The Analysis of the Information Users' Needs and Information Seeking Behavior in the Field of Science and Technology

국내 과학기술분야 정보이용자의 요구 및 정보추구행태 분석

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ABSTRACT

In this study, we investigated the information users' needs and information seeking behavior in the field of science and technology. We found that the science and technology researchers most frequently needed information while conducting the research & development related tasks and drafting research papers. The researchers attributed the main sources of research ideas to be the communication among colleagues and the literature review. The researchers's most preferred information sources were digital libraries, web search engines, and academic information portal. In conclusion, the science and technology researchers regarded the online use of electronic materials as the primary source of information. We hope that this investigation reported herein to be the foundation for developing user-centered information services for the science and technology discipline.

초 록

본 연구에서는 질문지법을 이용하여 과학기술분야 연구자들의 정보요구와 탐색 행태를 분석하였다. 분석결과, 연구자들은 주로 연구개발의 업무, 보고서 작성 등의 업무에서 정보를 필요로 하고 있음을 알 수 있었다. 연구의 아이디어를 알아내는 방법으로는 주로 문헌을 활용하고, 연구자간 커뮤니케이션도 빈번하게 활용하고 있었다. 또한 그들이 가장 많이 활용하는 정보원으로는 디지털 도서관, 웹 검색 엔진, 학술정보포털 등으로 응답하여 온라인을 통한 정보 요구가 높은 것으로 알 수 있었다. 이러한 이용자 요구 조사 결과를 토대로 이용자 중심의 과학기술 정보서비스를 개발할 수 있을 것으로 기대한다.

Keywords: information needs, information seeking behavior, information gap problem, science and technology information service

정보요구, 정보추구행태, 정보부족 문제, 과학기술 정보서비스

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1. Introduction

The timely distribution of reliable subject-specific information is becoming more important especially in the science and technology discipline. Due to the rapidly evolving nature of information technology, the information distribution methods are also changing in a fast pace. Obviously, these changes greatly impact how the science and technology researchers satisfy their information needs and their information seeking behavior. Consequently, the traditional science and technology information services also need to be adapted to reflect the changed information needs.

This study aims to understand the information needs of the science and technology researchers. We start from a premise that it will be possible to provide the user-centered information services given that we can accurately gauge the varying research needs. We hope this study's outcome can serve as a foundation for providing effective and efficient information services in the science and technology fields.

Traditionally, libraries, printed materials, and fee-paying academic databases such as Dialog were the key components of the science and technology information services. However, the rapid progressing information technology placed free academic information search engines such as Google Scholar (http://scholar.google.com) and CiteSeer(http://www.citeseer.com) as well as the Korean academic information portals such as yesKisti(http://www.yeskisti.net) as the most frequently used information services for publishing, collecting, and distributing the science and technology information. Furthermore, web-based informal information channels such as Naver's KiN(http://kin.naver.com), and a science and technology related knowledge sharing community such as yesKisti's Knowledge Community(http://www.yeskisti.net/yesKISTI/Knowledge/CommMain), which offer services in Korea, are becoming more popular than ever. These additional online information services made the current science and technology researchers to access many more means to access information possible in comparison to the previous generation.

The information technology evolution had also affected how the researchers use information. It has become more difficult for the researchers to find critical information necessary to solve problems from the vast amount of information. Thus, the importance of developing active science and technology information services, which can provide relevant information to the researchers as they become available, have continued to increase. The importance of providing the user-centered information services had been also recognized.

We started this study by investigating the information needs of the researchers to understand the status of the current science and technology services. This study utilized a quantitative survey method to collect and analyze the data about the science and technology information resource uses and the information needs of the users in the industry, academic, and research sectors.

The survey was used to identify the information

needs as well as the problems that users encountered when using the existing science and technology information services. We identified the problems from both the novice and expert users' points of view. This led for us to develop a guideline for providing customized information services, which can accommodate both general and specialized information needs. The guideline was developed by categorizing and statistically analyzing each user group's information needs.

2. Previous Studies

There are a number of information seeking behavior related studies targeting the users working in various science and technology disciplines.

Case(2002) explained the information seeking behavior of the scientists and the engineers by including them as one of the occupational categories within the user studies. He showed that the science & technology researchers and the engineers have professional and practical traits in using information based on many previous studies.

Ellis and Haugan(1997) studied the information seeking behavior of the researchers working at the Statoil's Research Center. The researchers showed similar information seeking behaviors such as surveying, chaining, monitoring, browsing, distinguishing, filtering, extracting, and ending. However, it was not conclusive whether these behaviors were specific to the science and technology researchers.

Fidel and Efthimiadis(1999) interviewed nine engineers to study the web-based information seeking behavior of the aeronautics engineers. The study showed that the engineers considered the suitability and the reliability of the information to be the most important factors when obtaining information from the web. The study also found that the engineers used the discipline-specific specialized terminologies to form their queries as the terminologies were familiar to them.

These studies focused on the general information seeking behavior of the science and technology researchers. There were also studies focusing on the information seeking behavior according to the individual characteristics such as ages, working environments, and positions. Zhang, Hermina, and Yuan(2005) investigated searching behavior and searching efficiency based on the engineering students' knowledge level. To determine the knowledge level, 200 thesaurus terms were presented to the subjects then measured the level of understanding about the terms by the students. There were statistically significant difference in understanding between the undergraduate and the graduate students. This difference was used to determine the knowledge level of the subjects. The searching behavior and the efficiency were assessed by analyzing computer log file from the database searches, the surveys conducted before and after the searching, and the output from the search sessions. The study found that the users with the higher knowledge level conducted more searches and also utilized more query terms than the lower knowledge level subjects. However, there was no difference

in terms of the search efficiency. We believe that this type of study will be helpful in designing customized information systems, which can better satisfy the varying types of the potential users and consequently improve the system use efficiency, in comparison to the systems, which only considers the disciplines the users belong to.

