

Research Use of the Internet Information and Communication Technologies by Faculty: An Interdisciplinary and Cross Cultural Comparison

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Abstract

Research use of the Internet is becoming more important over the last decade. What Internet information and communication technologies (IICTs) do academic researchers use and how are the IICTs used across disciplines and cultures? This project is to study the nature of the use as well as the factors for non-use. The findings can provide insight into the development of new IICTs for researchers.

Introduction

This study is motivated by the new e-science and e-research movement that has impact on our scholarly communication and information. The purpose of the study is two-fold: (1) to investigate *which* Internet information and communication technologies (IICTs) are used by academic researchers across disciplines and cultures; (2) to understand *how* the IICTs are used to support information seeking and communication. The ultimate goal is also two-fold: (1) to understand the factors affecting use and non-use of IICTs; (2) to guide future design and development of information resources using Internet technologies.

In this paper we report some preliminary results addressing the following specific research questions:

1. What IICTs are adopted by researchers across disciplines and cultures?
 - 1a. How long has each IICT been used in research?
 - 1b. How frequently is each adopted IICT used for research?
2. What is the perceived importance of the adopted IICTs in supporting research?
3. To what extent are information needs satisfied by digital resources?
4. What are the factors affecting the use, infrequent use, or non-use of different IICTs?

At the time of this writing, comparative data include two disciplines in two countries: computer science (CS) and engineering (Engr) in the United States (US) and China. The researchers in the two countries as Internet adopters show interesting patterns, some similar and some different.

Relevant Research

The most significant invention of the twentieth century is the Internet, because it has transformed our society and affected every domain of human life. The inception of the Internet marked the beginning of a digital age. Since 1999, the Pew Internet & American Life Project has been following the evolution of the Internet and its impact on the society and people. According to a report dated November 20, 2006, 42 ~ 67% of respondents said that they would turn to the Internet first for research topics such as stem cell, climate change, and origin of life. As a contrast, only 11~ 19% of respondents said the library as the first place for information. Convenience is a big driver of people to the Internet for science information. (Horrigan, 2006).

The Pew surveys, however, focus on America. What about the rest of the world? In the movement towards globalization in economy, finance, information, culture, etc., the Internet plays an important role. The World Bank has introduced new indexes to measure information infrastructures as world development indicators (WDI). We retrieved the index for the number of Internet users and constructed Figure 1 (URL: <http://devdata.worldbank.org/dataonline/>; accessed on November 6, 2006).

