciplines and cultures.

An ideal cross-cultural study should draw samples from countries representing diverse cultures using a standard cross-cultural methodology, typically a quantitative approach. The fact that information seeking is a basic element of scientific research implies that any countries with a substantial number of researchers having Internet access are our target sampling sources. Realistically, participants are hardly accessible or available. For example, in the U.S., many people have experienced survey fatigues, and thus are unwilling to respond to surveys even when monetary rewards are given. In China, people tend to feel uneasy about being observed for research purposes. Due to a lack of funding for participation incentives, we adopted several strategies: selective sampling with a focus on several disciplines, convenient and opportunistic sampling, plus the snowball technique, to include as many participants as possible within each discipline. Participants are from several academic units: the humanities (e.g., philosophy and religious studies), journalism, information science, computer science, and engineering. These disciplines are targeted based on their diverse research foci and methods ranging across the spectrum from human-centered to system-centered. Within each discipline, we use convenience and snowball sampling, and extend the study to different

countries opportunistically. We are fully aware of the limitation of our sampling method and take the limitation into consideration in data analysis. It must also be noted that in this study we do not focus on cultural communities. Rather, we focus on universal information behaviors, that is, the use of IICTs to support IS. We view culture as a contextual factor that sets the information environment in which a researcher carries out research. Therefore, this study is not a cross-cultural design using an ethnographic or case study approach. Rather it is a typical user study that combines quantitative and qualitative methods to interview researchers using the same semi-structured guideline to collect data in different countries. With this in mind, our results are useful in providing general ideas about how academic researchers seek information in different Internet environments. Further studies using a different design are needed if a generalization is called for.

This project began in summer 2005 and is still ongoing to include more participants from selected disciplines, especially the humanities. Our starting point was to observe academic researchers from different disciplines in the U.S. As an opportunistic move, we extended the project to collect data in China during winter 2005 and summer 2006 when some of us visited China on personal trips or for conferences.

Greece was the third country joining the project in summer 2006, when the second author came aboard as a collaborator. Being a member state of the European Union, the country represents an interesting case, since it is only during the last decade that its academic library system is offering services analogous to those of the most advanced member states in the European Union. A driving force behind this development has been the successful investment in IICT practices and services, as in the case of HEAL-Link (the Hellenic Academic Libraries Link): a national consortium established in 1998 which operates a portal (<http://www.heal-link.gr/enh/>) through which all higher level institutions in Greece and Cyprus have access to more than 10,000 research journal titles, today.

Several relevant cultural facts of the three countries are worth mentioning as background information. First, three different languages are spoken in the three countries. All Greek participants were interviewed in English. All Chinese participants were interviewed in Chinese using the Chinese version of the same interview guide. Second, the three countries have different political backgrounds: the U.S. is known as a longtime democratic country; China has been a socialist country for more than 50 years, but a recent focus has been on economic development. Greece has been a democratic country for more than 30 years and is an EU member. Third, the economic indicators by the World Bank put these countries in the order of the U.S., Greece, and China. China, although a developing country, has the fastest economic growth rate among the three in recent years. Fourth, the world development indicators (WDI) provide a profile of research and Internet use of these countries between 1997 and 2004 (Table 1). The U.S. has the highest number of researchers per million people and the highest R&D expenditure per GNP. China showed the fastest growth in both the number of researchers per million people and the R&D expenditure per GNP over the 7-year period. By

2004, the number of Chinese researchers had a 62% increase over 1997; China's R&D expenditure per GNP was more than twice as that of Greece. In the U.S. the number of Internet users had reached a significant majority by 2004, while in both Greece and China, the number lagged behind. At the end of 2006, China reported that the number of Internet subscribers has reached 132 million, a 30% increase over 2005, becoming the world's second-biggest population of Internet users after the United States (<http://www.msnbc.msn.com/id/16392877/>). According to the most recent statistics, 70% of the U.S. population, 30% of the Greek population and 10% of the Chinese population have access to the Internet by the end of 2006. A comprehensive study also reports that China has the most sophisticated filtering system to control information dissemination and access over the Internet ([http://www.opennetinitiative.net/studies/china/ONI\\_China\\_Country\\_Study.pdf](http://www.opennetinitiative.net/studies/china/ONI_China_Country_Study.pdf)).

Table 1. Research Profiles and Internet Users

Country	R&D Researchers (per million people)		R&D Expenditure (% of GDP)		Internet Users (per thousand people)	
	1997	2004	1997	2004	1998	2004
	US	4211.21	4818.24	2.58	2.68*	307
Greece	1014.01	1412.81	0.51	0.58	32	177
China	437.84	708.15	0.68	1.44	2	73

Source: World Bank (URL: <http://devdata.worldbank.org/dataonline/>; accessed via the University of Tennessee Hodges Library Website on December 29, 2006)

\*Data for 2004 was unavailable; the number was an estimation based on previous years' data.

By January 2007, we had interviewed 119 academic researchers in three countries. The Greek participants are from computer science and engineering. To make cross-country comparisons in this paper, we report on part of the preliminary results of three datasets including 82 participants from only two disciplines (computer science and engineering) in the U.S. (28 participants), China (35 participants), and Greece (19 participants).

## Related Studies

A substantial body of literature exists on information seeking and scientific communication. Due to space limitations, this review is extremely brief. Readers are directed to several excellent reviews and monographs for this line of research (Bates, 2005; Case, 2002; Dervin & Nilan, 1986; Fisher, Erdelez & McKechnie, 2005; Spink & Cole, 2005).

It has been well documented that information seeking and use varies by discipline, profession, task, situation, and context (e.g., Bates, 1994; Bates et al., 1995; Borgman, 2006; Bystrom, 1999; Case, 2002; Cool, 2001; Dervin, 1997; Kling & McKim, 2000; Hansen & Järvelin, 2005; Rice & Tarin, 1993; Savolainen, 2006a, 2006b; Solomon, 1997, 2002; Taliija

& Maula, 2003; Tenopir et al, 2005; Tenopir et al, in press; Vakkari, 2006; Vakkari & Taliya, 2005; Zhang, 2001). Using various research methods (Wang, 1999), the majority of the studies have focused on specific user groups or individual IICTs, such as e-journals, digital library, and online library catalog, etc.

