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Japan Advanced Institute of Science and Technology

Knowledge Management Survey in JAIST:

Analysis and Perspective

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Key Words:

Knowledge management, scientific knowledge creation, laboratory knowledge management

Abstract:

Research on knowledge management in academia has become a hot issue and a promising research area. However, most research has focused on general educational organizations, such as high schools and universities. This paper concentrates on understanding the problems of knowledge creators per se instead of the general student population, as disclosed in field research by a survey of the scientific knowledge management and creation process at the Japan Advanced Institute of Science and Technology (JAIST). By using comparison, classification, cross tabulation, and other analysis methods, some subtle issues and hidden problems have been discovered in this survey, such as the unevenness of technical support among different schools, ignorance of cooperation as one source of knowledge, different requirements of foreign and Japanese researchers, and so on. Along with these findings, we also present our corresponding analysis and suggestions for more effective knowledge management and better creativity support, and some perspectives and future research directions in this field.

1. INTRODUCTION

Research on knowledge management (KM) came into being in the early 1990s. With the growth of information technology and the knowledge economy, it has gained very tremendous and quick development in the business field and enjoyed an emerging popularity across disciplines and industries. KM was defined broadly as a loose set of ideas, procedure, tools and practices concentring on the capture, storage, sharing/communication, utilization and creation of knowledge in organizations [1][2][3].

In contrast to the significant successes and achievements of KM in the business area, it is only recently that educational administrators have begun to look at how they might apply KM principles and technologies to create effective teaching and learning

environments and support educational decision-making [4]. The subject studied was usually a general educational organization, for example, high school, colleges and universities rather than a research institutes. Moreover, the attention of existing papers concentrated mainly on building information systems or corporate portals to support the administration of educational institutes [5][6][7].

Recently, some researchers and scholars have realized it is important to apply knowledge management practice to facilitate the scientific knowledge creation in academia. Here, we define KM in academia as *any systematic activity related to support and enhance the creation of scientific knowledge and achievement of research goals.* As we know, universities and research institutes, as social communities, play a vital role in creating and transmitting scientific knowledge; thus, enhancing creativity as well as the management of knowledge in academia is quite significant to the world. In the work described here, we focus on KM in academia, especially the process of scientific research and scientific knowledge creation in research institutes. Our goal was to investigate their special and diverse requirements as well as complaints of knowledge creators, and to discover both their hidden troubles and obstructions and the corresponding underlying reasons, so as to improve creativity support and decision-making throughout the research institute, thus advancing and improving the creation of scientific knowledge.

To achieve this goal, we first carried out a KM survey at Japan Advanced Institute of Science and Technology (JAIST), a relatively new (1990) Japanese national institute, established to do research at the highest levels in selected fields of science and technology (Knowledge Science, Information Science, and Material Science). The population investigated consists of only masters students, doctoral students, post doctors, and research associates/assistants, i.e. the backbone of knowledge creators. In the survey we also considered many contributing factors, such as knowledge management technologies, personal IT skills, cooperation environments, laboratory knowledge management (LKM), knowledge sources for research, creativity support, and life environments.

Then, based on the statistical results, we discovered some hidden problems and obstacles that have not been mentioned in the existing literature. By using classification, comparison, and other methods, we deeply and comprehensively analyzed the reasons for these problems and present some corresponding suggestions and solutions as well as a perspective for future research. We think it is necessary and urgent to provide a computer-supported system or a computerized environment to improve knowledge sharing and creativity support in academic laboratory. Further more, we propose the framework of laboratory knowledge management system. We hope our experiences can be widely used for reference in scientific knowledge management and creativity support in academia, LKM, and other areas.

2. OVERVIEW OF SUEVEY

2.1 Background

This study is supported by the 21st COE (Center of Excellence) Program "Study of Scientific Knowledge Creation" at the Japan Advanced Institute of Science and Technology (JAIST), and funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT, Japan). This program will establish an interdisciplinary research field called the Study of Scientific Knowledge Creation. The goal of this program is to create a world-class center of excellence in the following areas. (1) Theoretical Research: With a final target of strategic research and the development of scientific technologies, COE researchers will study knowledge fusion and development in important scientific fields, and then establish a theory of scientific knowledge creation. (2) Practical Research: As theories are developed, researchers will apply them in scientific laboratories and improve them using feedback from practice. Through repetition, researchers will improve the theory and promote the creation of useful scientific technologies [8].

To achieve this goal, we should first understand the current situation of knowledge management in academia. That was the motivation for this survey, which casts new light on measuring current understanding of the concepts of KM, as well as its application and developing trends in the academic research environment. The survey sought to provide a snapshot of the situation in JAIST over a 4–month period, from January to April 2004, and to interpret that data.

JAIST was considered to be a representative research institute for our study. JAIST consists of three schools: Material Science, Information Science, and Knowledge Science. In terms of knowledge management, they are typical representatives for the study of basic, information, and interdisciplinary science. The School of Knowledge Science was the first school established in the world to claim knowledge as a legitimate target of science; the school has enlisted researchers from various fields to develop knowledge science that is trans-disciplinary in nature [9]. At the same time JAIST, as an Advanced Institute of Science and Technology, only enrolls masters students and doctoral students, who are more like researchers than general undergraduate or high school students. Moreover, there is a high proportion of foreign students (more than 10 percent) and scholars in JAIST. Based on these properties and advantages, it is possible to cross-tabulate the data from various aspects, which makes our analysis and conclusions more comprehensive and reliable. For instance, it is possible to cross-tabulate the data by nationality, by student's status (master or doctor), or by school.

2.2 Goal

Improved knowledge sharing is at once the keystone of KM and the most difficult

problem [10]. The shared knowledge is not only explicit knowledge, which can easily be processed, transmitted and stored, but also tacit knowledge, which is highly personal and hard to formalize. The creation of scientific knowledge is based on the learning of explicit knowledge (of course, learning involves sharing to some extent) and the sharing of tacit knowledge. Therefore, it is most important for us to understand the current status as well as the factors which inhibit knowledge sharing, along with identifying what kind of practices are used to promote the sharing and transferring of knowledge in the process of scientific research. Our goal was to better understand the current status and special requirements of knowledge management in JAIST and to discover existing and obstacles to study and research. Data collected in this survey was used to provide an insight into the different requirements in different research fields and for different researchers, and how best to adopt pertinent measures that will help researchers manage and create knowledge more efficiently.

