Journal of East Asian Libraries

Volume 2015 | Number 161 Article 6

10-2015

# Information Behaviors of Nuclear Scientists at Korea Atomic Energy Research Institute

Youngchoon Chun
*Korea Atomic Energy Research Institute*

Jiho Yi
*Korea Atomic Energy Research Institute*

Jung-ran Park
*Drexel University*

Sangki Choi
*Chonbuk University*

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Youngchoon Chun, Principal Librarian,
Korea Atomic Energy Research Institute, Daejeon, South Korea
Jiho Yi, Librarian, Korea Atomic Energy Research Institute
Jungran Park, Associate Professor, Drexel University
Sangki Choi, Chonbuk National University, Jeonju, South Korea

## Abstract

The goal of the study was to analyze the information use behaviors of researchers in the science and technology domain. A survey and interviews were conducted targeting nuclear scientists at the Korea Atomic Energy Research Institute. Study results indicate that the nuclear scientists mainly use the Institute library/information center and Internet portal/search engines during information acquisition. Easy access to information, accuracy, currency and cost are the most critical factors in selecting and obtaining information. The most frequently used database for executing research is the Institute's electronic library (NUCLIS21) followed by the Citation Index SCOPUS. The results of the study indicate that monographs, reports and journal articles are the most frequently used information sources in all stages of the research process. Contrary to our expectations, the usage of monographs and reports is at the same level as that of journal and proceedings articles. This indicates that it is necessary to provide monographs and reports to researchers through online information sources in addition to journal and conference proceeding articles. Provision of up-to-date lists of new monograph publications and reports would also be useful for researchers to scan for information relevant to their research in an effective and timely manner.

## 1. Introduction

Science and technology have played key roles in improving and shaping the digital world. Continuous scientific discoveries and technological innovations have offered infinite hope and challenging opportunities. Korea has become a knowledge-and-information-focused society wherein the source of wealth and growth has changed in a matter

of years from materials to knowledge and information. Science and technology fields are becoming more closely integrated with other fields of knowledge not just owing to accelerated innovations in science and technology but also because of lowered trade barriers and trade liberalization designed to promote trade among nations. In addition, intense rivalry for national profits and competitiveness, a strong desire for an improved quality of life and changes in value systems has contributed to a tighter interconnection.

In this complex society, the most important and realistic goals of researchers in science and technology are to pursue national growth and profits, improve the general welfare, and satisfy expectations by conducting research projects that can meet national and institutional needs for development. As more information is shared digitally, it affects the behaviors of researchers who are simultaneously information producers and information consumers.

How can librarians assist researchers in providing information actively and flexibly? To address this question, it is necessary to examine the types of information needed by the researchers. It should be taken into account that information demands and level of use by researchers will vary according to the project execution stage. This study focuses on nuclear scientists at Korea Atomic Energy Research Institute (KAERI). KAERI established in 1959 is the only comprehensive nuclear research institute in Korea with over a half-century-old history (54 years). The main objective of KAERI Technical Information Department (TID) is to support the nuclear research and dissemination activities of KAERI and to contribute to the development of the domestic nuclear industry through a timely supply of adequate technical information in the nuclear field. Toward this end, TID provides its users with technical information through acquisition, processing, and the digitalization of various information materials produced in South Korea and abroad. Also, TID plays the role of not only the specialized nuclear information center of South Korea but also the national center of the *International Nuclear Information System* of the *International Atomic Energy Agency*.

This study examines information access and acquisition methods as well as information sources at each research project stage that Korean nuclear scientists use. Through analysis of information-use behaviors in the research process, this study aims to determine the satisfaction level of current information services in KAERI. Although there have been various studies on researchers' information needs and usage behaviors, this study introduces a new method by examining information access and acquisition as well as information sources used.

## 2. Literature Review

In this section, we present studies dealing with information use behaviors in the research process. We look at studies conducted in Korea first followed by outside of Korea.

### 2.1 Domestic status

Since the 1980s in Korea, studies on researchers' information needs, use and behaviors were continuously conducted with specific fields of study or users. However, there was no study conducted on information usage behaviors during the research process. Jung (1997), investigating chemists' information needs and use behaviors, finds that researchers frequently combined information search and use instead of separating one from the other, and thus data acquisition was the most inconvenient part for researchers. Ahn (2002) employs information-use behaviors to establish a knowledge-based system that is accessible to general users and economy researchers. He proposed a model for information usage in the economy research process and created a system after investigating the researchers' familiarity and usage of information sources. Lee (2006) discusses the trend of research toward a more user-centered approach (i.e. focused on information pursuers). After analyzing foreign researchers' information pursuit characteristics and needs, the study proposed up to eight types of models for information-use behaviors: general, user-specific, information pursuit in daily life, methodology-focused, communication-focused, accidental discovery, cognitive access, and other models.

Based on the premise that a study on information access, acquisition, and interaction with an information system should consider various information environments, Park (2010) applied Wilson's information behavior model and tried to integrate qualitative and quantitative studies in order to analyze users' information acquisition as well as their needs, motives, and processes of information sharing in libraries and on the Internet. According to the study, users investigate the types and usefulness of information sources through the Internet before acquiring the information through the library. The author proposed improvement plans for information service based on the study results. Bae (2010) conducted an in-depth analysis of information needs and use behaviors by dividing academic information service users into undergraduate and graduate student groups and described more detailed information needs according to the groups. The study was conducted with 20 students from two colleges.

The results confirmed that there is a difference between undergraduate and graduate students in information needs and use behaviors.