In Korea, the user studies for the science and technology disciplines began to appear in 1980s. Lee(1987) analyzed how physics researchers communicated academic information formally and informally amongst themselves. He studied the researchers' communication behavior from the library and information service related perspectives. Cho(1987) developed a social organization model of the scientists by analyzing the informal communication and information exchange behavior of the biologists.

There was a study analyzing the information use characteristics of the engineering graduate college students(Lee 2003). Park and Paik(2001) conducted a similar study with the electronic engineering graduate students. These studies led to new reference service models, which were intended to increase the frequency of the college library uses.

There was also effort to analyze the information use behavior according to various information needs in Korea. Yoo(2001) conducted research to identify the information needs of college library users by analyzing the reference questions asked. In another study, Yoo(2002) identified several problems related to the information service functionality then made suggestions to improve the service offerings by analyzing the usage log files of the Korean National Digital Science Library.

It should be noted that these studies treated the information needs and information seeking behavior independently rather than studying their combined effects.

3. Methods

Questionnaire survey was used to investigate users' information needs and information seeking behavior in the field of science and technology. The questionnaire consisted of the typical demographic information related question and the question developed by analyzing the log files of two special libraries and one college library. The log files recorded the activities from 15 days to three months periods. The final version of the questionnaire was completed after having ten pre-tests to improve the reliability of the questions.

The questionnaire survey was administered to 302 Korean science and technology researchers. The survey respondents' characteristic information, such as affiliation, age, research experience, and final academic degree, is shown in the <Table 1>.

Two views were maintained in analyzing the survey data. One was 'information needs' and the other was 'affiliation' of the respondents. This led us to analyze the data according to the following four perspectives: 1) information search behavior by the types of information needed; 2) information search behavior by the types of affiliation; 3) infor-

〈Table 1〉 Demographic Information of the Survey Respondents

Sample Characteristics	Types	Number of Samples	Ratio(%)
Affiliation Type	Industry	90	29.8%
	College	105	34.8%
	Research Institution	106	35.1%
	Other	1	0.3%
Age(Years Old)	20 ≤	104	34.7%
	30 ≤	146	48.7%
	40 ≤	42	14.0%
	50 ≤	8	2.7%
	No answer	2	0.7%
Research Experience(Years)	5 ≥	155	51.8%
	6 ~ 10	78	26.1%
	11 ~ 15	33	11.0%
	16 ~ 20	24	8.0%
	20 ≤	9	3.0%
	No answer	3	1.0%
Final Academic Degree	Bachelors	89	29.9%
	Masters	127	42.6%
	Ph.D.	82	27.5%
	No answer	4	1.3%

mation sources used by the types of information needed; and 4) information sources used by the types of affiliation.

For the information search behavior, the data was analyzed to identify 1) where the respondents found the necessary information to conduct research and daily works; 2) what attributes of the information they considered to be important; and 3) how they dealt with the lack of information. With respect to the information sources, the data was analyzed to determine 1) the types of information needed for conducting research and daily work; 2) the information sources needed to identify the latest research trend; and 3) the needed but missing information sources.

4. Results

To understand the Korean science and technology researchers' information needs and information seeking behavior, we conducted an information requirement analysis in advance. We were able to confirm the reasons for having particular information needs by having the information about the goals of the recently conducted or ongoing research projects.

<Table 2> shows the information needs of Korean

〈Table 2〉 Information Needs of the Korean Science and Technology Researchers

Purpose of the Recently Conducted Research	Number of Respondents	Ratio(%)
Preparing Academic Thesis	36	11.92
Drafting Research Papers/Project Reports	64	21.19
Research & Development	197	65.23
Others	4	1.32
No Answer	1	0.33
Total	302	100.00

science and technology researchers. About 65.2% of the respondents needed information for the research and development purposes. While the research papers and the project reports preparation, or the research and development activities were usually carried out in collaboration with the colleagues, the academic thesis preparation was usually done by the individual researchers.