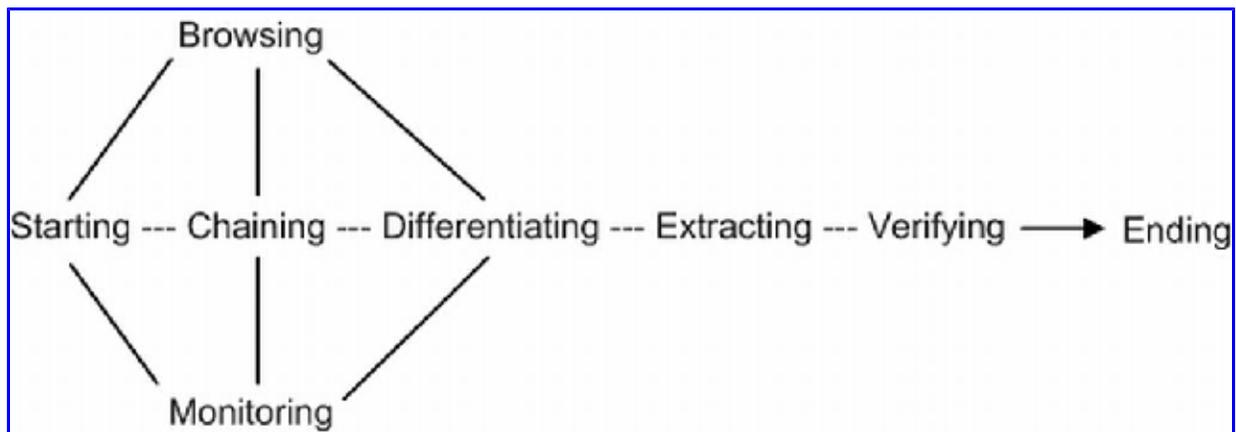
Taking various approaches, such as cognitive, sense-making, behavioral, etc., different models have been proposed at both the macro and micro levels (e.g., Belkin, 1980; Ellis, Cox, & Hall, 1993; Dervin, 2005; Ingwersen, 2001; Ingwersen & Järvelin, 2005; Kuhlthau, 1993; Marchionini, 1995; Saracevic, 1996; Wilson, 1981, 1999).

## **Research Framework and Research Questions**

A research framework is developed to guide data collection. We adopt Ellis's behavioral model with modification and expansion. Ellis's model is chosen for its simplicity with the focus on specific information activities rather than information needs. Our model comprises two dimensions: (A) IS (information seeking) behaviors pertaining to long-term research needs or corresponding to project lifecycle; (B) IICTs (Internet-enabled information & communication technologies/resources) providing information or supporting communication. The IS dimension adopts Ellis's behavioral model with modification; the IICT dimension includes commonly used tools and resources such as the Web, email, digital library, online library catalog, e-journal, etc. Due to the lack of agreed-upon definitions for IICTs, a phenomenological approach is taken to accept the way in which users conceptualize these terms, and identify and observe differences and commonalities in terminological use during data analysis.

The behavioral approach is appropriate for this study because it focuses on a small number of information activities that are tractable, thus it is feasible to use the semi-structured interview method to include a large number of participants in different countries. Ellis's model is well tested in various disciplines and has direct implications for information systems and services (Ellis, 2005). Some extensions have been made by other researchers. For example, Wilson (1999) rearranged the eight information-seeking activities into a stage process model:

**Figure 1. Wilson's Interpretation of Ellis's Behavioral Model. Source: Wilson (1999, p. 255)**



In a model by Garvey and his associates (1979), scientific work is broken down into 11 stages of research activities during which there are 10 types of information needs.

Meho and Tibbo (2003) revised Ellis's model by adding three information activities: *accessing*, *networking*, and *information managing*; they also proposed a new stage model by grouping the activities into three broader, overlapping categories: searching (starting, chaining, browsing, monitoring, differentiating, extracting, networking); processing (chaining, extracting, differentiating, verifying, information managing, synthesizing, analyzing, and writing); accessing (decision making). Ending was treated as an assumed stage.

Building on these major studies, our two-dimensional framework comprises: (A) IS behaviors; (B) research use of IICTs. The IS dimension is classified into (A.1) general activities pertaining to long-term research needs; (A.2) task-based activities corresponding to project lifecycle:

### ***A.1. General IS Activities Pertaining to Long-term Research Needs***

**Monitoring:** Keeping abreast of developments in research areas.

**Browsing:** Looking casually (semi-directed searching) for information of research interests.

**Managing:** Storing and organizing found information objects in personal collection.

**Archiving:** Depositing one's own publications to open access institutional or disciplinary repositories.

### ***A.2. Task-based IS Activities Corresponding to Project Lifecycle***

**Starting:** Initial searching for relevant information at the onset of a project.

**Searching:** Focused and systematic searching for information through specific resources.

**Accessing:** Obtaining a physical copy of the needed information objects.

**Chaining:** Following references (backward) or citations (forward) for additional information.

**Ending:** Stopping information activities; producing research output; disseminating.

Five of the above nine elements are adopted from Ellis's model: *monitoring*, *browsing* as

general IS behavior in A.1; and *starting*, *chaining*, and *ending* in A.2 as task-based behavior. We did not include Ellis's *differentiating*, *verifying*, and *extracting* (Figure 1) which are micro activities occurring at the time of information processing, searching or use. We must note that *browsing* is widely used in the field to mean often different activities by different researchers. As users interact with a retrieval system browsing is one of two major actions, such as browsing a directory vs. querying a search engine. Browsing as a system-level action is best observed during real searching sessions. It is not considered in this study. In our framework, we treat browsing as a general information activity that occurs without a specific research task in hand. We adopted three elements from the model by Meho and Tibbo: *managing* in A.1, and searching and accessing in A.2. We added *archiving* to our investigation to observe the influence of the new e-Science and open access movement (BOAI, 2002). Both *archiving* and disseminating research findings are likely to occur at the *ending* stage. This framework considers information exchange through informal communication channels, such as contacting other researchers about an idea or obtaining a copy of publications.

The IICT dimension also comprises two classes: (B.1) communication tools; (B.2) formal information resources. Although several IICTs in B.1 may be arguably classified into B.2, such as the Web, blog, and wiki, we intend to group the four standard formal scientific and scholarly information resources in B.2 so that our scheme is consistent with Garvey's formal domain of communication and information channels (Garvey, 1979). In the initial interview guide, we listed 9 of the 11 IICTs. Wiki and instant messaging were added when a few participants mentioned them. In the interview guide, these terms for IICTs were not defined assuming that if a participant recognizes a term, the participant has either experience with the tool or knowledge about it. During an interview, if the participant asks questions about any IICTs, a brief use-oriented description is given along with examples of the tool in question (see Research Method for explanation).