2.3 Study Assumptions and Scope

The respondents of this survey included all students (doctoral student and master student), post doctors and research associates/assistants. We did not include professors because we considered that they were a different group who used quite different methods to do their research as compared with our designated respondents, which would make it difficult to get valuable information from the same questionnaire.

The survey base included demographic information about the respondents' school, status, grade (masters students/doctoral students/research associates), age, gender and nationality.

Since the laboratory is an academic space devoted to work and study, and it is a basic organization entity for most researchers, we considered the laboratory as the basic unit in which we investigated knowledge management in academia. After consulting the definitions of knowledge management and knowledge management systems in the existing literature, we proposed the following two definitions in our questionnaire:

Laboratory Knowledge Management (LKM) involves any systematic activity related to the acquisition, capturing, sharing, creation and use of knowledge in the lab.

Laboratory Knowledge Management System (LKMS) is the computer-assisted system that helps with knowledge acquisition, sharing and creation in the lab.

2.4 Survey Instrument

The initial questionnaire was in English. Considering most of respondents are Japanese, we also prepared a Japanese version. Before we released the formal questionnaire, we had carried out a pilot study (several group discussions) among about 12 selected students and associates from each school, to investigate whether the

respondents could understand the questions and to glean their comments in order to improve the questionnaire. After that, we published the questionnaire online (on the homepage of COE program), along with a printed paper version for people who preferred it. To respect the respondents' privacy, all responses were received anonymously.

The survey was divided into four parts: personal IT skills, laboratory environment (including hardware, software, and cooperation environment), self-assessment of the research as well as the daily life environment, and a survey on knowledge management in the laboratory. It was timed to take approximately 20 minutes to complete. In answering the questions and statements, respondents were required to tick appropriate responses showing a preference ranking or to answer multiple choice questions phrased usually with a single option, or a single option with an "others – please specify" possibility.

The questionnaire was published on Feb.25, 2004. The online survey was closed on March 5. The final printed responses were accepted on March 12. A total of 118 responses were received, including 67 native (Japanese) respondents and 51 foreign (non-Japanese) respondents. The response rate was 11.8%. The details are listed in the Table 1 (the number in parentheses is the actual number of students or researchers at that time).

Status / School	Associate	Post doctor	Doctor student	Master student	Total	Rate
KS	4(13)	1(1)	18 (61)	15 (164)	38(239)	15.9%
IS	1(22)	3(5)	15 (90)	10 (263)	29(380)	7.6%
MS	6(25)	5(5)	21 (115)	19 (238)	51(383)	13.3%
Total	11(60)	9(11)	54 (266)	44 (665)	118(1002)	11.8%
Rate	18.3%	81.8%	20.3%	6.6%	11.8%	----

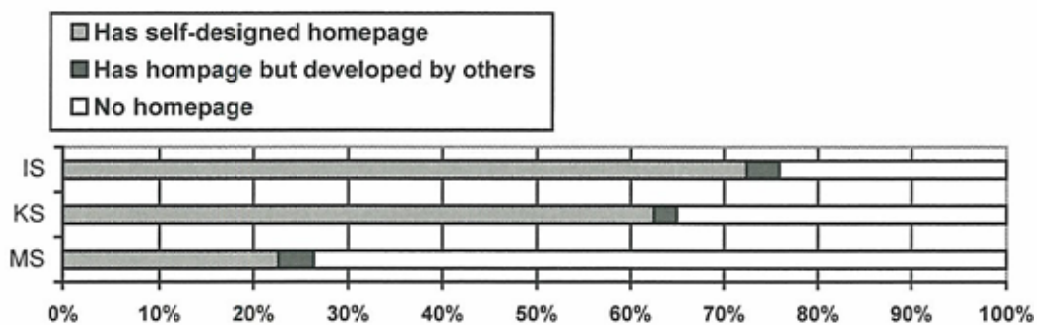**Table 1.** Response rate to the JAIST survey

3. SURVEY FINDINGS

The survey was completed and results analyzed at the end of April 2004. The results and analyses pertain only to this period. No claim has been made as to the generalization of these results to all general educational organizations, other than to argue the indicative analyses and perspectives of knowledge management in JAIST. The results can be only used as references for research institutes and universities similar to JAIST. In addition, we admit that since the sample size in each area (different school or different status of the respondents) of this survey is not very high (see Table 1), there may exist deviations in the findings by comparing the responses of respondents in different areas. This factor should be considered when analyzing the difference between these areas.

3.1. Personal IT Skill

The respondents were asked to describe their personal IT skills with respect to knowledge management. This part of the questionnaire was designed to explore the relationship between personal IT skills and efficient personal knowledge management, for succeeding analyses and comparisons. Some important results are listed below.

In Figure 1, we see that an overwhelming *72.41%* of respondents in the School of Information Science (IS) possessed personal homepages developed by themselves, while only *22.64%* of respondents in Materials Science (MS) were able to use this tool in order to introduce themselves and their research to others. That is to say, even though the Internet and WWW are very popular, there are still quite a number of

Legend:
☐ Has self-designed homepage
■ Has hompage but developed by others
☐ No homepage

IS
KS
MS

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

researchers (or students) who, handicapped by a lack of personal IT skills, have trouble efficiently managing their own knowledge and/or introducing themselves to others through the Internet. This is especially true for those whose subjects are not related to computer or information science, such as basic science. This prompts us to the conclusion that *for better communication and cooperation in terms of personal homepage construction, we should provide more technical support and help to researchers who are not familiar with basic network and programming technologies/knowledge.* The results shown in Figure 2 also support this point, showing that about 73.58% of respondents in MS could only use the computer to deal with basic applications and operations, such as writing papers with text processing software, and less than *16%* of them thought that their IT skill was excellent or good; while this ratio was up to *82.76%* for respondents in IS (44.83% + 37.93%). This is a significant practical difference that should be recognized by knowledge management researchers and practitioners.