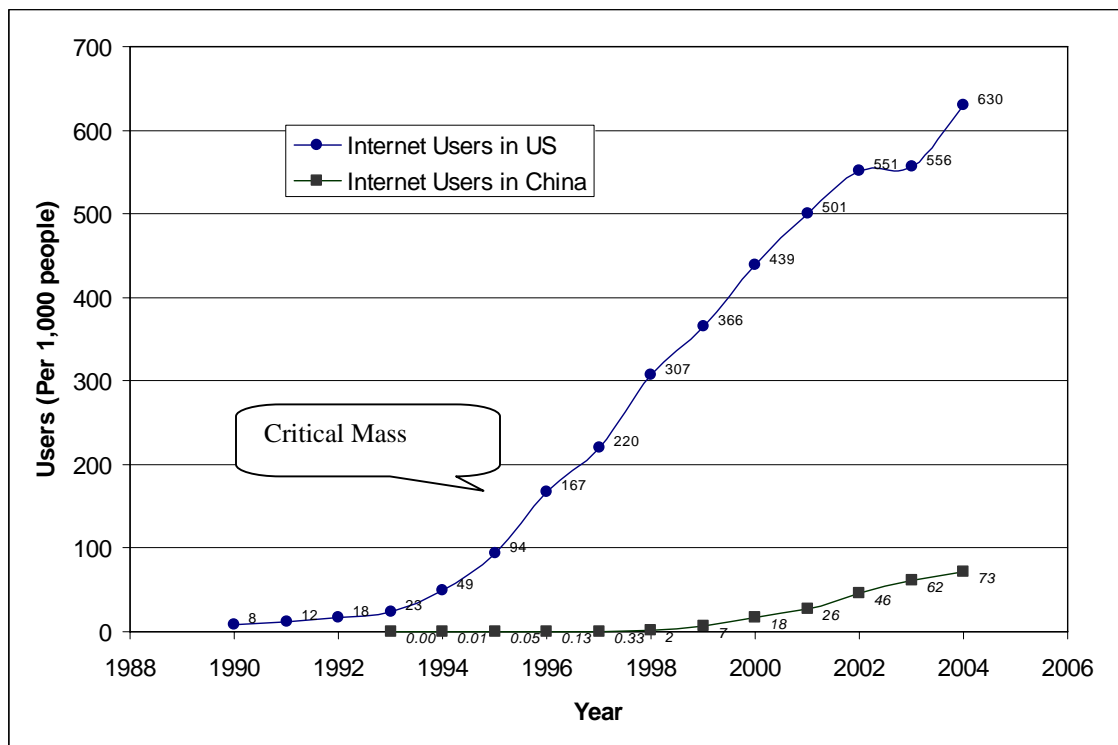


Figure 1. The Rate of Adoption of the Internet In US and China (Data Source: WDI by World Bank)

The diffusion of the Internet was an exemplary case for interactive communication technologies. The adoption of the Internet began in academic institutions and R&D labs in the United States. After the first adopters of BITNET in 1981 (the City University of New York and Yale University), BITNET quickly reached critical mass with West Coast universities joining it shortly within a year. Since then, the rate of adoption has accelerated; in the early 1990s,

BITNET grew into the Internet. Critical mass occurs at the point at which enough individuals have adopted an innovation so that its future rate of adoption becomes self-sustaining. The adoption of the Internet does follow the usual S-shaped Curve, but the rate accelerates after the critical mass point. (Roger, 1995). For any innovation, gaps are inevitable. The Internet has created a digital divide within societies and across countries. Figure 1 indicates that in 2004 one-third of the American people were not Internet users. This one-third of population of non-users of the Internet consists of people who either have no needs to use it or are affected by the challenges of availability, accessibility, information literacy, etc. The digital divide between users and non-users is a "gap between those who can effectively use new information and communication tools, such as the Internet, and those who cannot." (Gunkel, 2003). The gap between the US and China is obvious. China had a late start of the Internet; it is far from the critical mass point of the S-shape adoption curve.

Both the Pew surveys and the Word Bank indicators observe Internet use and users at a macro level. In fact, the Internet includes diverse technologies such as the Web, email, e-journals, digital library, ftp host, blog, etc. New technologies and functions are being developed rapidly. At the micro level, how each IICT is used and not used needs further research.

There is a growing interest in investigating IICTs from the perspective of scholarly communications and the change of information-seeking behavior of academic users. A number of studies can be found with a focus on how E-journals were used by astronomers (Tenopir et al. 2005), pediatricians (Tenopir et al. 2007), chemists (Brown, 2003), and humanities (Bevilacqua, 2005). Talja & Maula (2003) compared the reasons for use and non-use of e-journals in four disciplines (nursing, literature/cultural studies, history, and ecological & environmental science). Brennan et al. (2002) examined the perspectives of the early adopters of e-journals.

Another line of research has focused on the information-seeking behavior in the digital age with an effort to expand Ellis's information behavioral model originally developed before the Internet age (Ellis, 1993; Meho & Tibbo, 2002; Ge, 2005; Wang, 2006). How are the IICTs used for research? How do specific IICTs support specific information-seeking activities? What are the disciplinary differences? What are the cultural differences?

Research Design

This project adopts in-depth face-to-face semi-structured interviews to collect data. This method allows additional interactions with the participants to clarify questions or fill in certain missing data. Data collection started in summer 2005 in the US and China and is ongoing to including more participants from more disciplines and more countries.

Participants

Researchers in higher education from Computer Science, Engineering, Information Science, Journalism, and the humanities are the primary target populations for this project. The chosen disciplines represent the spectrum from computer-oriented to people-oriented in terms of research focus and methods. Productive and active researchers are identified from the WebPages of the departments or schools; they are contacted via email or phone. At the time of this writing

(November, 2006), we have interviewed 97 researchers in the United States and China. For the purpose of this paper, 59 participants are included (Table 1). The US participants in this data set are faculty members in a southeastern state university; the China participants are faculty members in province universities.