### ***B.1. Internet Communication Tools***

**Email**: An asynchronous communication tool between individuals (almost no need to define).

**Listserv**: An asynchronous communication tool to send messages to a large number of subscribers via email.

**FTP**: A tool for transferring files between two computers.

**Web**: A hyper-text and multi-media tool for authoring and publishing content, and for accessing information.

**Blog**: A Web-based diary on a particular subject and maintained by a blogger (person/organization).

**Wiki**: A Web-based collaborative tool: users can create, remove, and edit contents; changes are logged.

**Instant messaging**: A real-time communication tool using text chat, voice and video between individuals.

## ***B.2. Internet-enabled Formal Information Resources***

**Online library catalog:** Online library catalog has evolved from a tool to access library collections to providing links to various databases (free or subscribed), e-journals, or other library catalogs (supported by federated search).

**Database:** Many bibliographic databases, numerical databases, full text databases through library subscription or free are now available online via Web.

**E-Journal:** Two kinds of electronic journals co-exist: (i) with a print equivalent (evolved); (ii) pure e-journal (born in electronic format)

**Digital library:** The most diverse notions and often mentioned as a known portal, consortia, repository, and databases.

In this paper, based on the above framework and the three datasets, we address the following specific research questions:

1. What IICTs are used by academic researchers? Why are certain IICTs not used?
2. How do academic researchers engage in IS activities in the Internet environment? What IICTs do they use to support these IS activities?
3. What are the differences in IS activities and use of IICTs by academic researchers in the U.S., China and Greece?

## **Research Method**

This project started as an interdisciplinary study of Internet use for research in the U.S. in summer 2005. We adopted a hybrid quantitative and qualitative approach to our research questions. The quantitative data, on one hand, will give us a general idea on the differences based on descriptive or nonparametric statistics. The qualitative data, on the other hand, will provide some insights into participants' own IS behaviors and the reasons for use or non use of certain IICTs. Data collection started in summer 2005 and is ongoing to include more participants and additional countries. See Introduction for details.

**Participants.** Participants are from a U.S. southeastern state university (a Carnegie Research University), four national universities in China, and three national higher education establishments in Greece. Invitations were made via email and personal contacts to recruit active and productive researchers in the selected disciplines (the humanities, journalism, information science, computer science, and engineering). In some cases, the researchers identified and approached potential participants at research seminars and international conferences. Using the snowball technique, we are often connected to new participants via those who have just participated.

In the period between June 2005 and January 2007, a total of 119 faculty and doctoral students were interviewed. All doctoral student participants have either defended proposals or published research. Of the 119 participants, we include in this report only the 82 participants

from computer science and engineering in three countries: U.S. (28 participants), Greece (19 participants), and China (35 participants).

Interview guide and procedure. A well-formatted interview guide serves as a data collection instrument to ensure consistency of interviews carried out by the team.

(<http://web.utk.edu/~peilingw/research/> ) The research questions are operationally instrumented into open or closed questions to obtain both quantitative and qualitative data on the usage of IICTs, the reasons for not using certain IICTs, the perceived importance of the IICTs, and general and task-based IS activities and their supporting IICTs.

In developing the interview guide, we were challenged by the lack of both an appropriate taxonomy of IICTs and uniform definitions of the terms. It became evident that we must take a phenomenological approach to let participants express their own conceptions of IICTs. Therefore, we simply give the participant a list of IICTs without definitions assuming that if a participant has used them, he/she will recognize the terms. If the participant wants clarification on a term, we provide a brief description with examples, that is use-oriented, rather than technical details.

The interviews were conducted in a place preferred by the participant: his/her office, the researcher's office, or a meeting room. With the permission of the participant, the interview was recorded using a digital recorder. In a few cases, the interviews were not recorded because the participants preferred not to be recorded; the interviewer took notes as an alternative. During the interview, the participant has a copy of the guide in hand. A typical interview lasted about 40 minutes. All Greek participants were interviewed in English; all Chinese participants were interviewed in Chinese using the Chinese version of the same interview guide. The Chinese version of the guide was tested and revised using Chinese speakers.

## Results and Discussion

We focus on reporting qualitative data but will refer to quantitative results for the purpose of comparison. The quantitative results are detailed in Wang & Dervos (2007). The following subsections correspond to the research questions.

### *Use of IICTs by academic researchers (Question 1)*

This subsection reports general research use and perceived importance of IICTs. Table 2 summarizes the use of the 8 IICTs excluding three less-used types: blog, wiki, and instant messaging. The most-used IICTs across all researchers are email and the Web. Table 3 presents the aggregated importance ranking of 6 IICTs including the two most-used communication tools and four information resources. Table 4 presents frequency of the use of the 6 IICTs. Intuitively, Tables 3 and 4 are indicative of a possibly positive

association between frequency of use and ranking. We ran Kendall's tau\_b test (nonparametric) to identify possible associations between these variables. We found positive associations between frequency of database use and its ranking ( $p < .01$ ), between frequency of e-journal use and its ranking ( $p < .05$ ), and between frequency of digital library use and its ranking ( $p < .05$ ). In addition, we also tested associations between length of use and ranking. We found the longer the participants have used email or e-journal, the higher they tend to rank them. For e-journal, both length of use and frequency of use may have affected ranking. These results are suggestive but not conclusive.

Table 2. Usage of IICTs

Number of Users \		Country			
		US	China	Greece	All
\ IICTs		28	35	19	82
Email		28	35	18	81
		100.0%	100.0%	94.74%	98.78%
Web		28	33	19	80
		100.0%	94.29%	100.0%	97.56%
Internet-enabled digital resources	Digital Library	23	29	19	71
		82.14%	82.86%	100.0%	86.59%
	Online Library Catalog	24	26	15	65
		85.71%	74.29%	78.95%	79.27%
	Database	19	28	17	64
		67.86%	80.00%	89.47%	78.05%
	E-Journal	22	28	11	61
		78.57%	80.00%	57.89%	74.39%
	At least one of the above four	28	32	19	79
		100.0%	91.43%	100.0%	96.34%
FTP		22	21	11	54
		78.57%	60.00%	57.89%	65.85%
Listserv		18	5	9	32
		64.29%	14.29%	47.37%	39.02%
Note: Blog, wiki, and instant messaging are omitted from the table due to low use.					