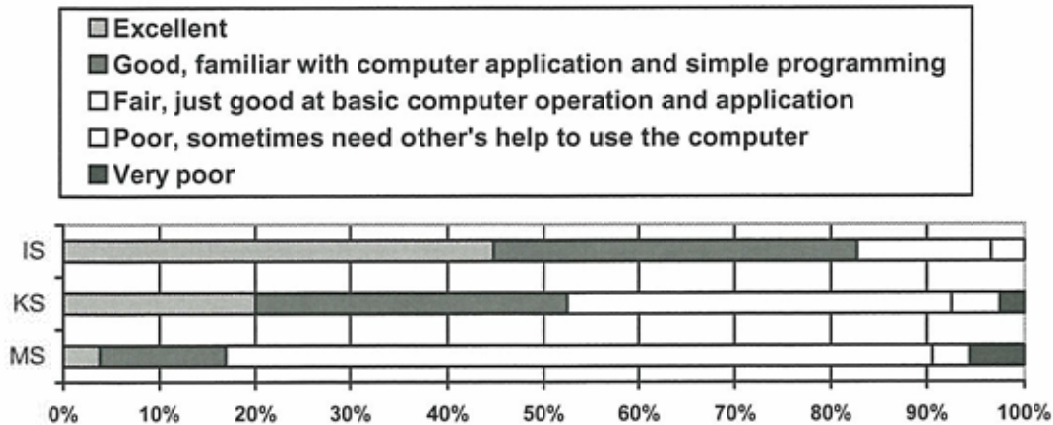Figure 1. Respondents' homepage construction

Figure 2. Respondents' IT skill

3.2 Laboratory Knowledge Management Environment

In this part, we focused on the laboratory environment for knowledge management, especially on the uses of technology to support knowledge management strategies, contributing factors for efficient laboratory management as well as for the satisfaction of the respondents.

First, the survey sought to establish the uses of technology to support a laboratory knowledge management strategy. The most notable aspect of technology use in laboratories, as reflected in the survey responses (see Figure 3) is the extensive use of text processing and presentation software, and of Internet and on-line information sources, databases, and search engines. On-line chatting software and document repositories were also widely used in the laboratories.

It should be noted that the totals described here were considered by respondents as individual responses to each item, that is, the totals were of 100% of respondents in each case. As shown in Figure 3, 97.55% of the respondents use text processing and presentation software extensively or to a certain extent (that is a natural result for researchers and students), 95.90% use Internet and on-line resources, 97.55% use search engines (such as Google) to look for documents and data, 63.12% use on-line chatting software (such as MSN Messenger and ICQ) for communication, and 51.64% use special document repositories or databases for their researches.

This compares with the fact that 52.46% of respondents had no plans to use or were not sure about using BBS or electronic bulletin boards in their laboratories; further, 63.93% had no plans to use data warehousing and data mining, 68.85% had no plans to use groupware such as IBM Lotus Notes, and 70.49% had no plans to use video conferencing, all technological tools which are often regarded as part of a decision support mechanism and facilitators of knowledge management in the business area[11]. Contrast the JAIST results to Zyngier's 2003 survey[11], which found that more than 70% companies of Australia used groupware or BBS, about 60% used

video conferencing, and more than 50% used data warehousing and data mining[11]. The role of technology in knowledge management represents a big difference between business and academia, and we will present our analysis later.
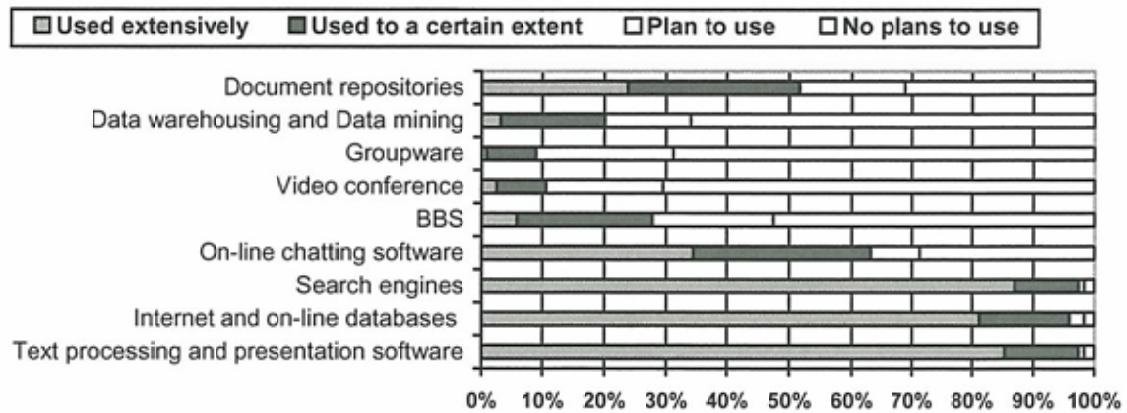