Table 1. The Participants

Country	Discipline	Full Professor	Associate Professor	Assistant Professor	Row Total
US	CS	4	5	5	14
	Engr	6	2	5	13
China	CS	5	3	7	15
	Engr	8	1	8	17
Column Total		23	11	25	59

Interview Guide

A four-part interview schedule was developed as a data collection instrument to ensure consistency among interviewers and to take notes during the interview. The questions are arranged to make the interview flow easily but not necessarily mapped in the order of the research questions.

The first part asks the interviewee to select from a list of 9 IICTs the ones they use for research. The participants are asked to add additional IICTs used if not on the list:

- Blogs**
- Databases**
- Digital libraries (portals)**
- E-journals**
- Email**
- FTP hosts (file transfer protocol)**
- Listserv (distribution list; messages come to email)**
- Online library catalogs (books or materials in library)**
- Web**
- Please add the ones you also use but not listed above here:**

The second part follows the selected IICTs to solicit data on the length and frequency of usage of each IICT. The third part asks the interviewee to sort the IICTs in the order from the most important to the least important. The interviewee is also asked for comments on the nonuse IICTs.

The fourth part asks how the selected IICTs support his/her information seeking (IS) activities based on the behavior model by Ellis and later researchers. In our research, these IS activities are placed into a framework of two parts: (1) General IS Behavior; (2) Task-based IS Behavior. General IS activities satisfy long-term goals while task-based IS activities meet current needs for information about a specific project:

(1) General IS Behavior

- **Monitoring:** Keeping abreast of developments in areas of research interest
- **Browsing:** Looking casually for information in research areas
- **Managing:** Storing and organizing information

(2) Task-based IS Behavior

- **Starting:** Gathering initial relevant information
- **Searching:** Searching through specific sources (focused)
- **Accessing:** Obtaining identified information objects
- **Chaining:** Following references (backward) or citations (forward)
- **Ending:** Stopping information gathering or writing

The following are two example questions about general IS behavior and task-based behavior:

Monitoring

<i>Keeping abreast of developments in areas of interest</i>	1	How do you keep abreast of developments in your research areas?
	2	Which Internet technologies are useful for this purpose?

(Answers to 1 are not limit to using Internet resources.)

The following questions are about a recently completed research project (or a significant research project) in which you have used electronic information resources:

.....

Chaining(*backward or forward*)

<i>Following references or citations</i>	1A	Did you follow references to obtain more relevant publications?
	1B	Did you also follow known publications to get new publications that cited the known publications?
	2	What Internet technologies are useful for this purpose?

For each part, there is an open question for additional comments or information. Alternative questions are used when needed. For example, the alternative to "*How long have you used ...*" is "*What year did you start to use ...?*" The former was preferred by some participants; the latter by others. In part three, ordering selected IICTs by importance, explanation is offered when needed: "*One way is to rank importance is to ask 'Can I do my research without it' or, 'Will my research be more difficult to carry out without it?'*"

Procedure

The interviews were conducted mostly in the participant's office and occasionally, when preferred by the participant, in the researcher's office. The session began with a brief description

of the project and procedure, which was followed with an explanation of voluntary participation and measures for data anonymity and confidentiality. Upon agreeing to be interviewed, the participant signed a consent form. The interview was audio recorded with only one exception when the participant did not want to be recorded (the interviewer took notes). A typical interview took approximately a half hour.

Data Analysis and Results

Results presented in this section include 59 faculty members from computer science (CS) and engineering (Engr) in the United States and China (Table 1). We present the results in the order of the research questions in the Introduction section.

1. The differences in adopting specific IICTs for research

All participants use the Internet for research. Table 2 includes seven IICTs used by more than 50% of participants; both blog and ftp are used much less. All participants use both Email and Web for research. For each of the other IICTs, differences are easily seen in Table 2. For example, Digital Library is used by all US computer science participants; E-journal by 94% of China engineering faculty participants; FTP by 93% China computer science faculty participants; and OPAC by 92% of US engineering faculty participants.