4.1 Characteristics of Information Search Behavior by Varying Types of Information Needs

4.1.1 Source of Research Idea

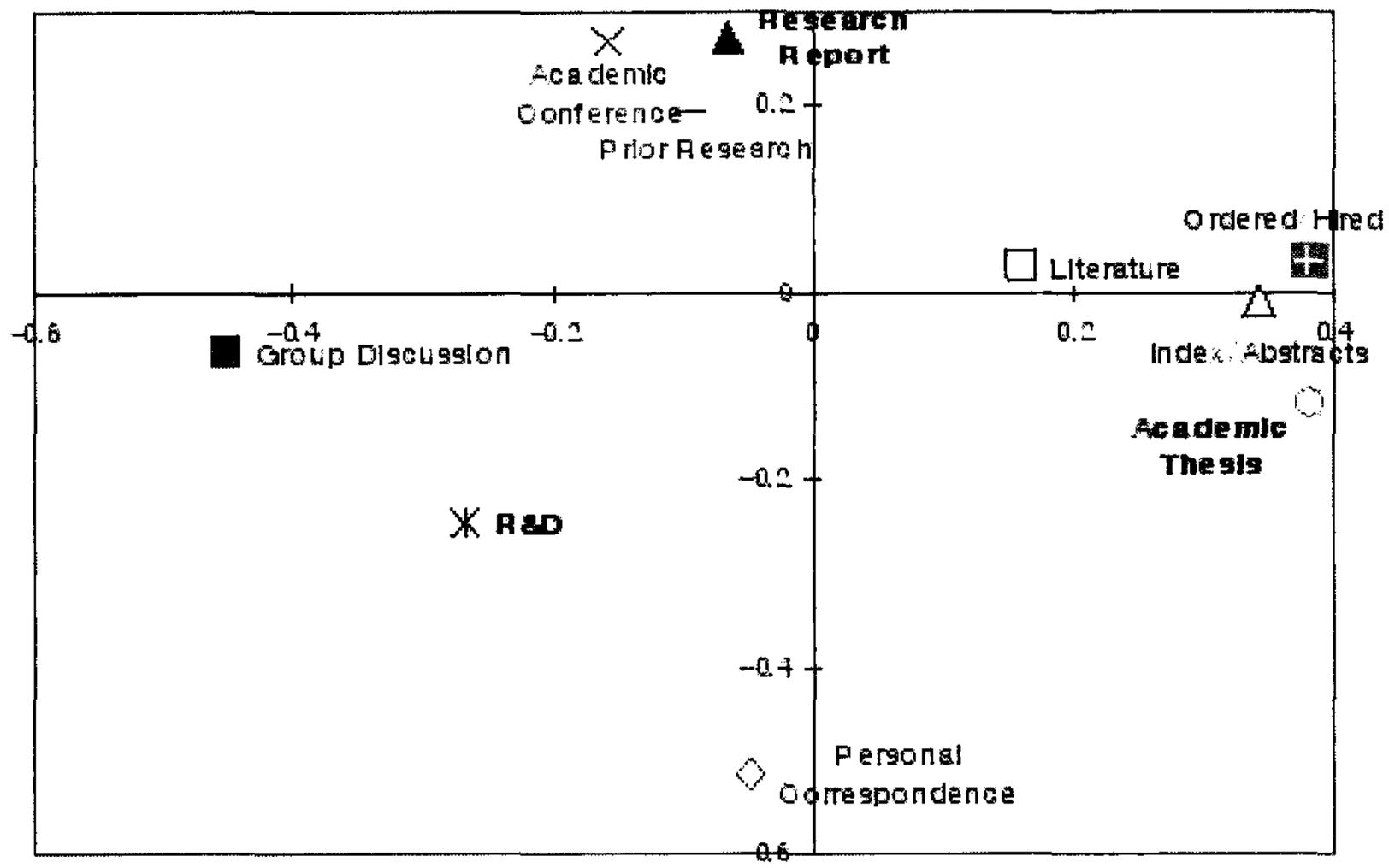
To identify the sources of the research ideas by the information needs, the researchers were asked to rank eight potential sources from the most important to the least important. We developed a point assignment system to come up with an overall ranking of the information sources. Each first ranked source by a researcher was assigned with three points. The second ranked sources were assigned with two points. Finally, the third ranked sources were assigned with one point. The sources, which were ranked by the total score assigned for each respective source, are shown in the <Table 3>.

The 'literature' was the top ranked source of research ideas. The 'prior research by the researcher him/herself' was the second and the 'group discussion with colleagues' was the third ranked sources while 'indexes/abstracts' turned out to be a less frequently used source of research ideas. The most notable finding from this analysis was that the sum of 'group discussion with colleagues' and 'personal correspondence,' which can be characterized as informal communication amongst the science and technology researchers, resulted in the second ranked source after the 'literature.' We consider this result to be one of the supporting evidences for our claim that 'informal communication plays a key role in acquiring research ideas for the science and technology researchers.'

When the research goal was to produce academic thesis, the ranking of the sources changed. Specifically, 'personal correspondence' and 'ordered or hired to a particular research' were ranked higher than 'group discussion with colleagues' and 'academic conference' sources. We consider that one of the reasons for this change to be a student researcher's frequent interaction with his/her advisor

〈Table 3〉 Sources of Research Ideas Ranked by the Importance

Source	Num. of First Ranked(1)	Num. of Second Ranked(2)	Num. of Third Ranked(3)	Total (1)×3+(2)×2 +(3)×1	Percentage (%)
Literature	111	64	37	498	29.57
Prior Research by the Researcher him/herself	56	43	43	297	17.64
Group Discussion with Colleagues	44	33	51	249	14.79
Academic Conference	19	51	46	206	12.17
Personal Correspondence	24	44	36	196	11.64
Ordered or Hired to do a particular Research	32	16	14	142	8.43
Indexed/Abstracts	5	14	33	76	4.51
Miscellaneous	5	3	0	21	1.25



〈Figure 1〉 Sources of Research Ideas by Information Needs

when preparing a thesis. It is common for the advisors to provide ideas for their students to work on. Thus, it makes sense for the ranking of 'ordered or hired to do a particular research' source category moving toward the top.

When the research goal was to prepare non-academic research reports, the overall ranking of the information sources was similar to the one shown in the <Table 3>. However, the academic conferences ranked higher than the group discussions

with colleagues. The academic conferences usually provide both formal and informal communication channels for the participating researchers and thus the conference attending can be beneficial in getting acquainted with newly emerging research trends.

The overall ranking was also similar to the <Table 3> when the research goal was to conduct research and development.

The <Figure 1> shows the correspondence analysis result for the sources of the research ideas. The <Figure 1> clearly reveals that the researchers, preparing the academic thesis, are likely to obtain new ideas by being ordered or hired to do particular works or by reviewing the indexed or abstracts of other researchers' works. The ones, engaged in research and development processes, preferred the informal communications channels, such as group discussions among the colleagues and the personal correspondences, as the idea sources. Analogously, the ones preparing research reports relied on academic conferences and prior research outcomes as their idea sources. The literature was a commonly used idea source for the ones who are preparing either the academic theses or the research reports.

4.1.2 Sources of Information

To understand how the researchers acquired necessary information to conduct research and to do their daily work, the researchers were asked to rank seven potential information sources according to their preferences. The ranking data was analyzed using the same method, which was applied to identify the sources of research ideas. The <Table 4> shows the analysis result.