Figure 3. Technologies used in laboratories

When asked about their satisfaction on the factors related to laboratory management, only 56.56% of the respondents were satisfied (somewhat satisfied or very satisfied) with the device management of laboratory (experimental apparatus, computers and software management); while the satisfaction with the other items (document management, equipment usage training and lab homepage) was less then 50% for all and decreased in turn (see Figure 4). More precisely, if we focused on the lab homepages in the various schools (see Figure 5), we found that from MS to KS and then to IS, the complaints (very unsatisfied and somewhat unsatisfied) on the construction of lab homepages decreased largely and quickly. That is to say, homepage constructions are quite uneven among the schools. As we know, the laboratory homepage is not only a portal (or introduction) for outside researchers, but more importantly, is also a significant knowledge source or 'database' shared by all the members of that laboratory. The most desirable contents of the lab's homepage, according to the respondents in this survey, are introduction of all the members and their research interests, basic and background knowledge in the field, introduction of or links to leading groups, labs and well-known researchers in the field, introduction of or links to the major journals or conferences in the field, a BBS for discussing and communicating with other members, links to on-line databases or document repositories, recording and sharing experimental experiences and good ideas, and so on. Thus, in combination with the results shown in section 3.1, we found that not only do the IT skills of the researchers themselves limit efficient personal knowledge management to some extent, but also that *the unevenness of technical support as well as laboratory management among different schools should be seriously regarded and improved.*
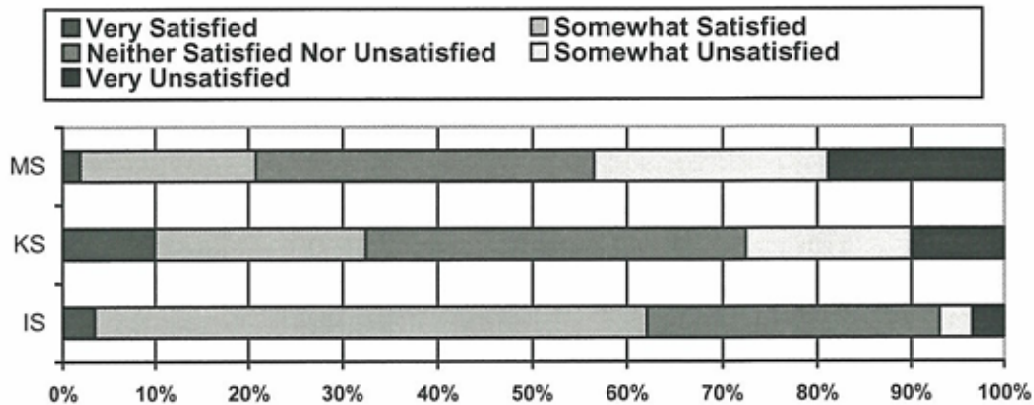
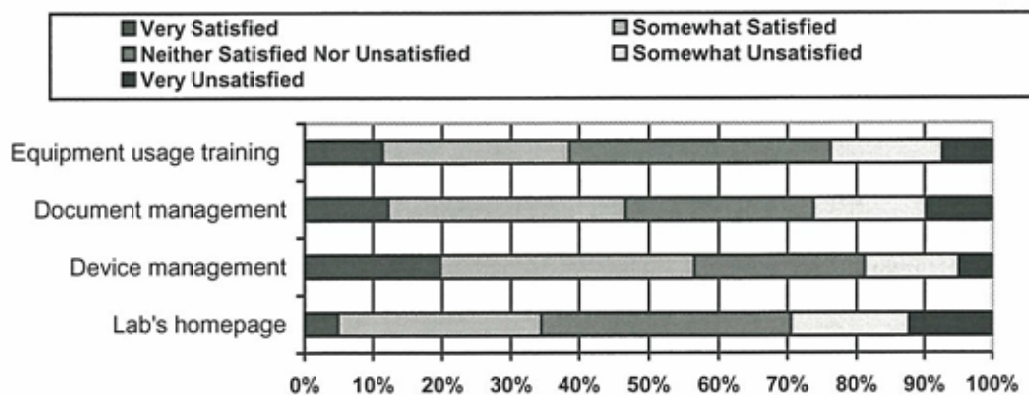Figure 4. Satisfaction with the factors of laboratory management

Figure 5. Satisfaction with lab's homepage

Moreover, when asked to evaluate the effect of regular laboratory seminars or group discussions, there was no big difference between native (Japanese) and foreign (non-Japanese) researchers as we expected (shown in Figure 6). But when asked about the reasons for their dissatisfaction, they gave different weights to the various reasons (see Figure 7).

As shown in Figure 7, 76.92% of foreign respondents thought that language was one of the important reasons for inefficient or meaningless seminars, compared with only 23.08% of Japanese respondents (notice this was a multiple choice question, and the totals given here were considered by respondents as individual responses to each reason/factor). A reason behind this phenomenon is that at JAIST only masters-level courses require foreign students to have good Japanese language ability, but for doctoral courses, English is enough. Thus, if a foreign PhD candidate who is not good at Japanese attends a seminar or group discussion, but the speaker can only speak Japanese (suppose the speaker is a Japanese masters student and not good at English), undoubtedly that seminar will be meaningless and quite tedious for him. Unfortunately, this case is quite common because of the labs' seminar regulations (60.7% respondents said they had regular meeting at least once a week) or for other reasons. In contrast to this case, another interesting phenomenon is that significantly more Japanese respondents than foreigners complained that the atmosphere of discussion were not open and free, the topics were not related to her/his interests

(there were various unrelated research topics in the lab), and/or there were some other reason for dissatisfaction.

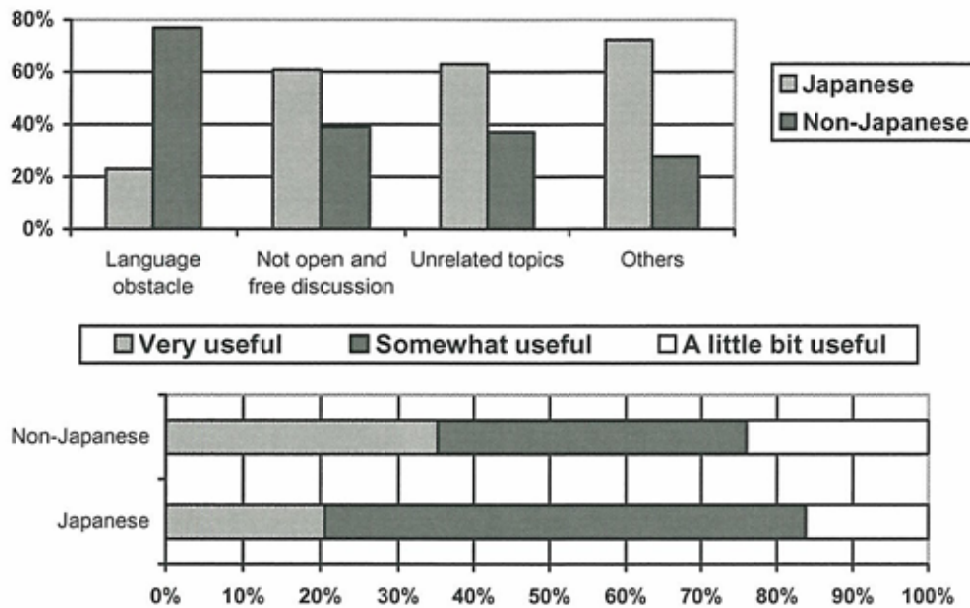Figure 6. Evaluation of seminar and group discussions