Table 2. Distribution of Adopters by Disciplines & Cultures

IICT	N=59	US		China	
		CS (N=14)	Engineering (N=13)	CS (N=15)	Engineering (N=17)
<i>Email</i>	59	14	13	15	17
	100%	100%	100%	100%	100%
<i>Web</i>	59	14	13	15	17
	100%	100%	100%	100%	100%
<i>Dig Lib</i>	48	14	8	11	15
	81.4%	100%	61.5%	73.3%	88.2%
<i>OPAC</i>	46	11	12	10	13
	78.0%	78.6%	92.3%	66.7%	76.5%
<i>E-journal</i>	46	10	11	9	16
	78.0%	71.4%	84.6%	60%	94.1%
<i>Database</i>	44	9	10	10	15
	74.6%	64.3%	76.9%	66.7%	88.2%
<i>FTP</i>	41	12	10	14	5
	69.5%	85.7%	76.9%	93.3%	29.4%

1a. Length of use compared

The usage of the two most adopted IICTs is measured by the length of use (the beginning year of the adoption) and the frequency of use. The length of Internet use is likely a S-shape curve that the diffusion theory predicts (Roger, 1995). In comparison, the Internet had a much

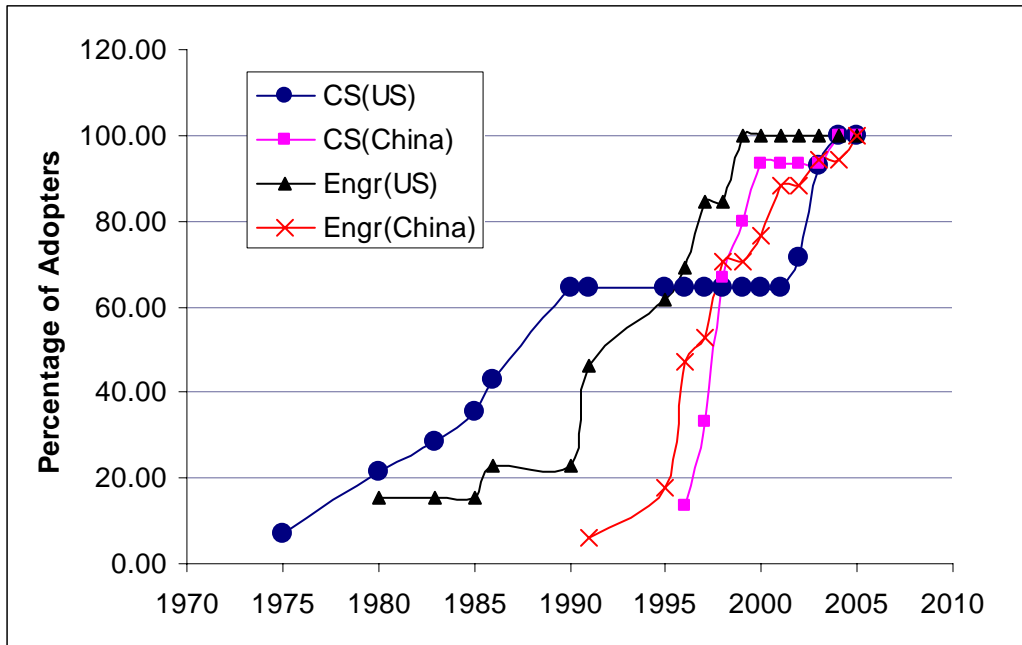


Figure 2. Email adoption by disciplines

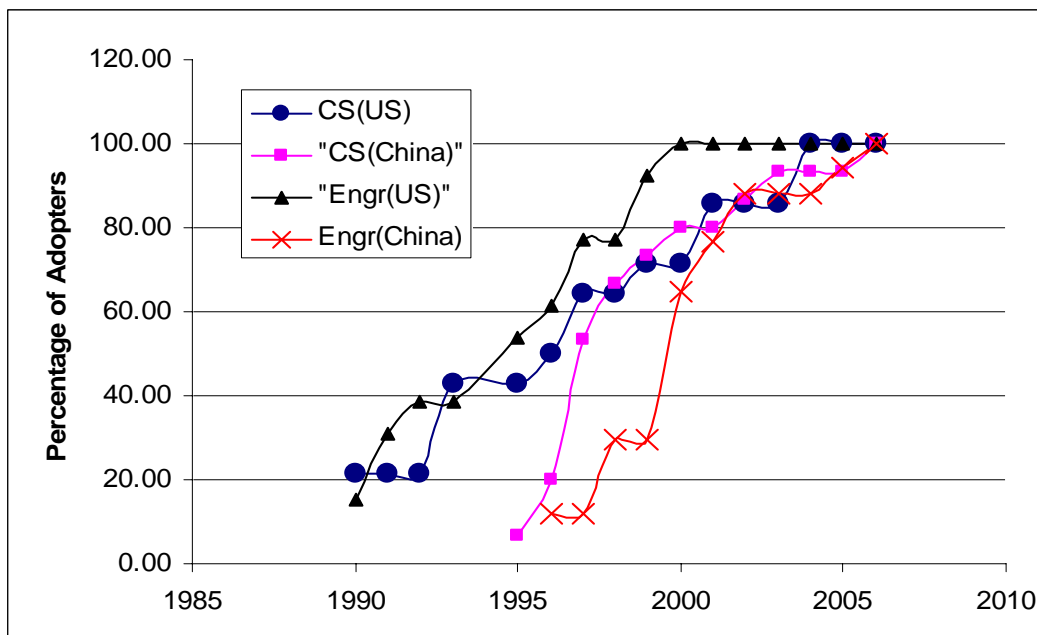


Figure 3. Web adoption by disciplines

later start in China, as the WDI indicates (Figure 1), therefore, the length of use will definitely be shorter for Chinese academic researchers than their US counterparts. Figures 2 and 3 depict that faculty participants from both computer science and engineering in the US began research use of the Web in 1990 and email in 1975, respectively. The adoption of the two IICTs by our participants in China, as well as in the US, has reached 100%; the early adoptions of both email and the Web started in approximately 1995. The