Table 3. Importance Ranking

Rank	All (N=82)	US (N=28)	Greece (N=19)	China (N=35)
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1st	Web	Email	Web	Email
2nd	Email	Web	Digital library	E-journal
3rd	Digital library	Digital library	E-journal	Web
4th	E-journal	E-journal	Email	Digital library
5th	Database	Online library cat.	Database	Database
6th	Online library cat.	Database	Online library cat.	Online library cat.
Note: Based on median; means are used as tiebreaker.				

Table 4. Comparison of Frequency of Use

Freq.	All (N=82)	US (N=28)	Greece (N=19)	China (N=35)
↑	Email (1)	Email (1)	Email (1)	Email (1)
	Web (2)	Web (2)	Web (1)	Web (2)
	Database (3)	Database (4)	Digital library (3)	Database (2)
	Digital library (4)	Digital library (4)	Database (3)	Digital library (3)
	Online library cat. (4)	Online library cat. (5)	Online library cat. (5)	E-journal (3)
	E-journal (4)	E-journal (5)	E-journal (5)	Online library cat. (4)
Note: Median is used for the order; mean is used as tiebreaker. Data were coded as follows: 1, Multi times a day; 2, Daily; 3, Multi times a week; 4, weekly; 5, Multi times a month; 6, monthly; 7, multi times a year; 8, yearly				

Among all the formal information resources, both the number of users (Table 2) and frequency of use (Table 4) for e-journal are relatively lower. Why is e-journal used by fewer researchers and less frequently; why is e-journal ranked lower than digital libraries for both the U.S. and Greece participants? A close reading of the transcripts revealed diverse conceptions:

I think e-journals are more recent than most of the acknowledged journals. They're not so well established. And up to now it didn't happen to me to find papers and consult e-journal contents. [A Greek participant]

I think the e-journals, there's a couple things, first, I mean, I've used it, I think I used it once, but I wasn't comfortable with it, I couldn't tell if it was legitimate or if it was valid or if it was solid research. [A U.S. participant]

... but it [e-journals] won't count in our department a lot of times. Many of those are not referred. [A U.S. participant]

... when I think of those [e-journals] they're usually in the portals,... so I think of e-journals as being refereed journals that are only online. [A U.S. participant]

Our participants often referred to using a digital version of the traditional journals as using digital library or publisher's database. Typically, e-journal means only the born-electronic journals that are free, online and not peer-reviewed. Evidently, the overlapping and convergence of Internet technologies and digital resources have blurred the boundaries between resources. As one participant said,

I don't pay attention to whether that's a digital library or what. I'm just happy that I found what I was looking for. [A U.S. participant]

What users need and want is information not systems; systems are simply a means to an end (information). Preference for a means-end approach by typical users can explain why distinctions between Internet information resources are ignored. Most users would not bother to make distinctions between information systems or individual components of an integrated information source.

Expectations or perceptions play an important role in use as well. Here is a case. A participant had used the print ISI citation indexes in the past. He stopped going to the library for these indexes because he could simply use CiteSeer instead. He was unaware that the same ISI citation indexes were accessible through the library website as Web of Science. If he had expected the evolution of the same resources from print to e-format, he would likely have explored the availability. This case supports Vakkari's (2006) conclusion from the FinELib user study: perceived availability is a strong predictor of the use of digital library services.

How to reach and keep these users is worth our special attention and effort; losing current users is a failure that libraries should avoid. It is unrealistic or unfair to expect or demand users to make fine distinctions while system and resource designers and developers have not chosen carefully the right terms that make sense to a majority of users and are easy to learn and differentiate.

### ***Comments on non use or low use of certain IICTs (Question 1)***

Participants explained why certain IICTs were not used or used infrequently for research. Table 5 presents the preliminary results from our first-round selective coding. Lack of time seemed the most frequently mentioned reason for not trying a new unknown IICT. Information overload and lack of appropriate organizational structure also made certain tools less desirable. Some values associated with traditional authoritative resources, such as peer-review still play an important role in use decision. Further analysis through systematic coding will reveal additional reasons and the relative importance of these reasons and will enable cross-country comparison.

Table 5. Reasons for Non Use or Infrequent Use

	Coding	Example Quotations
Personal situation & perception	time constraints information overload	o My opinion from the blogs I've seen so far, they're a lot of discussion, a <u>lot of information</u> , and you need a lot of <u>time</u> to process this discussion, and I don't have this <u>time</u> . ...
	availability	o Books are <u>not available</u> on e-format. o Our libraries have <u>no subscriptions</u> .
	convenience	o I can live without it. I could get them on paper and type them up, but that would be an <u>inconvenience</u>
	unknown	o Blog, ftp, listserv: to be honest, <u>what</u> are they? What is their <u>usefulness</u> , ... ?
	nature of projects	o In <u>my project</u> , I used a lot of drawings and blue prints that will never be in electronic format.
Field or social context	trust <sup>\$</sup> peer-reviewed	o Newsgroups, I don't <u>trust</u> their sources ... I tend to trust colleagues I know. o I put more faith in <u>peer-reviewed</u> literature information
	tenure tradition	o Even though we say "that's referred"[e-journals] ... I think it takes time for those old people to <u>recognize the value</u> of them.
	disciplinary norm	o In <u>our field</u> computer science there's <u>more emphasis</u> now on conference proceedings, for example, to an extent, cause journals take too long to get out.
	network externality	o "... but no others use it." vs. "... every one in our group is using it."
Resource characteristics	form or mode	o I don't like these democratic <u>forms</u> of communication [wiki]. It wastes your <u>time</u> .
	organization & structure	o They [blog, bulletin, listserv, ...] lack <u>organization</u> and <u>structure</u> . ...You don't know where to spend your <u>time</u> reading.
	focus	o Since our discussion is about research, from my experience ... at least maybe I'm not aware of particular blogs that are <u>focused</u> on my research, so that's why.
	usefulness	o We use it [ftp] sometimes and I don't find it very <u>useful</u> . o ... large files like several gigabytes data that ftp <u>couldn't support</u> .
<p><sup>\$</sup> Trust was identified to play a central role in scientific communication. (Kling &amp; McKim, 2000)</p>		

### ***IS activities and their supporting IICTs (Question 2)***

General IS activities pertaining to long-term research needs. Table 6 summarizes preliminary results that relate IS activities with specific IICTs as mentioned by the participants. Such relationships can provide suggestions on how information tools can be improved and

designed to facilitate IS activities. Although individual researchers' road maps to information differ, conferences and the Web are frequently mentioned favorite channels for keeping up-to-date on research areas:

I would probably have to immediately point out the conferences that I have been to have been a big source of that [monitoring], maybe as much, or more so, than anything that I get off the Web. [A U.S. participant]

... by consulting IEEE, ACM sites, my top priority. And then I consult certainly Elsevier, and some Springer journals, but not as regularly as ACM and IEEE and so on. Also I'm trying to follow some colleagues or other researchers' work who are experts in my area, so I'm trying to see their latest papers. [A Greek participant]

Most conference programs are now on the Web or coming to their email boxes (listserv) and definitely are a greater boon to researchers. Several participants who are editors or referees keep up with the developments in their areas of research through their professional services.