Figure 7. Obstructing factors to efficient seminar or group discussion

3.3 Self-Assessment of Research and Life

The survey sought to discover the importance of different knowledge sources to various research activities. According to Nakamori's *i-System* model, a knowledge creating system consists of five subsystems: intelligence, imagination, involvement, integration, and intervention subsystems from the viewpoints of science, creativity, human interactions, systemic knowledge, and issues and problems, respectively [12]. More precisely, scientific knowledge creation involves five major integrated research activities: confirming the research subject, acquiring the necessary knowledge and information for the research and experiments, understanding the social and practical significance of the research, finding new ideas, and finally writing papers. This is a spiral knowledge creation process in which explicit knowledge (or statistical data and an individual's fragmentary knowledge) is transformed into tacit knowledge, which is then converted into explicit knowledge (or new knowledge which can be shared by others); researchers (not including professors, as we defined in section 2.3) usually get support and help from four knowledge sources to finish this process: their supervisor or professor's guidance and advice, their colleagues' cooperation and help, self-study, and help from outside scholars. To clarify the relationship as well as the influences between the knowledge sources and the research activities, we designed a question that asked the respondents to rate the corresponding knowledge sources on the level of their importance to their research activities, using an integer number from 1 to 5, where 1 means unimportant, 3 means moderately important, and 5 means very important. By averaging the sums, we obtained the results shown in Figure 8.
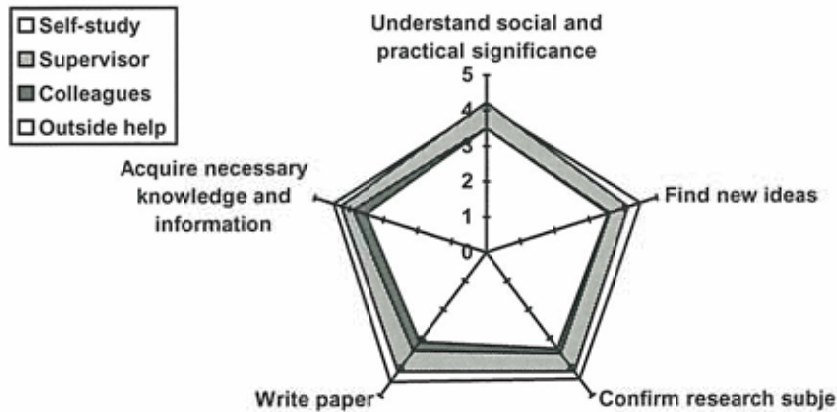
Figure 8. Importance of knowledge sources to different research activities

As can be seen in Figure 8, for all research activities except "understanding the social and practical significance of the research", the order of the importance of the knowledge sources is the same, that is, self study > supervisor > colleagues > outside help. This result is reasonable and clear, for in scientific knowledge creation, self study is the most important factor. It is interesting to note that respondents agreed that the contribution of their supervisor was more important than their colleagues' cooperation and help in terms of their research (the average value of the former is about 20% bigger than the latter). Thus, the survey reveals a significant difference between business and academia with respect to knowledge management and creation: *researchers in academia regard self study and the guidance of their leader (supervisor) as the most important factors, and put cooperation in a secondary place; while in business activities and projects, cooperation and team work is always regarded as one of the most fundamental factors for success because of the "cask theory"* (just as the cubage of a cask is dependent on the shortest lath, so business success is dependent on the endeavors of every participant; one person or department's neglect of duty will cause the whole project to fail).

A related result is that when asked whether the respondents joined one or several self-managed or appointed teams composed of individuals capable of learning from each other, 42.62% of the respondents selected "No, I almost always work alone". So, the problem is, do researchers really not need cooperation very much, or we should improve our management as well as people's cognition of cooperation to encourage team work? Compared with another question – "when you encounter problems and feel depressed, could you get encouragement from others", we found that the respondents who worked alone also got much less timely encouragement and help from others at the same time (see Figure 9). This result demonstrates the importance of cooperation and team work (except for those who have strong self-confidence and think they can solve every problem by themselves, but even then, they still need guidance from their supervisors, so, strictly speaking, they do not work alone). As we know, timely outside encouragement and help is a very important factor in study, it

can affect a person's mood and moral, and have a further impact on their study efficiency, performance, and achievement. Thus, from this point of view, we can not say that cooperation is a trivial factor in scientific knowledge management and creation, but rather that is a weak point that should be reinforced and improved.
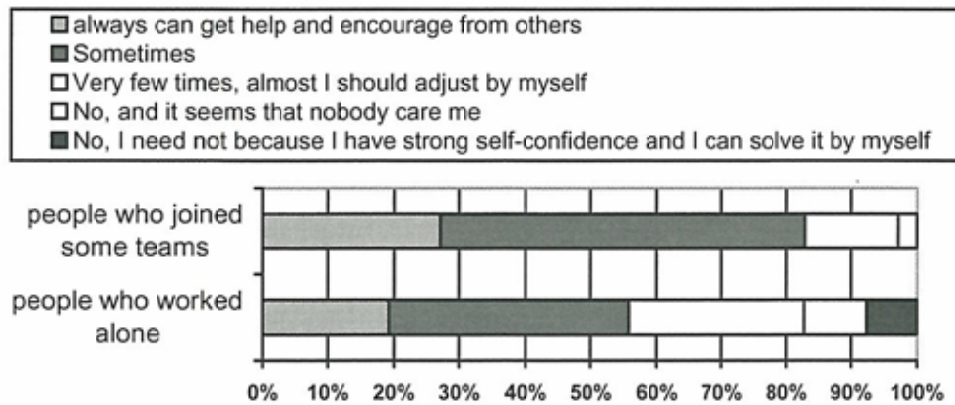