The science and technology researchers preferred to use the library and databases materials as the primary sources of information. It seems that the credibility and reliability of the information sources are the major concern for them to use information sources. The web search engine was the second ranked source. The academic information portal was ranked as the third frequently used information source. The result also shows that the

〈Table 4〉 Sources of Information Ranked by the Preference

Source		Num. of First Ranked(1)	Num. of Second Ranked(2)	Num. of Third Ranked(3)	Total (1)×3+(2)×2 +(3)×1		Percentage (%)	
Library & Database	Digital Library, Web Database	118	53	38	498	708	28.74	40.86
	Traditional Library	20	49	52	210		12.12	
Web Search Engine		70	75	68	428		24.70	
Academic Information Portal		37	42	49	244		14.08	
Colleague		32	30	46	202		11.66	
Private Collection		20	30	23	143		8.25	
Miscellaneous		2	1	0	8		0.46	

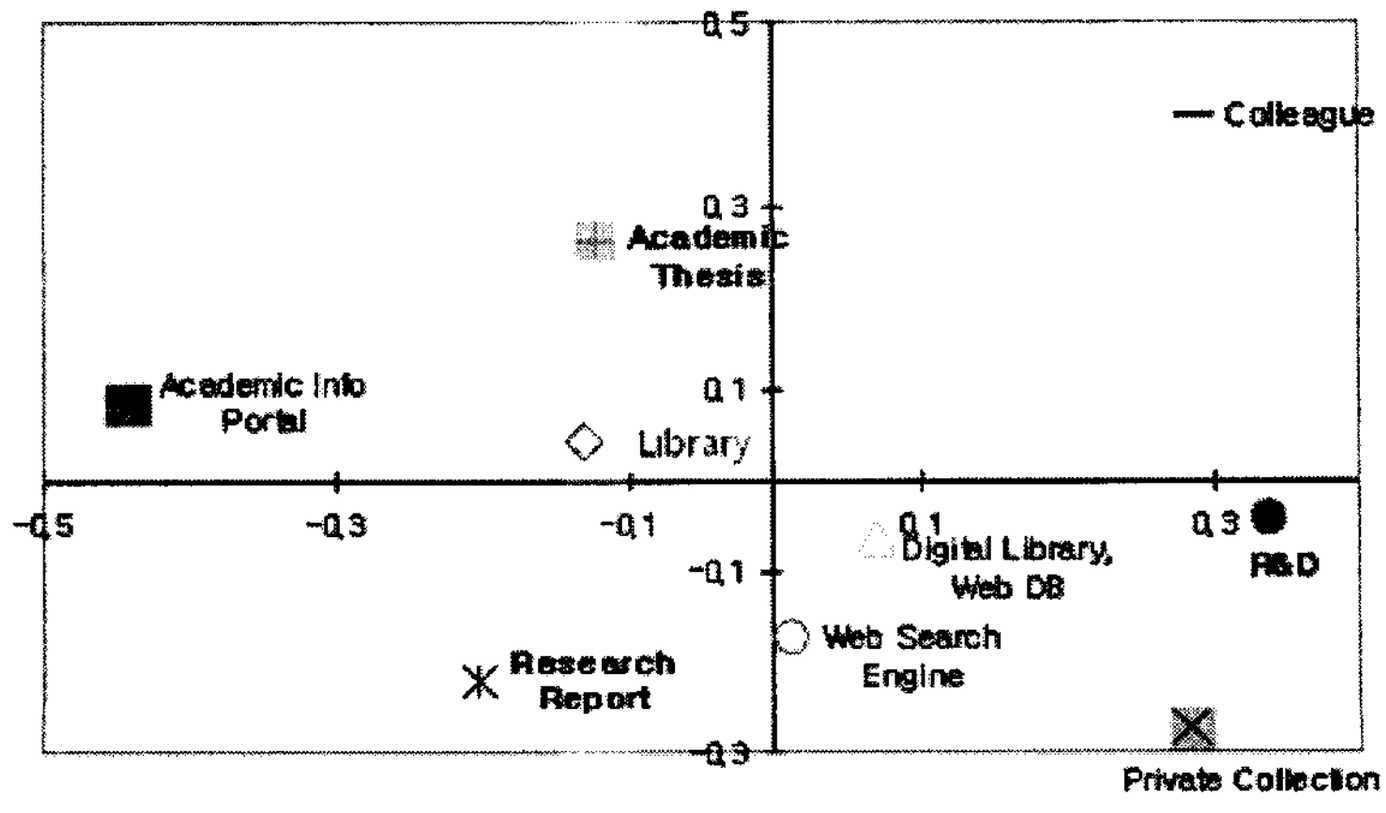
dominant way to access to information is through the wide use of digital library and the increased number of web-accessible full-text databases. Furthermore, the digital library and web-accessible databases are much simpler to use than going to offline and individual type of sources.

The colleague was the fourth ranked information source. We think that the convenience of asking one's colleagues to acquire the needed information in comparison to going to the libraries might be a reason for colleague being ranked at about the same level as the traditional library. From this, we can infer that the convenience of the informal communication channel plays an important role in the current information seeking behavior.

By analyzing the information sources used by different types of research goals, we found that the ranking of the information sources used while preparing the academic thesis is the same as the overall ranking shown in the <Table 4>. The ranking of the information sources for preparing research reports is also similar to the overall ranking. However, there were much less use of colleagues as the information source.

The information source ranking changed somewhat for conducting research and development related works. Most notably, the colleague ended up as the third ranked source of information by moving up two levels in comparison to the overall ranking. The academic information portal moved down to the fifth ranked information source from the third ranked source. This shows that the informal communication channels such as the colleague play an important role as the information source in the research and development works.

The <Figure 2> shows the correspondence analysis result for the information source data. Based on this analysis, the ones, who are preparing the academic thesis, preferred to use the traditional libraries and the academic portals. The libraries and the web search engines were preferred by the ones, who were preparing the research reports. To



〈Figure 2〉 Sources of Information by Information Needs - Correspondence Analysis

conduct research and development works, the researchers frequently relied on the information obtained from their colleagues and also the privately collected information. The digital libraries and the web-accessible databases were commonly used information sources for the researchers regardless of their research goal types.