Browsing is becoming a much easier task today in some fields; free table of contents as alerts are delivered to email boxes or made available on the Web. There seems to be no need to go to these sources in libraries as in the old days. Most experienced researchers browse regularly their associations' websites or known experts' homepages for monitoring, as well as for specific research information.

The answers to how they manage digital information are widely diverse. For digital information objects, there are basically three ways of using them: (1) print a copy only; (2) read on computer and save a file; (3) print a copy and save a file. For those who keep only a print copy, organization schemes are very much the traditional binders, file cabinets, and piles or stacks. Piles and stacks tend to be discarded after a period of time, such as 6 months or 2 years after project completion. Those who save a digital copy are using different organizational schemes to save files, all of which are file structure based: directory-subdirectory by project, subject, etc. (see Table 6). These participants do not delete the saved files, thus many are facing the problems of finding them later or of frequent computer updates. To aid later finding, many participants rename the files; some save multiple copies in different directories. Only a few participants use personal bibliographic tools such as ProCite, EndNotes. The participants who do not save digital files, or keep printed copies for only a short period, tend to rely on the Internet for later retrieval: "*good stuff will be there.*" Some do not see the need to maintain a personal bibliographic database since they can copy formatted citations from digital sources and simply paste them to their own papers' bibliography (e.g., ACM portal provides formatted citations via a Ref link). Thus, "*why spend the time?*"

Archiving in institutional or subject repositories for open access are the least familiar concept for the majority of our participants, although all have used some types of open sources, for

example, CiteSeer. A few wondered how their publications ended in CiteSeer. For those who have heard of institutional repository, there are both negative and positive attitudes. Depositing pre-prints in open sources can receive helpful comments from interested researchers. There are some concerns with copyright and plagiarism:

... publisher is going to own the rights of the final PDF. ... I respect the rights of the copyright on that. [A U.S. participant]

Papers, I don't have problems just putting free links out there so long as it doesn't violate copyright. Software, we generally prefer to create web forms for people to fill out ... By no means am I trying to be intrusive but we generally like to know, are you listing it in your dissertation? ... really nice when they come back and tell us, 'we've used your software and here's how it works, and here's what we got out of it.' And that's very great. That's really useful feedback for us. [A U.S. participant]

... But, you know, in terms of mailing out pre-prints and broadcasts, I stopped doing that. As a consequence it's good and bad. I found far fewer instances where it seemed like people would rip me off [without giving citations], which is nice. But then, you know, I'm less visible to the community. [A U.S. participant]

Table 6. General IS Activities and Supporting IICTs

How do researchers engage in general IS?	What IICTs do they use?(examples)
<b>Monitoring:</b> keeping abreast of developments	
<ul style="list-style-type: none"> <li>• attending conferences</li> <li>• talking with colleagues</li> <li>• browsing conference program</li> <li>• tracking known experts</li> <li>• browsing tables of content (journals alert)</li> <li>• serving as journal editor</li> <li>• serving as referee</li> <li>• receiving flyers and ads</li> </ul>	<ul style="list-style-type: none"> <li>• Web &amp; search engines               <ul style="list-style-type: none"> <li>○ Google, Yahoo, Baidu (Chinese)</li> <li>○ DBworld</li> <li>○ experts' homepages</li> </ul> </li> <li>• email</li> <li>• listserv (alert)</li> <li>• digital libraries / databases               <ul style="list-style-type: none"> <li>○ DBLP, CiteSeer</li> <li>○ HEAL-Link (Greek national e-resources library consortium for higher education)</li> <li>○ e-journals/magazines                   <ul style="list-style-type: none"> <li>■ BM Journal</li> <li>■ BYTE magazine</li> </ul> </li> </ul> </li> </ul>
<b>Browsing:</b> looking casually (semi-directed searching)	
<ul style="list-style-type: none"> <li>• table of contents of journals online</li> <li>• conference programs</li> <li>• Websites of professional associations</li> </ul>	(typical answer: similar to monitoring or part of monitoring)

<ul style="list-style-type: none"> <li>• email messages (listserv; alert)</li> <li>• journals</li> <li>• professional magazines</li> </ul>	
<p><b>Managing:</b> storing and organizing found information objects in personal collection</p>	
<ul style="list-style-type: none"> <li>• <u>keep e-copy in personal collections</u></li> <li>• <u>print a paper copy to keep</u></li> <li>• <u>for print documents or printout of digital</u> <ul style="list-style-type: none"> <li>• <u>file cabinets</u></li> <li>• <u>binders</u></li> <li>• <u>piles or stacks on desks/chairs</u></li> </ul> </li> <li>• <u>for digital objects directories &amp; folders</u> <ul style="list-style-type: none"> <li>• <u>by chronology</u></li> <li>• <u>by project</u></li> <li>• <u>by subject</u></li> <li>• <u>by author</u></li> <li>• <u>by context</u></li> <li>• <u>by importance as priority</u></li> <li>• <u>rename the file to a characteristic name</u></li> <li>• <u>save multiple copies to different folders</u></li> </ul> </li> <li>• <u>personal bibliographic databases</u> <ul style="list-style-type: none"> <li>• <u>ProCite</u></li> <li>• <u>EndNote</u></li> <li>• <u>RefWork</u></li> </ul> </li> <li>• <u>do not maintain a personal collection</u></li> <li>• <u>save for short-term (6-month–2-year)</u></li> </ul>	<ul style="list-style-type: none"> <li>• bookmarking webpages</li> <li>• collaborative (team) tool <ul style="list-style-type: none"> <li>○ Microsoft OneNote</li> </ul> </li> <li>• "wiki seems like a good method" (TiddlyWiki was mentioned by one U.S. participant)</li> </ul>
<p><b>Archiving:</b> depositing to open repositories for open access</p>	
<ul style="list-style-type: none"> <li>• no institutional repository</li> <li>• disciplinary(subject) repositories</li> <li>• did not know how their publications ended up in open access sites such as CiteSeer</li> <li>• concerns with submitting to repository: <ul style="list-style-type: none"> <li>○ ideas being plagiarized How to handle the copyright issue?</li> <li>○ Where to deposit?</li> <li>○ How many repositories to submit?</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• personal homepages (most U.S. participants)</li> <li>• team project server</li> <li>• disciplinary repositories (Greek participants)</li> <li>• university database to register completed research projects (in China)</li> </ul>