Figure 9. Encouragement and help from others when encountering problems or feeling depressed

When asked about the most difficult problem in their research according to the definitions of research activities in Figure 8 (with the addition of one more factor, "do experiments", which is a vital research activity for those in the hard sciences), 29.55% of the masters students respondents thought that acquiring necessary knowledge and information was their biggest problem (see Figure 10), which was also true for post doctors (about 33.33% of them). With respect to PhD candidates, 50% selected how to find new ideas in their research subjects. The results for research associates seem even for each factor, but this group had less difficulty in writing papers (9.09%) and no difficulty at all in doing experiments (0%). This provides a valuable and instructive insight or "picture" for professors as well as the managers of research institutes, helping them have a definite object in mind when teaching and managing different students.

When asked about their satisfaction with leisure life in JAIST, only 33.82% of the Japanese respondents said that their leisure lives were rich and colorful (very satisfied or satisfied), while up to 41.17% of them complained that their life consisted of only dormitory and laboratory or that they had few friends and felt lonely (unsatisfied or very unsatisfied). At the same time, the situation of foreigners is better (see Figure 11). One possible reason for this is that JAIST organizes more leisure activities for foreigners. But, total satisfaction is under 40%, which should be of concern to the managers and administration staff, since lower morale can result in lower efficiency in research. We investigated this problem in order to remind both knowledge management researchers and the managers of research organizations to pay attention to this factor, which is seldom mentioned in the existing literature. We found another cross-tabulated result supporting this point to some extent, that is, when asked about their satisfaction with the current situation and progress of their research, up to 44% of the respondents who answered unsatisfied or very unsatisfied complained about

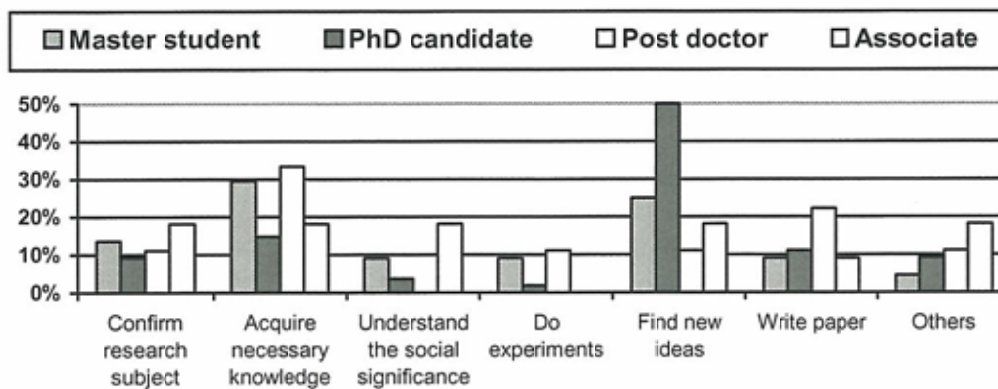their leisure lives (unsatisfied or very unsatisfied) at the same time.

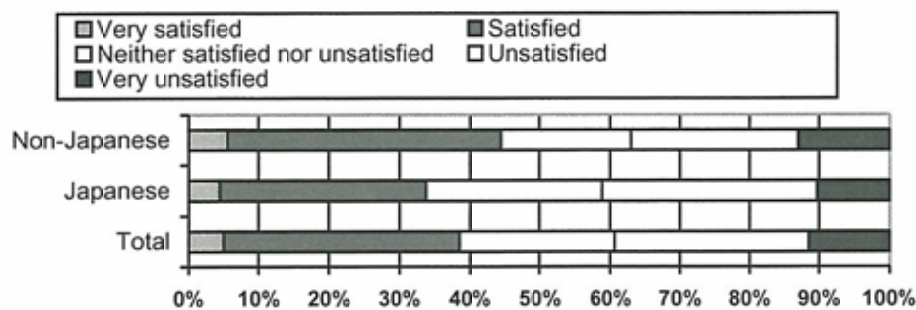

Figure 10. The most difficult problem in research

Figure 11. Satisfaction with leisure life in JAIST

3.4 Respondents' Attitudes towards Knowledge Management

In this part, we listed some statements which describe various knowledge management issues, so as to know what would motivate the students and researchers to join in LKM practices.

The large majority (74.6%) of the respondents believed (strongly agree and agree) that successful LKM can largely encourage every member to contribute and share experiences and ideas. The same percent of respondents (74.6%) hoped to develop a "LKMS" to capture and circulate special skills and knowledge both inside and outside of the lab. Figure 4 showed us that 65.58% of the respondents were not satisfied with the management of their lab's homepage (very unsatisfied, somewhat unsatisfied, or neither satisfied nor unsatisfied), and 76.25% of them strongly hope to develop a "LKMS". This demonstrates that researchers need an IT-supported "knowledge portal" (Wang Zhongtuo and Pan Donghua, 2002) for connecting to available information sources and knowledge sources, not only inside but also outside the lab.