4.1.3 Factors to consider when searching for information

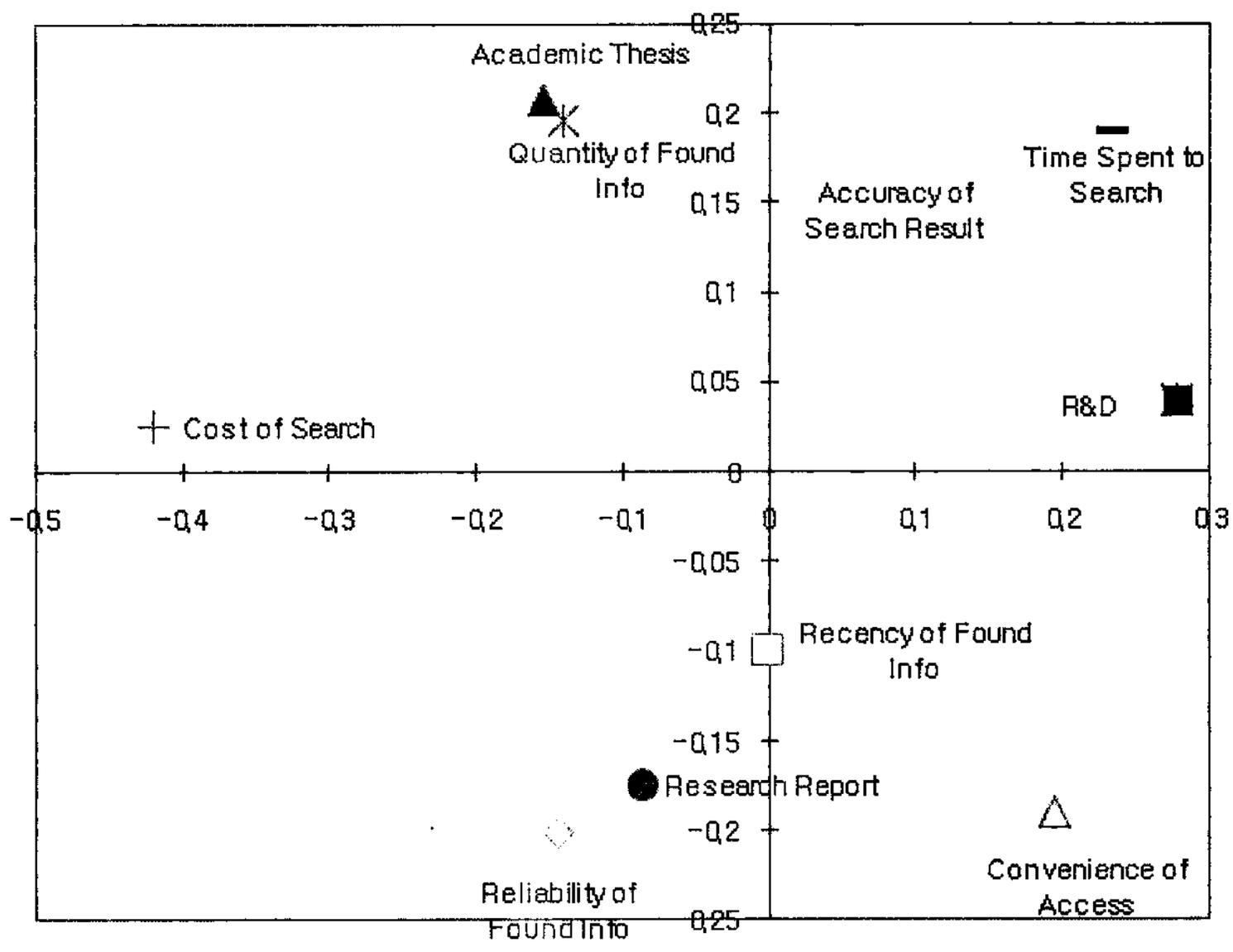
The researchers were asked to rank the seven factors they might consider when searching for information from the most important to the least important. The rankings were analyzed using the same method, which was applied to analyze the information sources. The <Table 5> shows the analysis result. The most important factor was identified as accuracy. The second was recency. The third factor was convenience of accessing information.

There was no rank order difference for all three types of research goals. However, the correspondence analysis, which is shown in the <Figure 3>, revealed somewhat different result from simple rank order analysis based on the preference frequency data shown in the <Table 5>. Most notably, the quantity of the found information is located near to the academic thesis. This is probably due to the researchers' need to review a large number of literature to prepare for the academic thesis.

The reliability of the found information is very closely located to the research reports. This probably means that the ones, who were preparing the research reports, value the reliability of the information to be very important. Both the accuracy of the search result and the time spent to search were shown to be important in preparing the academic thesis and conducting research and development works. The high importance of the time spent to search for the research and development tasks makes sense as there has been always strong competition to publish earlier than others among the ones, who are engaged in the research and development tasks.

〈Table 5〉 Factors Considered When Searching for Information Ranked by Importance

Factor	Num. of First Ranked(1)	Num. of Second Ranked(2)	Num. of Third Ranked(3)	Total (1)×3+(2)×2 +(3)×1	Percentage (%)
Accuracy of Search Result	148	80	31	635	36.18
Recency of Found Information	48	93	71	401	22.85
Convenience of Access	64	44	61	341	19.43
Reliability of Found Information	17	37	52	177	10.09
Time spent to Search	16	21	34	124	7.07
Quantity of Found Information	5	3	26	47	2.68
Cost of Search	0	9	12	30	1.71