Task-based IS activities corresponding to project lifecycle. Table 7 presents the preliminary

analysis relating specific task-based IS activities and their supporting Internet tools mentioned by the participants. There are two typical patterns of the starting stage: (1) no need to gather information when a project continues from previous research or on a familiar topic; (2) preliminary searching if a new area or topic. For the latter, the Web was the most mentioned:

Well, it never starts from scratch. It builds on things that have been going on, ... cause I already have, you know, the basis in place. [A U.S. participant]

I start with a search engine, a web search engine, Google Scholar, Google, or a generic type of search engine. [A Greek participant]

Both the Web and the four formal resources are used for systematic and focused searching. Assuming not all the information objects are digital or readily clickable, we are interested in how they obtain retrieved information objects. A typical pattern is to try free online systems first and to use library services as alternatives:

I'd probably just see if I could get a PDF online. (laughs) Cause then I could get it here and now. And if I can't, I go through the library, since they have access to more than I do. And step three is I'll email the librarian ... get it into interlibrary loan. ... If it requires any more than that, I'll probably ask anyone else who knows how to do it. [A U.S. participant]

Another method is to email authors for a copy, which was mentioned by most U.S. participants. In two cases, one U.S. participant and one Greek participant obtained all needed information in digital format. If a retrieved source is not available in digital format, an alternative digital source will be used as a substitute.

All researchers frequently follow citations backward. Today's online systems are very convenient for such chaining with hyperlinks. The use of forward chaining to find new information seemed to be less frequent than backward chaining. Users of Web of Science, publisher's databases, and ACM portal have noticed and used citation links. Several participants did not know how to do systematic citation searches and would like to learn. A few mentioned having searched for citations to their own publications. Most have used CiteSeer instead of citation indexes, either being unaware of ISI citation indexes' new delivery system (Web of Science) or preferring its alternatives ("*CiteSeer would be the most useful and digital library is the second.*"). A few participants asserted that the publications they found were current and too new to have citations, thus no need to do citation search.

Almost unanimously, our participants responded to the questions on ending with "*no, research project never really ends.*" However, all acknowledged that purposive information searching was no longer intensively pursued when writing was completed. Few did search again to check missing information.

How do researchers engage in Task-based IS?	What ICTs do they use?(examples)
<b>Starting:</b> initial searching	
<ul style="list-style-type: none"> <li>• may not need if a familiar topic</li> <li>• searching the Web by key words</li> <li>• talking with colleges or experts</li> <li>• visiting experts' homepages</li> <li>• browsing tables of content of journals (alert services)</li> </ul>	<ul style="list-style-type: none"> <li>• websites <ul style="list-style-type: none"> <li>○ funding agency's website (e.g., EPA)</li> <li>○ experts' homepages</li> </ul> </li> <li>• search engines <ul style="list-style-type: none"> <li>○ Google, Google scholar, Yahoo, Baiduo</li> <li>○ DBworld</li> </ul> </li> </ul>
<b>Searching:</b> focused and systematic	
<ul style="list-style-type: none"> <li>• databases</li> <li>• online library catalog</li> <li>• digital library</li> <li>• professional journals (may be digital format)</li> <li>• experts' webpages</li> <li>• e-journals</li> </ul>	<ul style="list-style-type: none"> <li>• Web &amp; search engines <ul style="list-style-type: none"> <li>○ Google, Google scholar, Yahoo</li> <li>○ agency or learned/professional society' websites</li> </ul> </li> <li>• digital libraries/databases <ul style="list-style-type: none"> <li>○ ACM portal</li> <li>○ IEEE Explore</li> <li>○ DBLP</li> <li>○ CiteSeer</li> <li>○ HEAL-Link (see Table 6)</li> <li>○ publisher portal (ScienceDirect, Spinger))</li> <li>○ Web of Science</li> </ul> </li> </ul>
<b>Accessing:</b> obtaining a physical copy	
<ul style="list-style-type: none"> <li>• through library subscriptions</li> <li>• download from portals</li> <li>• download form e-journals</li> <li>• download from personal homepages</li> <li>• contact authors for pdf or word files</li> <li>• interlibrary loan</li> </ul>	<p style="text-align: center;">similar to those listed above</p>
<b>Chaining:</b> backward or forward	
<ul style="list-style-type: none"> <li>• references of relevant articles</li> <li>• who cites us</li> </ul>	<ul style="list-style-type: none"> <li>• Web <ul style="list-style-type: none"> <li>○ CiteSeer</li> <li>○ Web of Science</li> </ul> </li> <li>• publisher portal <ul style="list-style-type: none"> <li>○ ScienceDirect</li> </ul> </li> </ul>
<b>Ending:</b> stop information activities to write; disseminating results	

- never stop (conclusively, completely)
- external deadlines (conference, grant, RFP ...)
- submissions information
- saturation
- most do not use listserv to announce publications

- Web
- post a pre-print on personal homepage
- post a pre-print on group/project webpages
- make a link on homepage to the journal

### ***Comparisons of three countries: the U.S., Greece and China (Question 3)***

Although our samples are small and may not be representative in a statistical sense, we have tried to recruit as many participants as possible from the same academic units (departments). The participation rates range from 30% to 70% of the faculty members in these units. The three datasets are comparable by including only the 82 participants from two disciplines (computer science and engineering) in three countries. To make a cross-country analysis, the two disciplines are merged into one group based on the fact that standard deviations are reasonably small, indicating that the participants in these two disciplines are more similar than different. In the tables reporting quantitative data (Tables 2-4), the results are broken down by countries.

A cursory look at the tables led us to perform nonparametric analysis to gain a better picture of the data and differences: Kruskal Wallis Test for three-country comparisons and the Mann-Whitney Test for pairwise two-country comparisons. It is found that the length of the use of email, the Web, and online library catalog is significantly different between China and the U.S. as well as between China and Greece. This is not surprising because of China's later adoption of the Internet. Using email as a benchmark, Chinese participants on average had 8 years experience by 2006, which is approximately 5 years behind Greek participants and 7 years behind the U.S. participants. Table 4 indicates that Chinese participants are using the formal information resources more frequently. The differences are significant for database, digital library, and e-journal.