But this is not to say that researchers considered information technology to be more important in successful LKM compared with administrative and managerial measures: only about half of the respondents (49.2%) agreed or strongly agreed with this point (see Figure 12). Compared with the contradictary statement, that it would be possible,

through more effective managerial measures (not the technology) to capture and circulate knowledge both inside and outside of lab, many more respondents (73.8% of the total) expressed their strong agreement or agreement (see Figure 12). It is interesting that very few respondents expressed their disagreement (disagree or strongly disagree) to either of these two statements. We do not, however, consider this a 'specious contradiction' because of the large number of respondents (45.08% of the total) who did not express a clear opinion (neither agree nor disagree) on the first statement. To our understanding, it just demonstrates the conclusion again from another aspect, that *technology plays an important role in LKM, but it is not the unique and most important factor*, in other words, *increasing the management and use of tacit knowledge is more important than explicit knowledge*.
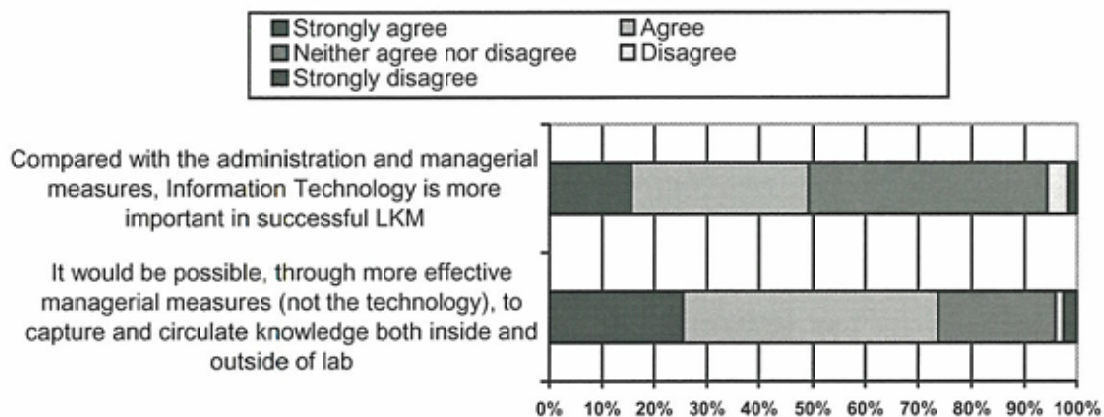

Figure 12. Attitudes on technology and managerial measures in LKM

4. DISCUSSION AND ANALYSIS OF RESULTS

The image as defined by the respondents shows both positive and negative characteristics. On the positive side, there was a high awareness of knowledge issues, knowledge resources, knowledge tools and the concept of knowledge management, along with the respondents' strong desire to develop a knowledge management system or LKMS. Some results were negative, in that they showed that there were still some serious obstacles and hidden problems preventing efficient knowledge management and personal research.

The survey evidence reveals that there is a great disparity in personal IT skills among the various sciences or schools, along with an unevenness of technical support for laboratory knowledge management among different schools (see Figure 1, Figure 2 and Figure 5). This is not to say that there are no or fewer people in charge of maintaining the laboratory homepage in MS (the school with weakest average personal IT skill and technical support). When asked about management of the homepage, 83.02% of the MS respondents said that there were people appointed to maintain and update it, which was quite similar to the responses from KS (90%) and IS (89.66%). Thus, the disparity results from the IT skills and responsibilities of the maintainers per se. This unevenness should be seriously considered and corrected

since it can largely impede explicit knowledge management for the researchers, especially those who are not familiar with computer science and technology. From the point of view of developing and implementing a knowledge management system, we think the most practicable and effective way is to focus first on the requirements of non-computer science background researchers, smoothing the unevenness and accumulating experiences, and then try to extend it across the board in the organization.

With respect to the definition or functionality of a knowledge management system (KMS), or more specifically, a laboratory knowledge management system (LKMS) in our case, we think that an integrated knowledge portal or platform connecting to all kinds of information and knowledge sources is most desirable; it must be user-friendly as well as easy to operate, so that every participator can record and maintain her/his own data and experiences (best practices) to be shared by others (since it is impossible to ask everyone to develop and maintain their homepage or data by themselves, see Figure 2). According to *i*-System methodology [12], if we hope to solve problems (*Intervention*), usually we can get required knowledge from the important knowledge sources -- scientific, social and creative dimensions by mobilizing our capabilities of intelligence, involvement and imagination. And then we construct the new knowledge or systemic knowledge (*Integration*) from above three fronts. It inspires us to design the architecture of LKMS and develop functional subsystems to integrate knowledge based on *i*-System theory. The architecture of LKMS is shown in Fig. 13. Considered the requirements of respondents and feature of research activities, the flowing contents of various functional subsystems should be provided and integrated into the system as a whole seamless platform:

1. *Scientific knowledge repository subsystem* (Scientific Dimension), storing and linking the theoretical and practical knowledge for the research concerned. For instance,
   - Basic and background knowledge in the field;
   - Skill knowledge, e.g. how to do research; how to write paper; how to use apparatus and so on.
   - Laboratory information, including introduction of all members, their research interests, publication list and laboratory schedule, seminar and so on.
   - Introduction and links to the leading groups, labs and famous researchers in the field;
   - Introduction and links to the major journals and research organizations in the field;
   - Links to literatures database, etc.
2. *Social information subsystem* (Social Dimension), offering the information from professional database, periodicals, and relevant web site, even newspapers so that researchers can look for the collaborations and easily search the information they need. For instance,
   - Information and knowledge about government industry policy;

- Industry database built by agencies;
- Patent database, etc.

3. *Communication subsystem* (Social Dimension), for the exchange of knowledge and ideas between the members of lab as well as outside researchers through e-mail, Bulletin Boards System (BBS), video conference, and etc.