In order to analyze information needs and pursuit patterns of researchers in Ph.D programs in Korea in various information environments, Kim, et al (2011) conducted group interviews. This was based on the premise that in a digital environment where the Internet and technology for information and communication are radically changing, academic researchers are using information through more complex and diversified media. The results showed that there was little difference in the ratio of usage of electronic data to that of printed materials and methods for acquiring research ideas. Lee and Jung (2012) examine information-use behaviors of professors in the design field; they found that professors frequently use gray literature (informal literature) such as materials obtained from conferences, exhibitions, and seminars. The study also found that the professors use non-printed materials, especially through the Internet, more frequently than printed materials; on the other hand, professors in the design field seldom use databases.

### 2.2 International status

Since the 1980s, studies have focused on analysis of individual information use behaviors and the associated research process within a specific field or of specific users. Ellis' study (1989) was one of the first studies to modeled researchers' information search behaviors in the research process. Ellis's study representing this new trend focused on researchers' information search and use behaviors. In order to design an information search system, Ellis (1989) observed Social Science researchers. He reviewed the performance of the search system in the environment that was intended for the Cranfield Test which was proposed by the Cranfield Institute of Technology.

Hildreth (2001) presents the Cranfield model as a classsic system-oriented approach for evaluating the effectiveness of an information retrieval system. The Cranfield evaluation was conducted in controlled experimental settings using test collections, a set of test queries, and a set of documents relevant to test queries. Human factors were not part of the experiments; that is, the researcher's entire search process during interaction with the system was not considered in these experiments.

Ellis (1989) found the Cranfield Test inadequate because it was based on data obtained under an artificial environment where the actual information search processes were ignored. Ellis investigated the elements that make up researchers' actual information search patterns and

constructed an information search behavior model for the purpose of designing information search systems. The study analyzed information search behaviors by categorizing them into six stages of research: *starting, chaining, browsing, differentiating, monitoring and extracting*. Based on the results, He then proposed a model named "Ellis Model".

Cox and Hall (1991) examined the information search and use behaviors of physicists and chemists, respectively. As a follow-up study based on the initial six stages of the Ellis Model (1989) that was conducted on Social Science researchers, Ellis (1993) conducted a joint study with Cox and Hall on the comparison of information search behaviors of physicists, chemists, and social scientists in the research process. The study presents a total of eight characteristics in relation to information search behaviors of physicists, chemists, and social scientists. Six information-search characteristics in the research process were derived from the Ellis Model (1989): *starting, chaining, browsing, differentiating, monitoring and extracting*; there are two additional characteristics: *verifying and ending*.

Ellis (1997) proposed another model based on information search behaviors of engineers and researchers in the industrial environment. Information search behaviors of engineers and researchers were categorized into eight stages: *surveying, chaining, monitoring, browsing, distinguishing, filtering, extracting, and ending.* This model is unique in the sense that its research processes and purposes were different from those of social scientists, physicists, or chemists. Ellis' analysis of information search and use behaviors in the research process showed no big difference in information use behaviors among physicists, chemists, and social scientists. This is aligned with the previous studies by Garvey et al. (1970, 1971) and Skelton (1973), which studied scientific communication behaviors of social scientists and scientists.

In conclusion, the information search behaviors can be flexible depending on the individual characteristics, process, and purpose of the research. The models from Ellis' study results are summarized in <Table 1> below:

<Table 1> Information search behaviors in the research process

| Social Science researchers | Physicists and chemists | Industrial engineers and researchers |
|---|---|---|
| Ellis (1989) | Ellis (1993) | Ellis (1997) |

| | | |
|---|---|---|
| (1) starting<br>(2) chaining<br>(3) browsing<br>(4) differentiating<br>(5) monitoring<br>(6) extracting | (1) starting<br>(2) chaining<br>(3) browsing<br>(4) differentiating<br>(5) monitoring<br>(6) extracting<br>(7) verifying<br>(8) ending | (1) surveying<br>(2) chaining<br>(3) monitoring<br>(4) browsing<br>(5) distinguishing<br>(6) filtering<br>(7) extracting<br>(8) ending |

Dutta (2009) conducted a comparative analysis of the information needs by reviewing 56 articles that were published in the last 40 years by categorizing the natives of nine developing countries into city residents and country residents. The results showed that the poor economic conditions had a major impact on information accessibility and use, and that the education level of the users was directly related to their information needs and information pursuit behaviors. In addition, the author stresses that further studies on the information-use behaviors of researchers in developing countries is necessary to examine in depth the following aspects: first, to study the information-pursuit patterns of untrained citizens; secondly to study the information-pursuit patterns of scientists in the world's poorest countries. Research on these aspects of information use should determine the effects of public information sources such as public libraries and local broadcasting stations on the improvement of the residents' quality of life.

By surveying 2,063 natural sciences, engineering, and medical science researchers at five U.S. colleges, Niu et al (2010) examined information pursuit patterns of researchers in various fields. The survey inquired about information search, use, and preservation behaviors. One notable finding is that the use of electronic media is radically increasing not only for library services but also for information search, use, and storage. According to the study, there was little difference in information pursuit patterns of researchers from the five colleges and there was no difference in academic and demographic characteristics. The study also found a notable trend of increasing number of innovative ways of academic communication through cooperative information sharing. According to the study, the changes in information sharing started within research labs or group academic communities.

For quantitative analysis of factors affecting information pursuit patterns and information use behaviors, Al-Muomen (2012) conducted a survey with written interviews and in-person interviews targeting graduate

students, librarians, and professors of universities in Kuwait. The study results showed that the major factors affecting information pursuit patterns can be found in library awareness, information literacy, library organizational and environmental issues, and demographics (specifically gender and nationality). In addition, the study introduced a new information model that analyzes and subdivides micro-factors, which come from the micro-factors and macro-factors in Wilson's information behavior model (1999) and Urquhart and Rowley's information behavior model (2007).