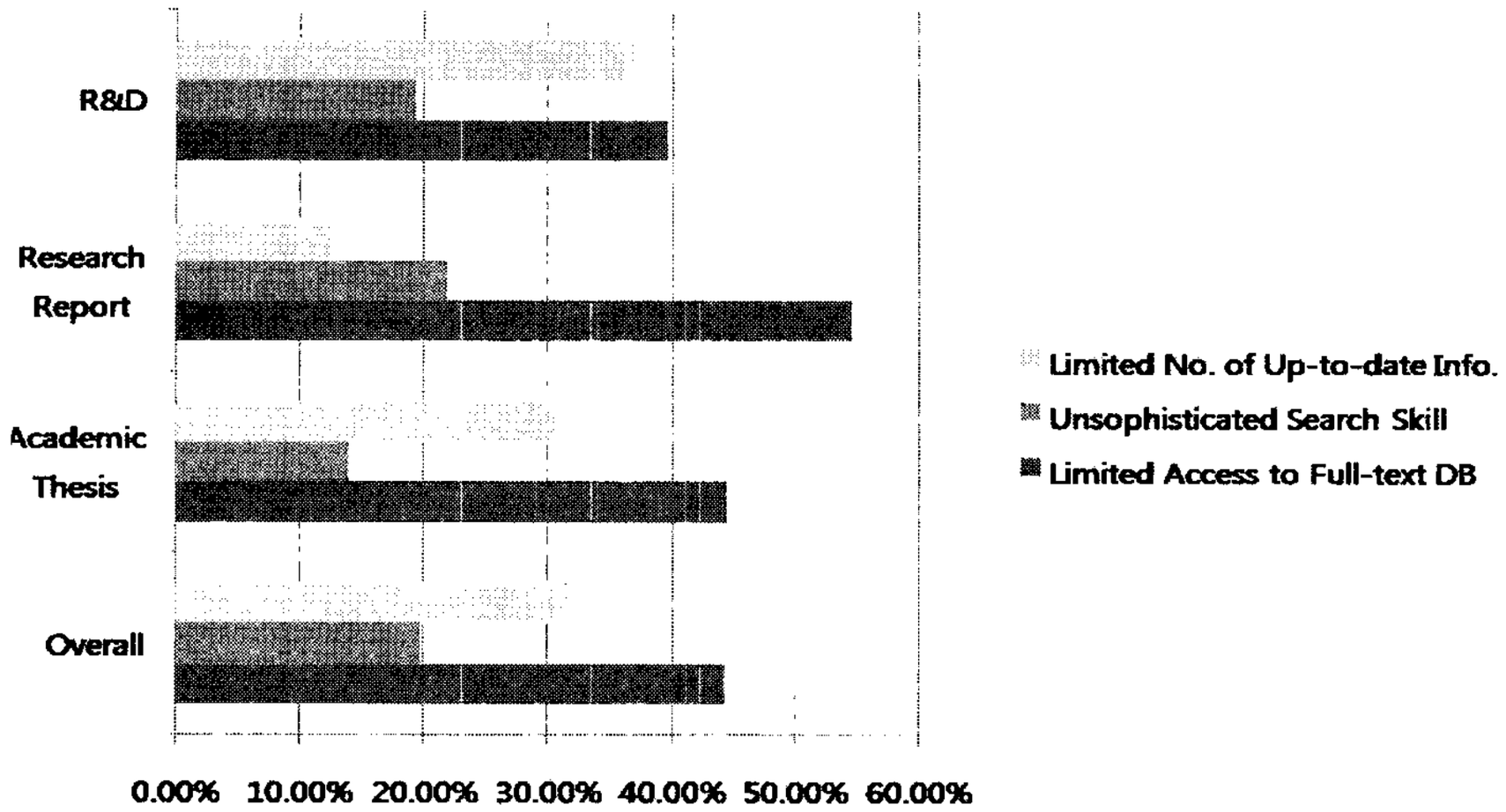
〈Figure 3〉 Factors Identified to be Important in Searching Information - Correspondence Analysis

4.2 Information Gap Problem and its Solutions

4.2.1 Experience and Cause of Information Gap

The researchers were asked whether the lack of information caused any delay or incompleteness in their work. We think the information gap problem is serious for the Korean science and technology researchers as more than 80 percent of them had experienced the lack of information in their work. More specifically, 18 percent of the respondents frequently experienced the information gap problem and 64 percent of the respondents sometimes experienced the information gap problem.

44.22 percent of the overall respondents listed the limited access to the full-text databases as the main cause of the information gap problem. The <Figure 4> shows that the full-text database problem as the most significant problem regardless of the researchers' goals. However, there were some differences in the second ranked cause. The ones, who were conducting research and development work and working on the academic thesis, listed a limited number of up-to-date information as the second ranked cause. The researchers working to generate reports ranked the unsophisticated information search skill as the second ranked cause of the information gap problem. This difference was probably caused by the stronger desire to consider the leading-edge information in their work by the ones engaged in the research and development and academic thesis related works.