Focusing on the importance ranking of the formal information resources (Table 3), we found a significant difference between the U.S. and China in ranking e-journal. Chinese participants ranked e-journal significantly more important. This finding should be related to the substantial confusion about e-journals. Chinese participants did not show much confusion about e-journals, which may be attributed to the way e-journals are organized in libraries. The users are more aware of their existence and evolution from their print counterparts. For digital library, significant differences are found between Greece and the U.S. and between Greece and China. In other words, Greek participants ranked digital library significantly more important than the participants in the other two countries did. As mentioned earlier, Greek participants often refer to consortia and portals as digital library. The establishment of

HEAL-Link, Greek national e-resources library consortium in 1998, has changed significantly the situation of information access from a dearth of information resources in libraries:

We're using our university's digital library, and ACM, IEEE through the HEAL-Link thing. [A Greek participant]

... in terms of libraries, we are much behind. ... you would look for something and you wouldn't find it. It was impossible. ... thanks to the Internet ... [Another Greek participant]

In contrast, Chinese participants commented, "*digital libraries in China are not yet well developed.*" Both Chinese and Greek participants ranked database significantly higher than the U.S. participants. Many Chinese participants mentioned that they heavily use the professional societies' Websites and databases.

A unique practice is found in China. Universities maintain internal databases for researchers to register the abstracts of their completed projects, for which there is a mandate plus a small cash incentive. These are not yet open access repositories, but the practice has potential for developing institutional repositories because the managerial structure is already in place.

As a last interview question following the task-based IS questions, we asked the participants to estimate what percentage of information was digital (vs. print) in a recent complete project or a typical project. On average, participants in Greece used 84% digital resources to satisfy information needs, slightly more than those in the U.S. (81%) and 10% more than those in China (74%). Such differences may be explained by contextual factors as already mentioned above: Greek participants heavily use English scientific literature due to the lack of Greek scientific literature, and also because the participants have all studied in the U.S. or the UK. Most Chinese participants rely heavily on Chinese publications, and the majority of the Chinese literature is not yet accessible in digital format.

Perception of the Web for research has changed from unacceptable to the first channel for information:

I know with myself I've changed. When the Web first came out, then the students started to say, or if you asked them 'yeah, I looked on the Web and I couldn't find it.' 'Well that's not good enough. Go to the library, you know. Check the library.' But now, even I don't do that anymore, because it is, it is there. You got to be careful filtering the data. But, yeah, I think that the role of the library will have to change. [A U.S. participant]

As information is becoming more accessible through the Web, the roles of libraries and librarians are becoming less visible. There are expressions of mixed feelings:

I like to go to the library. I like to touch the book. I like the way the library smells. ... there's something about coming back with all your books ... [A U.S. participant]

Basically, the only reason I would go to the library is to get coffee. [Another U.S. participant]

... thanks to the Internet, I don't have to rely on the library. ... There's no need for library anymore. Why would you need printed material? I don't know. I have Google search, and I find whatever scholar I want to find. Why do I need the library? [A Greek participant]

Sometimes I will go down to the library, but not as often as before, because now I can find online everything that I need. [Another Greek participant]

The information world has changed fundamentally as the world is becoming flat (Friedman, 2006). The field of information science must respond effectively to the impact of the Internet and digital resources (Borgman, 2001; Markey, 2007). In many ways, information needs and seeking are still essential to scientific research, although the ways for getting information are changing. Since the study by Garvey et al. (reprint in Garvey, 1979 as Appendix D), the national meetings as the first place for early dissemination of research findings and a unique channel for information exchange still hold well their irreplaceable grounds. All participants value conferences and personal contact as the most useful channels for monitoring information and getting new ideas:

... now that I think about it, that you get a lot of information verbally from people. When you go to a conference, it's to get your name out there and for other people to put a face to your paper so they know who you are and all that. But also, I personally learn more in the coffee breaks, and, you know, in between sessions, when you talk to people, what they do, what the real issues are, ... that will seed ideas and find out 'don't go there cause someone's already done it, that kind of thing.' ... And so you can always stay on top of it that way, which is actually, I think, a lot more informative than having to find it all on your own. It's more like using a collective knowledge, which is harder to quantify. [A U.S. participant]

I would probably have to immediately point out the conferences that I have been to have been a big source of that [monitoring], maybe as much, or more so, than anything that I get off the Web. [Another U.S. participant]

In our field computer science there's more emphasis now on conference proceedings, for example, to an extent, cause journals take too long to get out. [Another U.S. participant]

I do want to add that attending conferences and keeping in touch with my colleagues, like classmates, are the most important for me to keep up-to-date and get new ideas. [A Chinese participant]

Today using Web technology, conferences are further enhanced and extended. Many conferences have a strict referee process similar to peer-reviewed journals. Most conference

programs are posted on the Web early on. Conference papers and presentations (video or slides) are also accessible online for free. Some fields such as computer science value conference papers as much as (if not more than) journal papers, which is an important factor for encouraging researchers to present and publish with conferences.

Interpersonal communication remains an important information source as reported by Garvey (1979). What is new, perhaps, is the fact that email and the Web have expanded interpersonal communication beyond researchers' local colleagues:

I think really that there is a revolution in doing research. When I started my Ph.D., early nineties, things were very, very different. And I find this fascinating, I'm really very excited with the way we can do work and with the way we can communicate with people worldwide. And for me it has been really amazing to, you know, contact people from all over the world ... [A Greek participant]

In a Web-based survey conducted in Finland, Pertti & Talia (2005) found that colleagues had a minor role in finding literature in FinELib (Finland national electronic library consortium), especially in the humanities group. Our study cannot be quantitatively compared with the FinELib study, because of methodological differences. Our participants did not rank the importance of conferences or personal contact in relation to IICTs. As we continue data collection, we will consider including the two traditional channels in both the importance ranking and percentage estimation of digital information use.

### ***A Methodological Note***

In this study, we used selective and convenience sampling strategies. Samples are from selected disciplines on the spectrum from system-centered to human-centered. By opportunistic expansion, we are able to obtain three samples from three countries in computer science and engineering. As far as the participation is concerned, we observed that those who were invited but declined participation were either too busy or felt themselves to be not much of an Internet user. Therefore, it is fair to say that our results describe more the frequent and enthusiastic Internet users from the fields which are more or less at the system-centered technology end of the continuum of sciences.