Wilson's (1999) information behavior model focuses on humans in relation to information rather than focusing on the use of information systems and sources. Wilson (2000) defines information behavior as "the totality of human behavior in relation to sources and channels of information, including both active and passive information-seeking, and information use. Thus, it includes face-to-face communication with others, as well as the passive reception of information. Rowley and Urquhart (2007) present two main factors for research on information behavior. First, micro factors impact directly on specific individual information behaviors such as student information behavior. Second, macro factors define the context of information behavior; such factors concern research on the patterns of usage of resources, information resource design, policies and funding, organizational leadership and culture, and information and learning technology infrastructure.

## 3. Research Method

This study examines nuclear scientists' information-use behaviors while focusing on the research process rather than looking at general information-use behaviors. For this purpose, we followed three steps. First, we reviewed all relevant literature dealing with information-use behaviors during research process of unclear related work. Second, a research process model for information use in the research process was designed based on interviews with the researchers/scientists in Korea Atomic Energy Research Institute (KAERI) and the literature review conducted in the earlier step. In order to increase the validity of the research process model, we created a draft for a basic research process model using research project execution stages. After an iterative process of reviewing and revising the draft, we completed the final model. Third, we developed a questionnaire for the survey after reviewing existing literature on information-use behaviors especially in relation to researchers' information acquisition method, information use and main sources used. A separate questionnaire for research project execution stages was created.

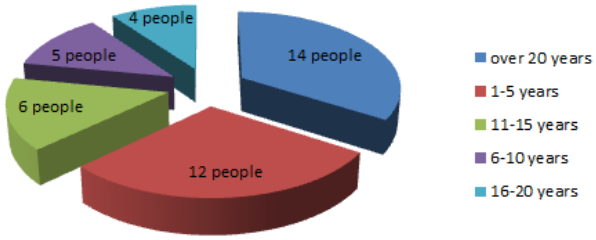
The questionnaires were distributed to a total of 50 nuclear scientists in KAERI in July 2012. The survey participants comprise KAERI's nuclear scientists with various research experiences and those working in nuclear subfields regardless of their years of experience or fields of study. Out of 50 scientists, we received 41 completed survey questionnaires (82% response rate) by August, 2012. We believe that the relatively high response rate was owing to the personalized reminders sent to the nuclear scientists individually for completing the survey. The completed questionnaires were analyzed using the Excel program and questions requiring plural answers or ranking were analyzed after weighting the discrete variables.

## 4. Research Results

### 4.1. Background information on survey participants: research experience, education, and major field of study

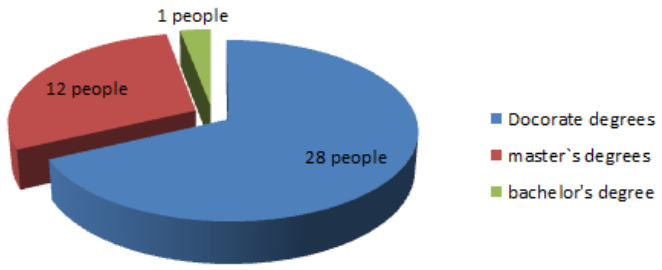
In order to execute research tasks, it is necessary to determine the range of research experience. Table 2 below presents research experience broken down in the following way: over 20 years (14 people, 34%); 1-5 years (12 people, 29%); 11-15 years (6 people, 15%); 6-10 years (5 people, 12%); and 16-20 years (4 people, 10%).

<Table 2> Research experience

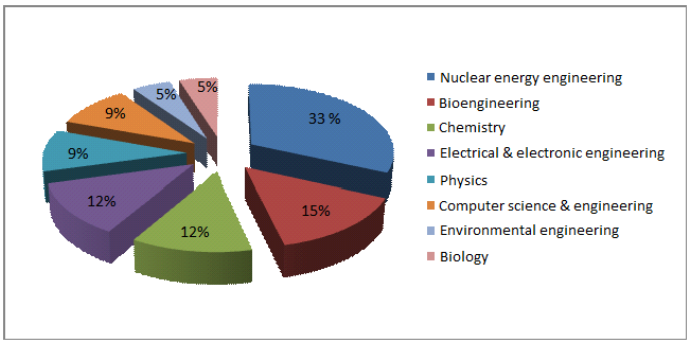



In order to understand the relationship between research workforce configuration and education level, we questioned the education level of researchers. As shown in <Table 3> below, a high percentage of researchers hold doctoral and master degrees: 28 with doctorate degrees (68%), 12 with master's degrees (29%), and 1 with a bachelor's degree (3%), indicating that most of the researchers have either a doctorate or master's degree.

<Table 3> Education level




The following <Table 4> illustrates the relationship between research workforce configuration and researchers' major field of study: 13 in nuclear energy engineering (33%), 6 in bioengineering (15%), 5 in chemistry (12%), 5 in electrical & electronic engineering (12%), 4 in physics (9%), 4 in computer science & engineering (9%), 2 in environmental engineering (5%), and 2 in biology (5%).



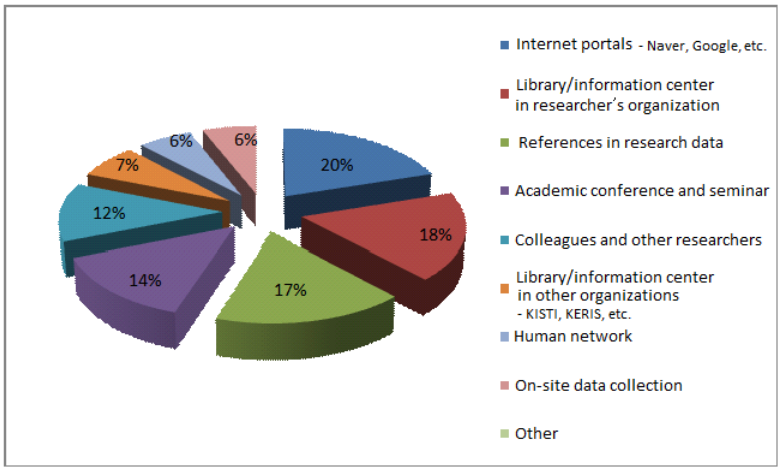

<Table 4> Major fields of study

### 4.2 Information acquisition method and information source usage

- **Information acquisition method**

It is important to determine which types of information acquisition methods a researcher employs when executing research tasks. The Table 5 below illustrates these information acquisition methods that nuclear scientists employ.