curves in Figures 2 and 3 are illustrative only because they are based on a relative small number of participants in each group. It is typical that each department representing a discipline has only about 10 to 20 faculty members. Some of the departments have more or less junior faculty members who started their education in the late 1990s. The length of use is thus determined by their professional age not merely availability. In contrast, the earliest email use was 1975 by a senior faculty member.

When usage is compared by country, we see a different pattern in the two disciplines (Figure 4). Computer science faculty in the US adopted email for research much earlier than the Web while their counterparts in China adopted both at about the same time. Engineering faculty in both countries have similar adoption patterns, with email being adopted somewhat earlier than the Web.

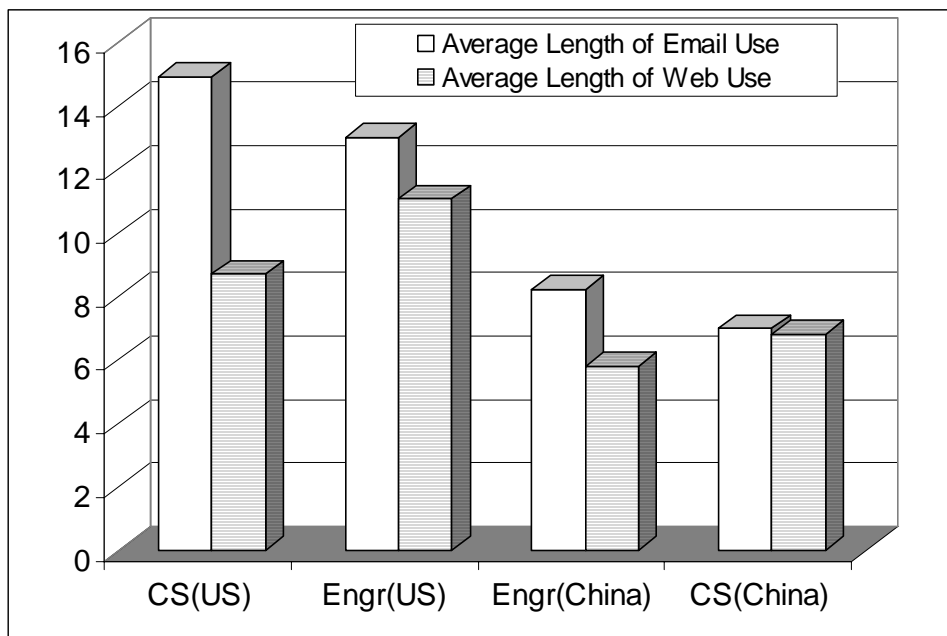


Figure 4. Length of Email and Web Use for Research

1b. Frequency of use compared

The most frequently used IICTs, email and Web, are used daily or multiple times a day (Table 3), followed by digital library and online library catalog, used on a weekly basis. The frequency of E-journal and database use varies by discipline and country. Chinese Engineering faculty members use them more often than their counterparts in the US or their fellow computer

science faculty; US computer science faculty members use them less frequently than their fellow engineering faculty or their Chinese counterparts.