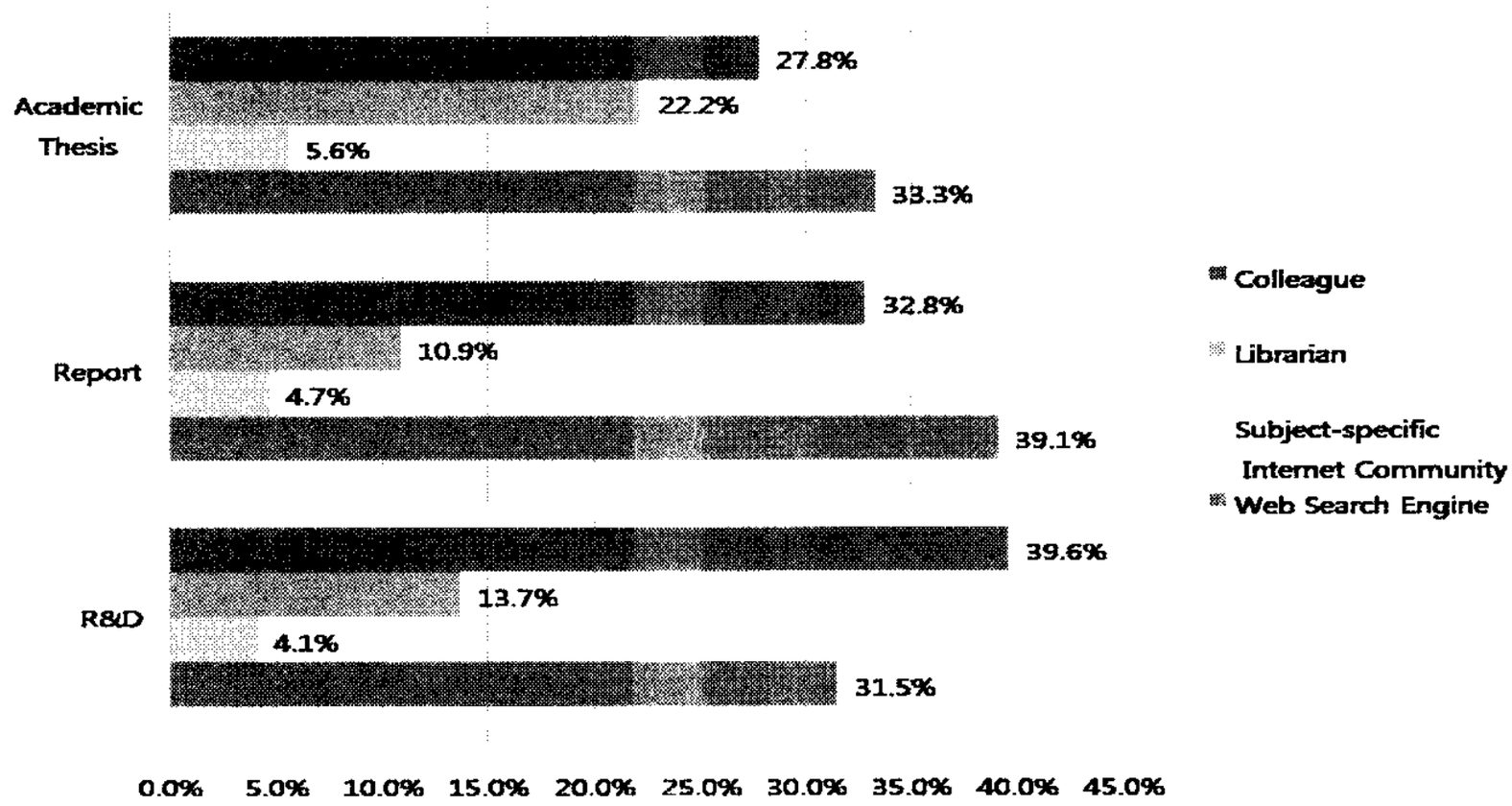


〈Figure 4〉 Causes for Information Gap Problem

4.2.2 Solution to Information Gap Problem

To understand how the researchers dealt with the information gap problem especially through the use of informal communication channels, we asked them to describe their employed solutions. 41.4 percent of the researchers asked their colleagues for the missing information. 38.0 percent of the researchers used the Internet search engines. The distant third ranked solution, which accounted for the 15.8 percent of the researchers, was asking the reference librarians or the ones, who were responsible for managing information resources within the organizations. There were fewer numbers of researchers, who relied on the subject-specific Web-based communities, to get the needed information. This last option accounted for the 4.9 percent of the sample.

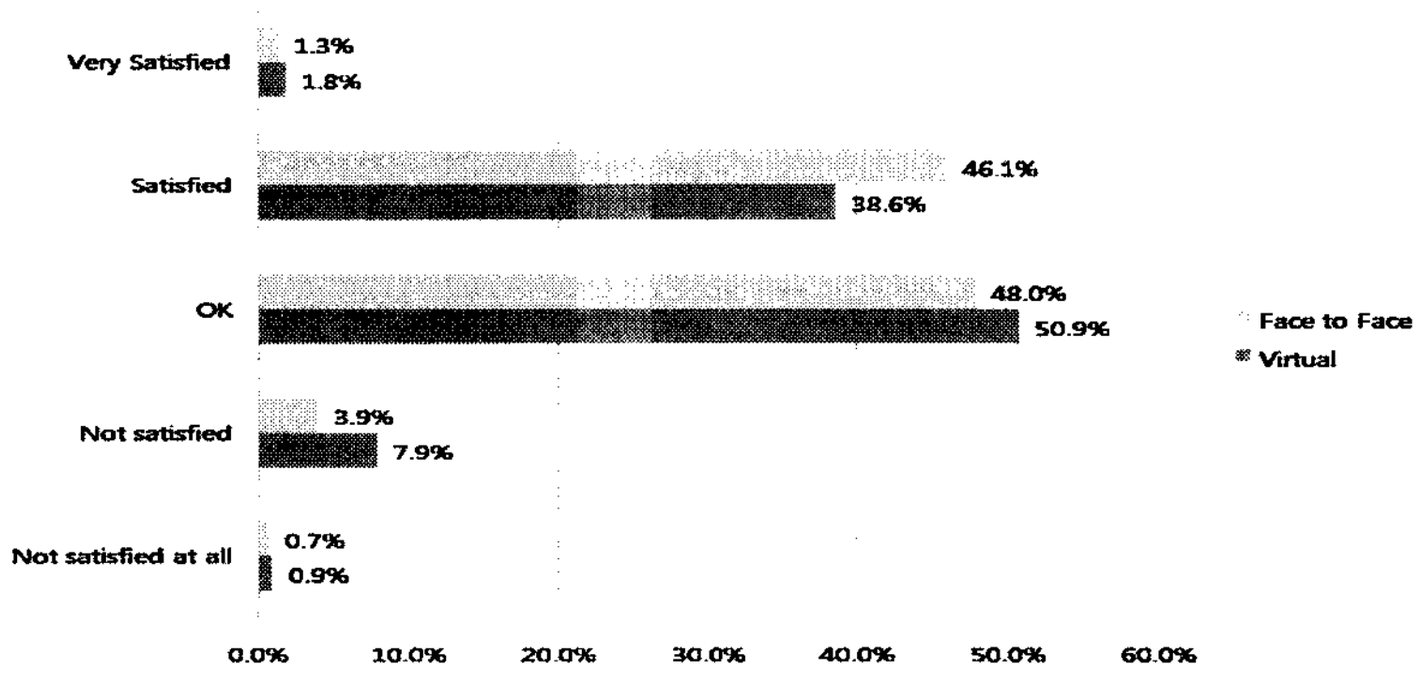
Four types of information seeking could be grouped into two categories. One is a face-to-face information seeking category, which includes the asking colleagues and asking reference librarian/ corporate information resource mangers. The other is a virtual information seeking category, which includes searching the Internet and exploring the subject-specific Web-based communities. The face-to-face category accounted for the 57.2 percent of the respondents. The remaining 42.9 percent of the respondents belonged to the virtual category. This shows that the researchers slightly prefer to use the face-to-face type information seeking methods than the virtual ones. <Figure 5> shows the informal communication preferences of the researchers in dealing with the information gap problem. The ones engaging in the research and development activities relied more on the colleagues while the ones preparing the academic thesis or the reports had used the web search engines more frequently.