<Table 5> Information acquisition methods in research



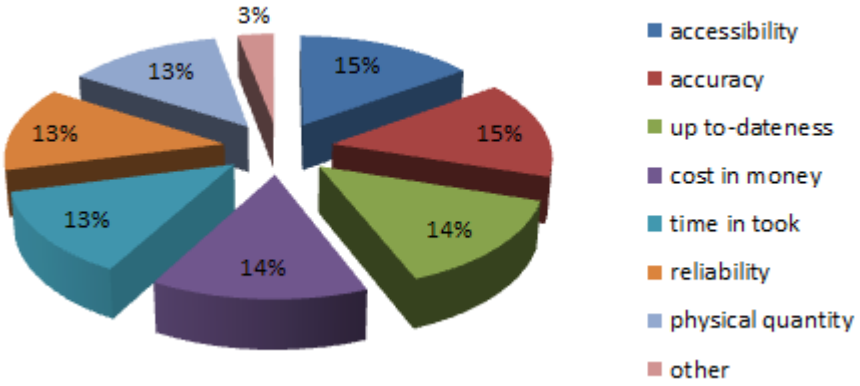

As shown, the most commonly used method is through Internet portals (20%) followed by the library/information center in KAERI (18%). Our survey participants indicated that they also use library/information centers in other organizations (7%). If we combine library/information centers in KAERI and other organizations, the most commonly used method is through library/information centers (27%). This indicates the libraries and information centers are important and highly relevant for Korean nuclear scientists to conduct their research. Followed by libraries/information centers and Internet portals, bibliographic references/citations in research data (17%) are a frequently used method. Nuclear scientists at KAERI also employ their colleagues and other researchers (12%) in addition to other human network (6%).This indicates that one's interpersonal network is an important method for information-seeking. When we combine these two methods (i.e., colleagues/other researchers and other human network), the interpersonal network (18%) takes third place as the most frequently used information seeking/acquisition method followed by library/information center and Internet portal. On-site data collection (6%) and academic conference and seminars (4%) are the least used methods.

The Table 6 below represents critical elements in selecting information acquisition methods:

- Easy access to relevant information (15%)
- Accuracy of relevant information (15%)
- Up-to-datedness of obtainable information (14%)
- Cost to acquire relevant information (14%)
- Time taken to acquire relevant information (13%)
- Reliability of relevant information provider/source (13%)

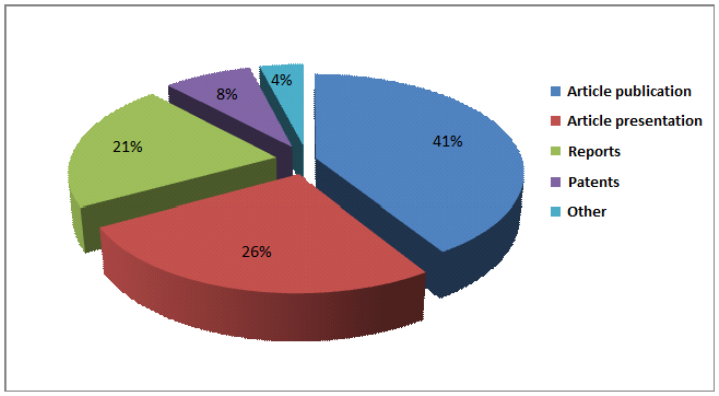
- Physical quantity of relevant information (13%)

<Table 6> Critical elements in information acquisition

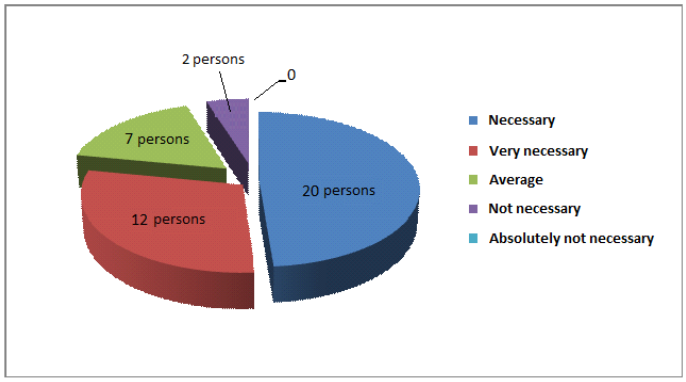



In terms of the format of the research product, article publication (41%) shows the highest usage followed by conference proceedings (26%), reports (21%), patents (8%), and others (4%). The table below illustrates this:

<Table 7> Research output format



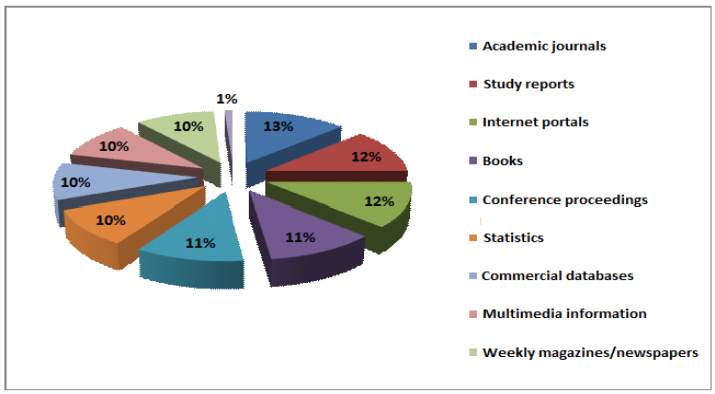

It is also critical to determine the importance of the technical information team at KAERI. <Table 8> below presents the views of nuclear scientists and researchers on the degree of importance of the technical information team: 20 people answered necessary (49%), 12 answered very necessary (29%), 7 answered average (17%), and 2 answered not necessary (5%). As shown, high number (78%) of scientists indicated the necessity of the technical information team.