This is a small scale project with limited resources. It was impossible to include thousands of participants as in Garvey and his associates (1979), and Tenopir and King (2004). With a compromise in sampling, we executed the project as rigorously as possible to insure internal validity. We adopt an appropriate research framework to guide data collection and analysis, take a hybrid quantitative and qualitative approach in design, and follow a well-developed five-page interview guide during the interviews. The interview method allows us to clarify confusing concepts, and ask follow up questions if needed. In measuring importance of IICTs, we weighed pros and cons of two different techniques: using a Likert-scale or sorting cards. The former would ask the participant to assign a score to one tool at a time, while the latter

would place all selected IICTs in a relative importance order. We therefore choose the second technique instrumented using a deck of cards as part of the interview guide. The participant can put more than one card as a tied ranking. Blank cards are also prepared for additional IICTs if needed. In the cases when the participant has placed more than one IICT in the same rank, we adjust the scores accordingly. For example, if both the Web and email are placed as the most important, each will be rescored to 1.5 and the third IICT will have the original score 3.0. Finally, the researchers have conducted these interviews. The direct interaction with the participants allows good rapport and familiarity with the data.

Over the data collection period, we have made minor changes to the interview guide to make data collection easier. For example, the original question on the length of use was phrased as "How long have you been using [*the Web*] for research information?" It became evident that some participants would do a calculation in order to answer this question. To speed up the interview, we modified the question as "Since what year have you been using ...?" One version works better for certain participants.

If we would change one thing to tighten the interview, it would be to omit *browsing* from the framework. In most cases, the question on browsing following the question on monitoring sounded redundant because the participants already mentioned *browsing* as a means to *monitoring*. In talking about starting for task-based information, the participants also mentioned browsing the Web, journal table of contents, etc. With the browsing question in the digital environment, we did not obtain new information as it would be in the traditional environment where the user would go to different shelves to browse new titles or pick up a journal to browse the table of contents.

## Summary of Findings and Implications

This summary is intended to highlight our findings that contribute to current knowledge of information and communication behaviors of academic researchers. Our results indicate the importance of information seeking using informal channels, such as reciprocal interaction at conferences and contacts with colleagues and subject experts. This is consistent with Garvey's findings. Garvey's research gave a vital place to scientific journals as a formal channel. Our participants also valued formal resources for quality information that has been peer reviewed. What has changed over the last three decades, however, is that most conferences today have adopted rigorous peer processes just like scientific journals, with a much shorter delay in publication. Refereed conferences today have achieved high status in certain fields such as computer science. Our speculation is that in these fields, many researchers would be motivated to publish their final research output in conference proceedings. Thus the long standing practice and belief that true recognition of a researcher comes through publishing in refereed journals, a process that prioritizes formally registers scientific discoveries, may be about to change in some disciplines.

Our results also show that the major IS activities proposed by Ellis continue to play important roles in research, but these activities are now handled in both traditional and diverse new ways in the Internet environment. The Internet is becoming more and more central to research information seeking. Researchers now can identify field experts in the world and reach them via email. The lines between formal and informal domains of information are blurred as technology and resources are converging and being integrated into Web-based systems. The use or non-use of Internet information and communication technologies/resources by researchers depends very much on how well these tools support their established IS activities, how reliable the delivered contents are perceived to be, and how easy and convenient one can use them for information exchange.

Many researchers have realized the need to effectively and efficiently manage retrieved digital information resources and are experiencing difficulties in organizing them. The current practice seems to be storing these digital objects on personal computers or group servers and in personal bibliographic database, which is evidently no longer a cost-effective approach because of frequent hardware and software updates and the use of multiple computers. We are enlightened by the few participants who claimed that they simply do not save digital information obtained from public domains and rely on the Internet for later retrieval. This led us to believe that we need to ensure and secure digital resources in public information spaces permanently. We need to redesign our current personal bibliographic tools, which focus on downloading records from information resources and importing these physical objects into personal databases. Not only do such bibliographic tools not meet the new needs, but also they are too complex to learn and use. A more effective information management tool at the personal or group level needs to incorporate the widely familiar methods by researchers such as saving multiple copies to different directories. A more effective model will be to rely on public information spaces for maintaining digital objects, or to store only one copy in personal information space with personalized multiple access points or access paths. What is also needed is to extend researchers' memory so that a roadmap of how certain information objects are found and used is kept, as well as the relationships between these objects.

The participants in different countries show some differences in use and perception of the IICTs, as reported in a previous section. These differences are likely due to their respective information environments. Library consortium has made a significant change to the access to scientific journals in Greek universities. The unique practice of registering research projects in Chinese universities provides a good foundation for establishing institutional repositories. With increasing access to scientific information globally, researchers across countries are expected to be more similar in engaging research and seeking information. The United States has always been an information-rich environment with great research output and excellent library collections. Now, other countries have benefited from digital information resources and the Internet. The open access movement will definitely be a boon to researchers living in a less privileged information environment.

Our results also have several implications. Active researchers should maintain an updated homepage to post their research output and publications (preprints). Personal homepage has become an effective channel for disseminating research output, simply because experienced researchers are likely to visit known subject experts' Webpages for information. Libraries and librarians must find new niches and new roles in the Internet age and actively transform traditional libraries entered on service and user instruction to a new information entity. It is clear that one of the new domains is the institutional repository for long term preservation of intellectual output and to facilitate open access. Librarians also must take more active roles in research to understand information users in today's fast changing environment, and to help physically scattered users effectively and efficiently use and manage new information resources and tools. Designers and developers of information resources and tools must be aware of the reasons for terminological and conceptual confusion when existing resources and technologies are being transformed, converged and integrated into a new entity. To meet researchers' needs to manage information from various resources, current bibliographic tools are inefficient and must be redesigned to incorporate users' behaviors such as putting digital files in multiple folders. Internet collaborative tools such as blog and wiki did not appeal to the majority of our participants because of their lack of organization or structure, and lack of quality control of content through a peer process. As the new concept Web 2.0, turning the Web into a greater user-created collective intelligence space as O'Reilly persuasively articulated in 2005, is being proposed, we offer a cautionary note: the approach "if you build, they will come" may not work in certain disciplines where established traditions and norms guide practice and behaviors. Much research is needed to understand how new technologies and resources can meet and best support user needs in different contexts.

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