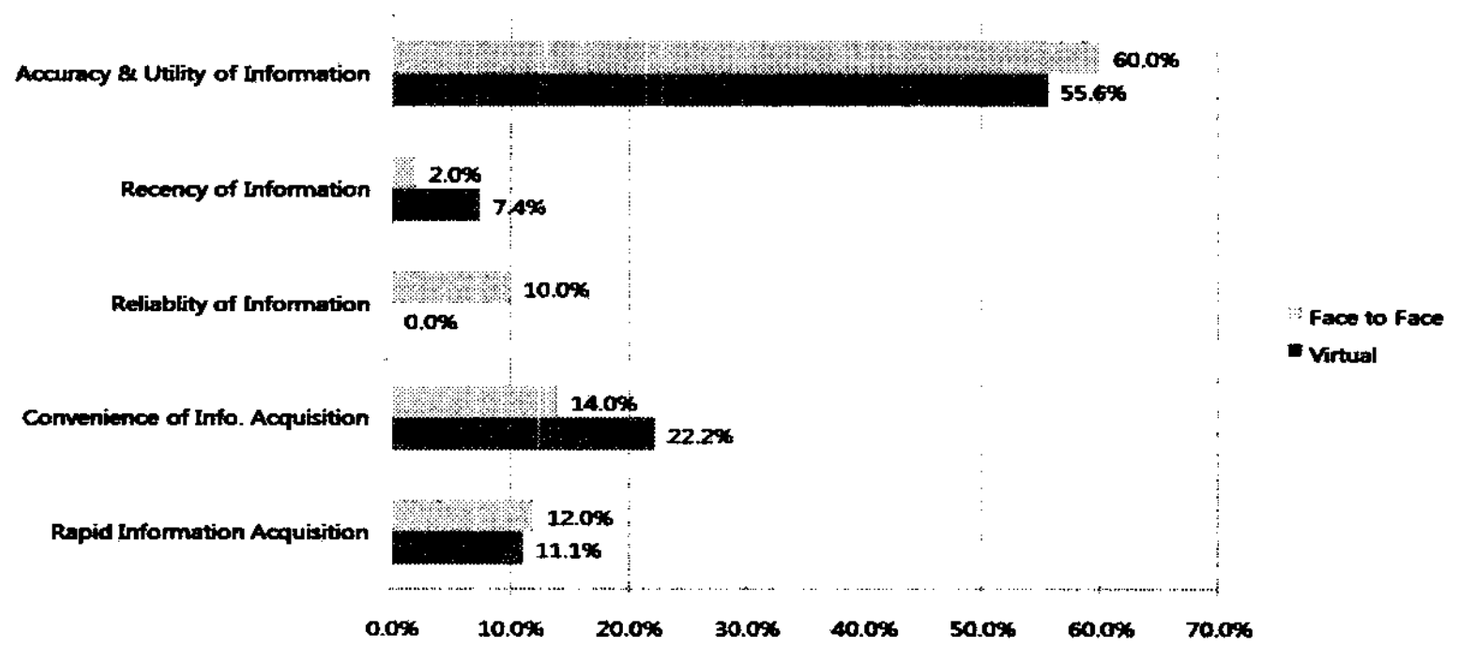
〈Figure 5〉 Preferred Methods to Deal with Information Gap Problem

<Figure 6> shows how satisfied the researchers were in terms of the methods they used to solve the information gap problem. More researchers were satisfied with the face-to-face methods to solve the information gap problem than the virtual methods. This means that the researchers had preferred and gotten more satisfaction from the face-to-face methods.

<Figure 7> shows the reasons listed by the researchers for being satisfied with the selected means to solve the information gap problem. The researchers found that the accuracy and utility of information as the top reason for being satisfied with both face-to-face and virtual information seeking methods. This shows that the acquired information from both the face-to-face and virtual sources were useful for solving their information problems. The researchers found that the reliability of information and the rapid information acquisition were better in the face-to-face methods than



〈Figure 6〉 Degree of Satisfaction by the Selected Methods to Deal with Information Gap



〈Figure 7〉 Reason for Being Satisfied with the Selected Information Gap Solutions

the virtual ones. However, the researchers found the virtual methods were better in terms of the recency of information and the convenience of information acquisition. This probably means that the online information sources were updated more frequently and the researchers were more comfortable in using the virtual information source.

5. Conclusion

This study confirmed that there are differences in the information seeking behavior, information use behavior, and the information needs by the different science and technology researcher groups.

With respect to the information seeking behavior, the industry group considered the information communication among colleagues to be important. The ones, who work at the research institutions, preferred to conduct research and development activities and information seeking independently from their colleagues. Academic researchers were in between the collaborative and independent modes of working.

All three groups relied heavily on the web-based information seeking methods such as web databases, digital libraries, and search engines.

We found that all three groups had the highest reliance on the journal papers to fulfill their information needs. However, they all had the difficulty accessing the academic journal papers especially in the full-text format. In addition, all three groups had high demand for research report type information source. However, the research reports were difficult to obtain through the formal information seeking and delivery systems that they currently use.

In the following, we provide a science and technology information service guideline based on our study.

Firstly, it will be important to add more channels to access the science and technology related electronic resources given the increased demand for the web-based information resources. The acquisition of the electronic and full-text information will become increasingly more important as well.

Secondly, it will be necessary to provide the informal communication channel as the information service with the informal community functionality will allow the scientists and engineers to easily share the practical knowledge and technologies.

Finally, it will be essential for the search engines to provide the relevant information as the scientists and the engineers require high retrieval accuracy. Furthermore, it will be important to have the information updated as the science and technology researchers and the engineers want to have the most up-to-date information.

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