<Table 8> Necessity of the technical information team

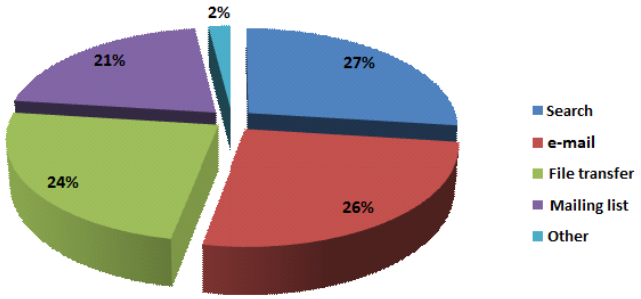
- **Information source usage**

<Table 9> below represents the information sources most frequently used in research: academic journals 13%; study reports 12%; Internet portals 12%; books 11%; conference proceedings 11%; statistics, commercial databases, multimedia information, and weekly magazines /newspapers 10 % respectively.




<Table 9> Main information sources used in research

Internet use ranked first among major information acquisition methods and third in the use of information sources, indicating its very high usage rate. <Table 10> represents major Internet and online tools used in the research process: search engine 27%; e-mail 26%; file transfer 26%;

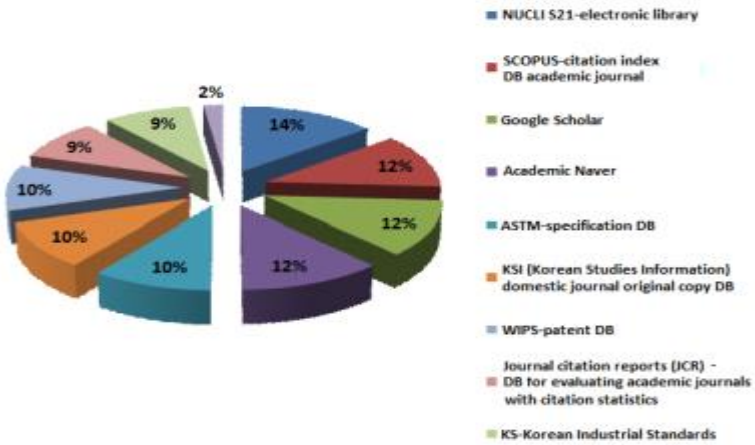



mailing list 21%; and others 2%.

<Table10> Internet and online tool usage

The Table 11 below represents the main databases used by researchers: the most commonly used source is NUCLI S21- electronic library of the institute (14%). The content of NUCLI S21—electronic library of the institute—mostly concerns science and engineering domains (over 95%). The following represents the rest: Citation Index SCOPUS 12%; Google Scholar 12%; Academic Naver (Korean search engine) 12%; ASTM-specification data base 10%; Korean Studies Information domestic journal original copy data base 10%; WIPS-patent data base 10%; Journal Citation Reports9%; KS-Korean industrial standards 9%; others 2%.

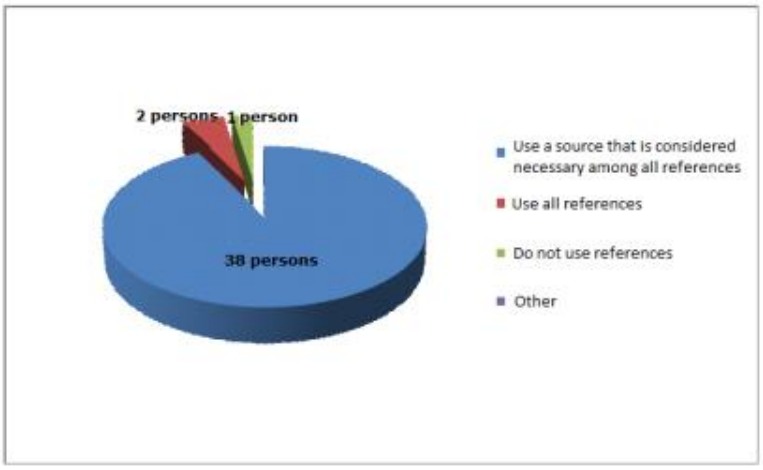
<Table 11> Main databases used in research




In terms of bibliographic references/citation sources in existing studies, the majority scientists (93%) use sources that are considered necessary for their research. Very small number of scientists (5%) reported