2. Perceived importance of the adopted IICTs

The participants ranked the selected IICTs in order of importance. Aggregated results are presented in Table 4. The perceived importance varies across disciplines and cultures. On the high end of the scale, email was ranked first by engineering participants in both countries, and second by CS participants, while the Web was ranked first by US CS participants, second by US engineering participants, and third by Chinese participants of both disciplines. On the low end of the scale, OPAC, Database, and FTP were all ranked no higher than fourth by any group.

Table 3. Median Frequencies of Use of IICTs Across Disciplines and Cultures

IICTs	US		China	
	CS (N=14)	Engineering (N=13)	CS (N=15)	Engineering (N=17)
<i>Email</i>	Daily	Daily	Daily	Daily
<i>Web</i>	Daily	Daily	Daily	Daily
<i>Dig Lib</i>	Multi a month	Weekly	Weekly	Weekly
<i>OPAC</i>	Multi a month	Weekly	Weekly	Weekly
<i>E-journal</i>	Monthly	Multi a month	Weekly	Daily
<i>Database</i>	Monthly	Weekly	Multi a week	Daily
<i>FTP</i>	Monthly	Multi a year	Weekly	Weekly

Table 4. Perceived Importance of IICTs Across Countries and Disciplines

Rank	US		China	
	CS (N=14)	Engineering (N=13)	CS (N=15)	Engineering (N=17)
1st	Web	Email	Dig Lib	Email
2nd	Email	Web	Email	E-journal
3rd	E-journal	Dig Lib	Web	Web
4th	Dig Lib	OPAC	E-journal	Database
5th	FTP	Database	Database	Dig Lib
6th	OPAC	E-journal	OPAC	OPAC
7th	Database	FTP	FTP	FTP

We ran a non-parametric analysis to test if there is correlation between length of use, frequency of use, and importance ranking. There seems to be a significant correlation between

length of use and importance ranking for *email* ($p < 0.05$). That is the longer the person has used email the higher he/she will likely rank its importance.

3. The satisfaction of information needs by digital resources vs. print

The difference in the amount of electronic information resources used in a selected research project can be visualized in Figure 5. It is not surprising that the US researchers used more electronic resources than their counterparts in China. Within each country, the disciplinary differences seem to reverse: for the US, participants in computer science use slightly more e-resources than engineering; for China, participants in computer science use slightly less e-resources than engineering.

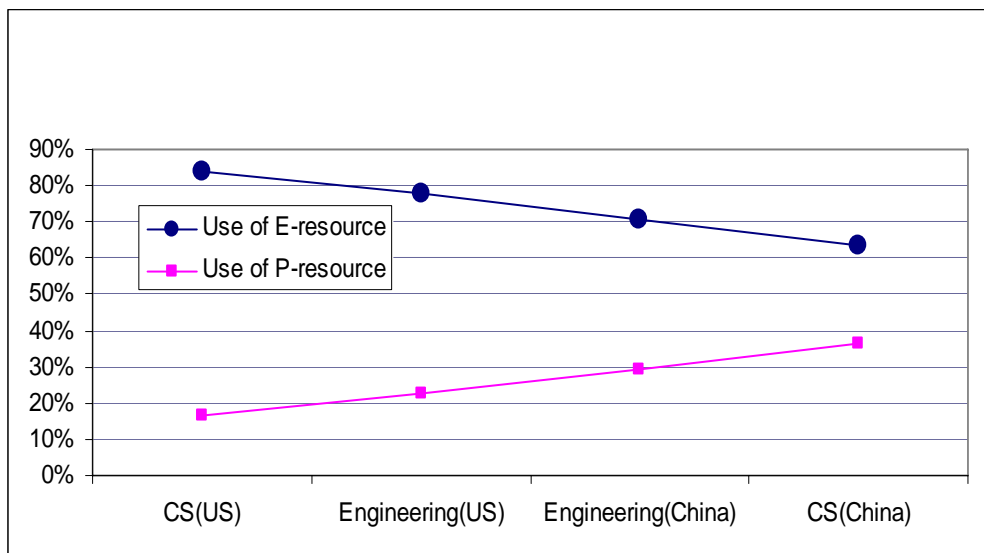


Figure 5. Satisfaction of Information Needs by E- or Print Resources

4. The factors affecting the use, infrequent use or non-use of different IICTs

The preliminary analysis of qualitative data indicates that the adoption of IICTs depends on a number of factors:

- *availability* of the existence of the resources in e-format
- *nature of projects/research studies.*
- *awareness* of the availability of the e-resources
- *accessibility* of the e-resources made free or via a service (library)
- *convenience* of the access
- *cost* of the access
- *format* of the source (e.g., e-journal)
- *perceived quality*
- *attitude/emotional* (e.g., affinity for traditional library)
- *network externality* (being part of the current communication network)

Below are some excerpts from the interview transcripts illustrating some of the factors:

"Books are not available on e-format." [*availability*]

"In my project, I used a lot of drawings and blue prints that will never be in electronic format." [*nature of projects*]

"I'm not sure what might mean by blog?" [*awareness*]

"UT libraries have no subscriptions." [*accessibility*] (Although the source is available in e-format, the access is limited by the subscription.)

" we can find it on the web a lot of times"

"... but it [e-journals] won't count in our department a lot of times. Many of those are not referred. Even though we say 'that's referred' ... I think it takes time for those old people to recognize the value of them." [*perception*]

"I think newsgroups are better than listserv. I think that the discussion is actually better." [*perception*]

"[FTP] faster in speed to download." [*perceived quality*]

"I don't trust their sources." [*perceived quality*]

"I am old-fashioned. I used to love to go down to a library and just browse through, you know, the old card catalogs, and flip through the cards and so forth. And when they did away with that and made it all electronic, you know, I found it just doesn't have the same feel about it" [*attitude/emotional*]

"It's once a year [refer to database]. I don't like it. I hate databases." [*attitude/emotional*]

"I don't like these democratic forms of communication. [refers to wiki] It wastes your time." [*attitude/emotional*]

"... but no others use it." "... every one in our group is using it." [*network externality*]

Discussion and Conclusions

In this paper, we present the preliminary analysis of the interviews with 59 faculty participants from two disciplines and two countries: computer science and engineering in the US and China. In spite of the differences in usage, all participants use *email* and the *Web* for research. *Digital library* is used by all computer science participants in the US. There are diverse percentages of adopting other IICTs. For example, *OPAC* is used by 92% of engineering participants in the US. *E-journal* is used by 94% of engineering participants in China, and *FTP* is used by 93% of computer science participants in China. *FTP* has the least engineering adopters in China. Following the least effort principle, researchers tend to adopt the IICTs that are most available and accessible. Because of their discipline backgrounds, none of the participants have complained about usability issues of any IICTs. As a comparison, Ge (2005) found that usability is an important factor for non-use. The length of use for Chinese participants is much shorter than their US counterparts because of the availability factor. The Internet became accessible in China only at near the turn of the century. The frequency data show much less differences across the groups (Table 3): At least fifty percent or more participants use *Email* and *Web* for research on a daily basis (or multiple times a day). The other IICTs are used less frequently, from weekly to a few times a year, with the exception that Chinese engineering faculty do use *E-journal* and *databases* more frequently than these other groups. The importance ranking of the used IICTs varies across disciplines and countries. The rank of email seems to correlate with the length of its use by an individual user. No other significant correlations are found.

It is not surprising that researchers in both countries are able to satisfy their information needs by using electronic resources as opposed to print resources; the means are between 62% and 85%. It is obvious that satisfying information needs with e-resource may never reach 100%.

There are many factors affecting use, infrequent use, or non-use of IICTs: *convenience, availability, awareness* of the existence, *accessibility, perception of quality, attitude/emotional, network externality*, and the *nature* of projects/research studies.

A methodological note: the method we use for data collection has its strengths and challenges. One of the strengths is the interactive nature of face-to-face interviews. The follow-up questions to clarify the questions or confirmations about the answers ensure data validity. A second strength is the setting in which the interviewer can establish a good rapport and the interviewees can refer to their materials in their offices. The third strength is the opportunity to contact the participants in case of missing data. On two occasions, the participants were contacted in order to collect data that was missing in the original interview. The main challenges of the 100method used in this project are the time needed to schedule and conduct the interview for data collection; and transcribing and coding, both demanding tasks, for data analysis.

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