4. *Personalization subsystem* (Creative Dimension), providing individual module for researchers to manage their personal research.
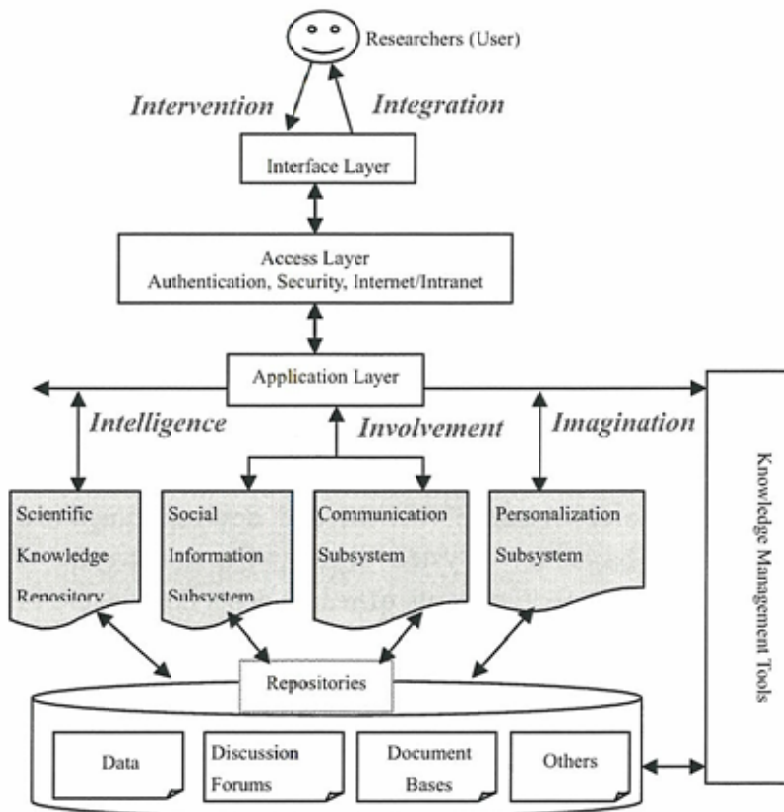

Figure 13. The architecture of LKMS.

Another discrepancy exposed in this survey is that while some important knowledge management technologies and software, such as groupware and video conferencing are very popular and play a important role in the business area [11], they still are not popular or accepted by the researchers at JAIST (see Figure 3). To our understanding, one important reason for this lies in the characteristics of scientific knowledge management and creation, in which people put more emphasis on self study and their supervisor's guidance than on cooperation (see Figure 8). As we discussed in section 3.3, cooperation is a weak point that should be further reinforced and improved with regard to scientific knowledge management and creation (see Figure 9 together with Figure 8); but we are not predicting that groupware or other business collaboration software will occupy a big market and become popular soon in JAIST. The most urgent problem is to smooth the unevenness discussed above, while the function of cooperation can be replaced and implemented by existing simple technologies and software, such as email and on-line chatting software (see Figure 3) at present.

A crucial hidden problem discovered in the survey is that the importance of cooperation and team work is not emphasized enough at JAIST, and nearly half of the respondents work virtually alone. As mentioned in section 3.3 (Figure 8), we realize that because of the characteristics of scientific research, cooperation is less important compared with self study and supervisor's guidance, especially for graduate students and higher researchers (PhD candidates, post doctors and research associates), whose research subject is very deep and 'narrow', and usually difficult for others to understand (see Figure 7). On the other hand, we do not think that the big variance in importance between the supervisor's guidance and cooperation is reasonable and acceptable (see Figure 8). On the contrary, professors and laboratory administrators should seriously consider how to encourage and reinforce collaboration in academia, such as organizing some small study groups composed of individuals capable of learning from each other. As far as we know, this property has not been found in the theoretical literature to date, and we consider it an urgent and promising issue both for theoretical and practical research with respect to knowledge management in academia. A related recent survey on team building in the Australian Defence Organisation (Leoni and Irena, 2003) can be used as a reference on this point.

An interesting fact found in this survey is that compared with foreigners, Japanese respondents are more prone to complain about their leisure life (see Figure 11) and a constrained seminar discussion atmosphere (see Figure 6 and Figure 7). This seems contrary to our common sense; we would expect foreign respondents to be more nervous because of the new and unfamiliar environment. There are many possible reasons for this situation, and there may even be distortion in our results, since the response rate is not very high. But at any rate, we believe that the common characteristics of Japanese culture may help explain this fact. As we know, the common impression of the Japanese is that they are well mannered, soft-spoken, and hard-working while maintaining a strict ranking concept in their minds. From this point of view, it is easy to see why very few Japanese respondents might think that seminars are open and free, especially when the speaker is an elder member and their professor is present wearing a serious expression. Moreover, the advantages of good manners and a hard-working attitude may sometimes leave less time and initiative for communication; this can be explained as one of the reasons for the complaints about leisure life. A discussion of national characteristics is beyond the scope of this paper; our object here is simply to point out this problem and bring it to the attention of the professors as well as the administration staff. In contrast, we suggest that it is not necessary to ask foreigners who are not good at Japanese to attend the seminars conducted in that language, since it is obviously tedious and useless for them (also see Figure 7). Considering the actual effect is more important than maintaining a façade of good manners, so from this point of view, we think that some laboratories' regulations on seminars and discussions could be improved. Dividing the members of the lab into different groups for discussion may be better and more efficient.

5. CONCLUSTIONS

This study focused on a special group of respondents consisting of graduate students and researchers (masters students, PhD candidates, post doctors, and associates), called the knowledge creators of the Japan Advanced Institute of Science and Technology. It has identified a number of complex and interwoven contributing factors and inhibitors to scientific knowledge management and creation in academia. Some important findings as well as the conclusions discovered by this survey are as follows.

- There is a serious disparity in the technical supports and average personal IT skill between the different schools at JAIST, which largely hinders efficient and effective knowledge management and sharing among some researchers.
- There is no systemic KM framework for the scientific research in the lab. In this case knowledge is highly fragmented and inefficient to access what, when and where needed.
- Scientific cooperation and dispute have not been recognized or emphasized enough in JAIST; encouraging and reinforcing it should be considered more seriously and studied further in the future.
- The most difficult research problem varies with respect to respondents of different status, such as masters students and PhD candidates; this fact should be taken into account by the professors and managers.
- Some varying requirements and obstacles between foreign researchers and Japanese have also been exposed.

At the same time, this study will enable and contribute further research in other possible directions.

- It will allow comparison with studies at other educational organizations on the understanding of knowledge management in academia, especially on the crucial topic of scientific knowledge management and creation.
- It will contribute a solid basis for our COE program, providing a comprehensive understanding and insight in the current status and problems of knowledge management in JAIST.
- It will allow possible comparison and research of the knowledge management technologies used between business field and academia, along with some useful instructions and guidelines for developing knowledge management systems and laboratory knowledge management systems for academic organizations.
- It will allow review of current academic teaching and research practices in this area.

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