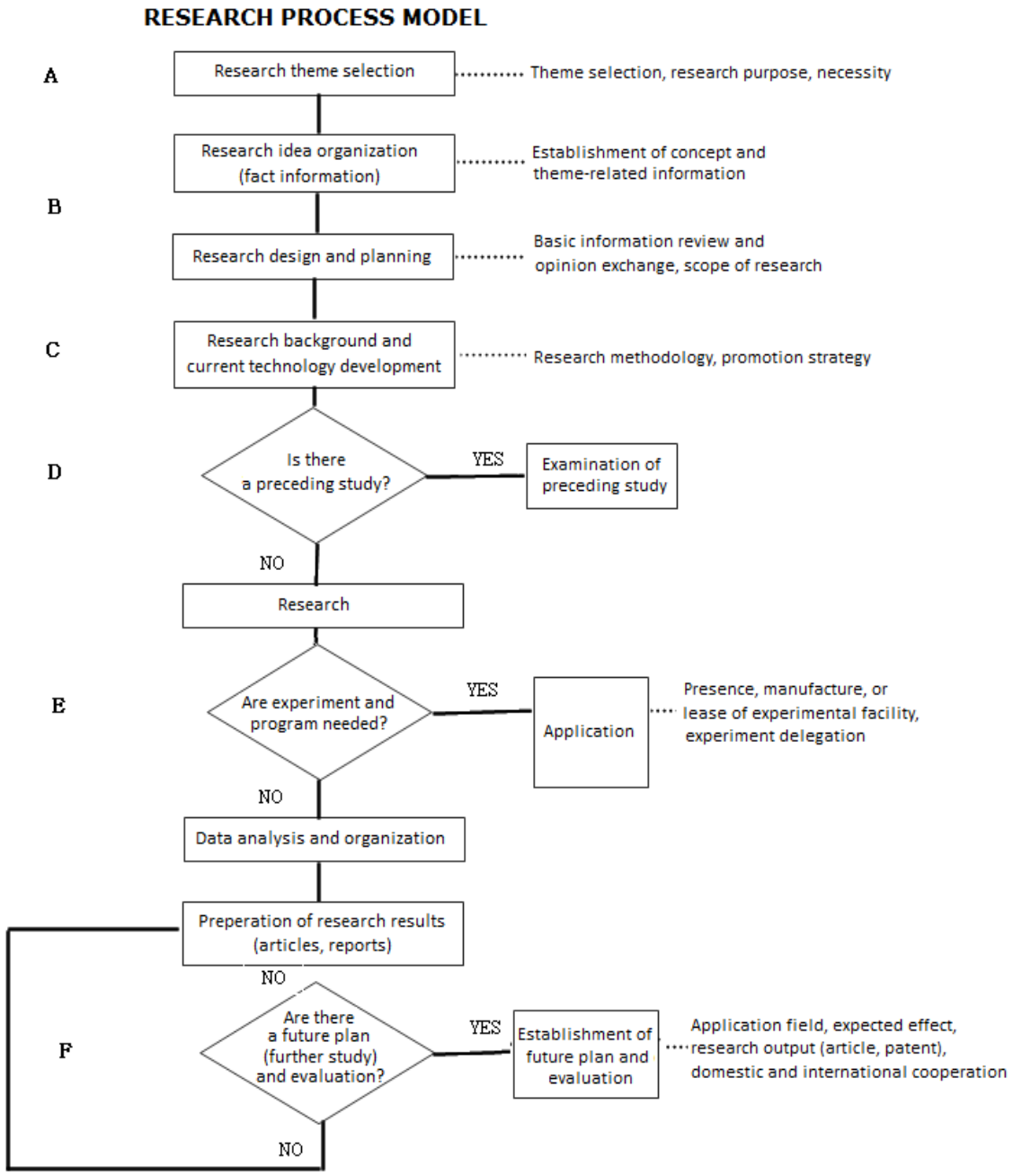
that they use all the bibliographic references/citation sources in existing studies regardless of relevancy to their works. On the other hand, one scientist (2%) reported that s/he does not employ bibliographic references/citation sources at all. <Table 12> below illustrates this.

<Table 12 > Use of bibliographic references




### 4.3 Research Process Model

In order to optimize information provision in each research process in time, it is necessary to investigate the type of information used during research. The <Figure 1> below is a research process model showing the use of information sources by nuclear scientists. It modeled the entire gamut of research project execution stages. The proposed research process consists of seven stages: research theme selection, research idea organization, research design or planning, research background and current status of technology development, research execution, data analysis and organization, and creation of research results (articles, reports, etc.).

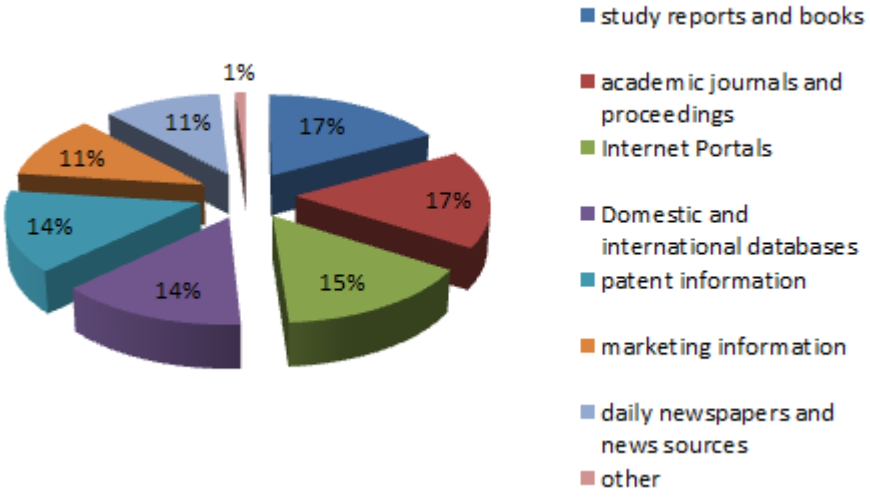



<Figure 1> Information use model in the research process

- **Frequently used information sources at the research project execution stage**

*Stage A: Research theme selection:*
Research theme selection is the most basic process in research; it includes information related to subject selection, research purpose and research necessity. The information sources used for this purpose were investigated. Table 13 below illustrates this:

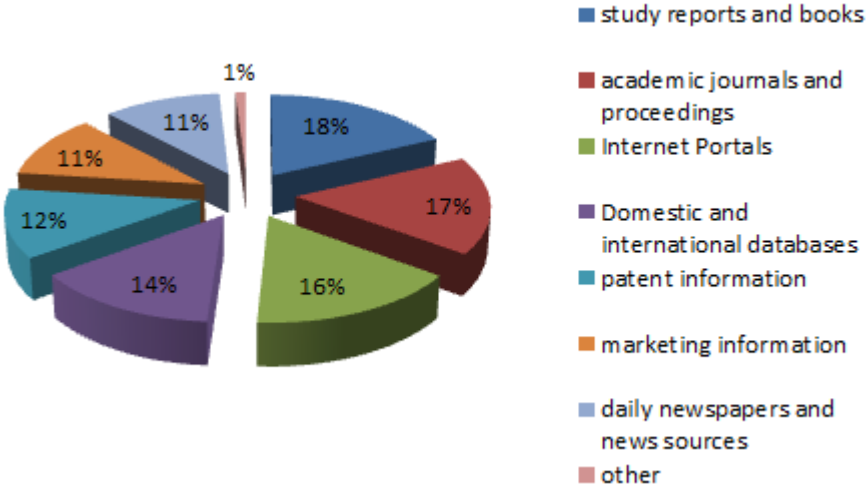
<Table 13> Stage A: Main sources used for research theme selection




<Table 13> above represents the main sources used for selecting a research theme at stage A in order according to the percentage: study reports and books 17%; academic journals and proceedings 17%; Internet portals 15%; domestic and international databases 14%; patent information 14%; marketing information 11%; and daily newspapers and news sources 11%.

*Stage B: Research idea organization and design:*
After a research theme is selected, a design is created to execute relevant tasks. It involves the collection of information related to research concepts and topics. The information sources used for this purpose were investigated as shown below:

<Table 14> Stage B. Main sources used for research idea organization and design creation



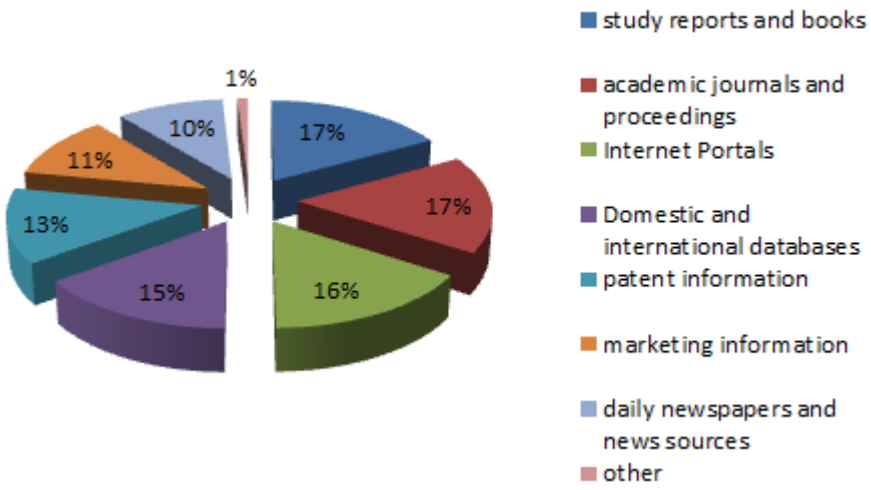
The main sources used for research idea organization and design creation are illustrated in the above Table 14: study reports and books 18%; academic journals and proceedings 17%; Internet portals 16%; domestic and international databases 14%; patent information 12%; marketing information 11%; and weekly magazines and news sources 11% in order.

*Stage C: Research background and current technology development status*:

Upon the completion of the research idea organization and design, all research execution stages are confirmed and the design for all stages, which includes promotion strategy for research methodology, is completed. The sources used for this purpose were investigated.

<Table 15> illustrates sources used for this purpose:

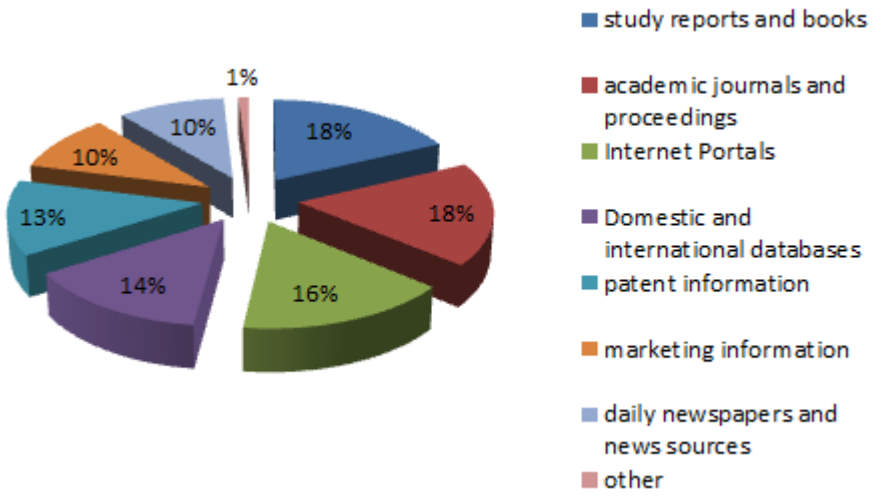
<Table 15> Stage C: Main sources used for analysis of research background and current technology development




The main sources used for research background and current technology status are shown in the above Table 15: academic journals and proceedings 17%; study reports and books 17%; Internet portals 16%; domestic and international databases 15%; patent information 13%; daily newspapers and news sources 11%; and marketing information 10%.

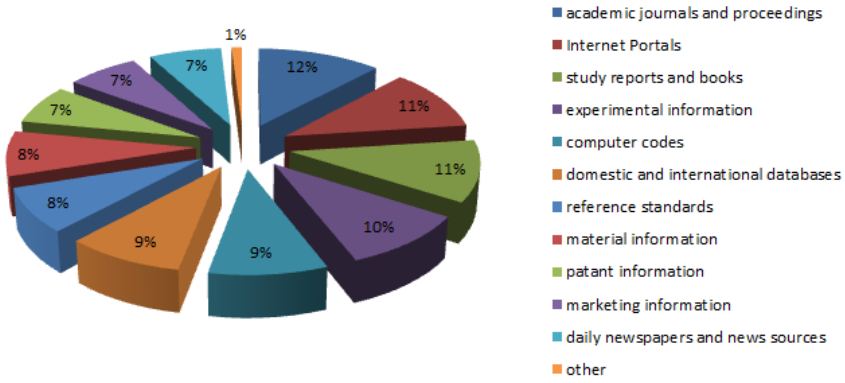
*Stage D: Literature review /examination of preceding studies*
Literature review is absolutely necessary for successful research execution. This stage investigates preceding studies, focusing on the specific research topic to be examined. The sources used for this purpose were investigated as shown in the Table 16 below:

<Table 16> Stage D: Main sources used for literature review




As shown, the most frequently used sources used for creating preceding studies at literature review stage are the following in order: study reports and books 18%; academic journals and proceedings 18%; Internet portals 16%; domestic and international databases 14%; patent information 13%; marketing information 10%; and daily newspapers and news sources 10%.

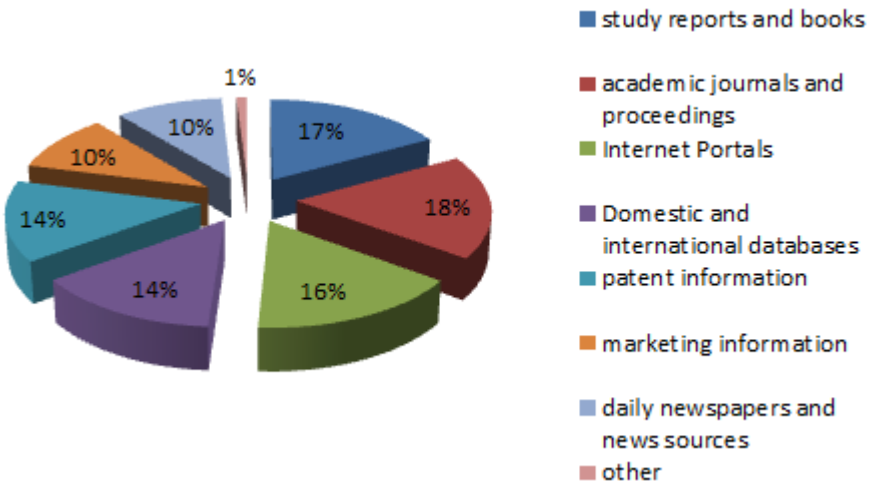
*Stage E: Research execution/conducting original research*:
At this stage, the main research tasks are executed based on the previous stages described above. The sources used for this purpose were investigated. <Table 17> below represents the most frequently used sources for executing the research: academic journals and proceedings 12%; Internet portals 11%; study reports and books 11%; experimental information 10%; computer codes 9%; domestic and international databases 9%' reference standards 8%; material information 8%; patent information 7%; marketing information 7%; and daily newspapers and news sources 7%.
<Table 17> Stage E: main sources used for executing research




*Stage F: Preparation of research results*:

We also examined the main sources used for preparing the research results that were produced after successful execution of the entire research process described above. The table 18 below illustrates this:

<Table 18> Stage F: main sources used for creating research results




The main sources used for creating research results are in order: academic journals and proceedings 18%; study reports and books 17%; Internet portals 16%; domestic and international databases 14%; patent information 14%; marketing information 10%; and daily newspapers and news sources 10%.

## 5. Conclusion

In order to analyze information use behaviors of researchers in science and technology domain, survey and interviews were conducted targeting nuclear scientists on their information acquisition methods, information sources and use of information in the research process. The differences in information use behaviors and inherent information needs at each stage of the entire research process were examined. We also examined the importance of the technical information team at KAERI. Data analysis shows that a high number (78%) of KAERI nuclear scientists consider the team necessary and essential during the research processes.

The study results show that nuclear scientists primarily use Internet portals/search engines and the institute library/information center for information acquisition. The following elements are most critical in selecting and obtaining information: easy access to information, accuracy, currency, and cost. The most frequently used database for executing research is the institute's electronic library (NUCLIS21) followed by the Citation Index SCOPUS and Google Scholar with Academic Naver (Korean search engine).

The high usage of the NUCLIS21 database indicates that the researchers use the electronic library frequently.

The stages presented in the research process model follow: A- research theme selection; B- research idea organization and design; C- research background and current technology development status; D- literature review/existing studies; E-executing research/conducting original research; stage F- creating research results. The results of the study indicate that monographs (i.e., books), reports, and journal articles are the most frequently used information sources regardless of the different stages of the research process. Contrary to our expectations, the usage of monographs and reports is at the same level as that of journal and proceedings articles.

This indicates that it is necessary to provide monographs and reports to researchers through online information sources in addition to journal and conference proceedings articles. Up-to-date lists of monograph publications and reports would be useful to researchers in this regard. The study results also indicate that the provision of the following resources and information services would be useful to the researchers: domain subject expert lists, pathfinder information resources, domain classification/categorization scheme, conference information, statistical raw data, and information on how to write articles in English.

There are inherent limitations to this study. The results of the study are based on a limited number of nuclear scientists at KAERI. The study results might be applicable as a reference in science and technology domain with similar institutions. However, this study cannot be generalized across other research domains and institutions.

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