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Investigation of Knowledge Management Environments in Academia

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Abstract

This paper reports an investigation of knowledge management environments using a checklist on research capabilities and research environments. The check list was developed based on a knowledge management model called the Trefoil Model which was developed at Japan advanced Institute of Science and Technology. After describing this model the paper introduces a questionnaire survey result on the research capabilities and environments of the graduate students in the research fields of material science.

Keywords: Knowledge management models, technology creation environments, evaluation.

1. Introduction

It is expected recently that knowledge science should help researchers produce creative theoretical results in important natural sciences. For this purpose, we have to establish a Ba (a Japanese term meaning: place, center, environment, space, etc.) or an environment or circumstance, which supports the development and practice of scientific knowledge creation. What we mean here by Ba? Is not a physical space, but rather the entire system which makes mastery and embodiment of knowledge possible, including factors like time, place and context [1] [2]. Toyama and Nonaka [3] defined a knowledge creation Ba, as a dynamic context which is shared and redefined in the knowledge creation process?

This paper reviews two knowledge creation models for academia: the *i-System* [4] [5][6] and the Triple Helix Model [7][8][9], and proposes the Trefoil Model for evaluating knowledge creation environments in academia. Based on this model a checklist was developed for investigation of the growth of graduate students and the investigation of research environments including infrastructure and guidance. We have carried out a questionnaire survey on the research capabilities of the graduate students and environments in the research fields of material science at Japan advanced Institute of Science and Technology.

2. Knowledge Creation Models

Nonaka and Takeuchi [1] developed an organizational knowledge creation model called the SECI Spiral with an international publication: The Knowledge Creating Company. This model is revolutionary because it stresses steps leading to knowledge increase surely, based on the collaboration of a group in knowledge creation and on the rational use of irrational mind capabilities, namely tacit knowledge, which consists of emotions and intuition. The SECI Spiral results from four consecutive transitions between four nodes on two axes. One is called the epistemological dimension, counter posing tacit epistemological dimension, counter posing tacit and explicit knowledge; the other is originally called the ontological dimension which counter poses individual and group.

Almost at the same time, another more basic theory of knowledge creation came directly from philosophy. Motycka [11] in Poland proposed another theory: that of basic knowledge creation in times of a crisis preceding a scientific revolution. This is actually a historical macro-theory of knowledge creation, but it can as well be interpreted and used as a micro-theory. Motycka also used the irrational abilities of the human mind – mostly instincts and myths, namely the concept of collective unconscious, and also intuition. She postulates that, in times of a crisis of a basic science, scientists use a regression to myths and instincts in order to stimulate novel approaches to their field of science.

A few years after the international publication of the Knowledge Creating Company, several approaches directly stimulated by this book were also published. We shall mention here only one of them: Gasson[12], who observed that in order to mobilize the distributed individual knowledge of employees, a western company would use a process very much resembling the SECI Spiral but moving in just opposite direction; the model is called the OPEC Spiral: Objectives – Process – Expansion – Closure.

An important contribution to the field of brainstorming comes from Kunifuji [13], whose laboratory at JAIST specializes in brain-storming group support software. Kunifuji rightly argues that a creative process involving brainstorming should include at least four phases, which we can identify with following transitions: Divergence-Convergence – Crystallization – Verification and represent as a Brainstorming DCCV Spiral.

3. The *i*-System

The knowledge creation model called th*e i-System* is comprised of five subsystems [4][5][6]:

Intervention: Taking action on a problem situation, which has not been dealt with before. First we ask: what kind of knowledge is necessary to solve the new problem? Then the following three subsystems are called on to collect that knowledge.

Intelligence: Raises our capability to understand and learn things. The necessary data and information are collected, scientifically analyzed, and then a model is built to achieve simulation and optimization.

Imagination: Creating our own ideas on new or existing things. Complex phenomena are simulated based on partial information, by exploiting information technology.

Involvement: Raising the interest and passion of ourselves and other people. Sponsoring conferences and gathering people's opinions using techniques like interview surveys.

Integration: Integrating heterogeneous types of knowledge so that they are tightly related. Validating the reliability and correctness of the output from the above three subsystems.

Th*e i-System* can be called a knowledge creating system. The system integrates statistical data and individual persons? Fragmentary knowledge, and then creates new knowledge nobody had before. Such knowledge must be tacit, otherwise someone including the system had it; this is a contradiction. Therefore, the system should have a process to convert tacit knowledge into explicit knowledge. This means that the members of the project or relevant people constitute a part of the system.

Th*e i-System* can be used for constructing roadmaps.

Intervention can be understood as a motivational dimension, a drive, or determination, or even dedication to solving a problem. Starting a road-mapping process can be thus thought as an intervention for issues motivating strategic plans. In this dimension, firstly, initiators of the road-mapping process should have a deep road-mapping process should have a deep understanding what is the motivation for making the particular roadmap. Secondly, they should also know what roadmaps and road-mapping are, what advantages road-mapping has, and how to do road-mapping. Thirdly, initiators or coordinators must also consider who should participate in the road-mapping them and motivate them to join, customize a road-mapping process and schedule, and let all participants know the purpose and schedule and their roles in road-mapping.

Intelligence has to aspects: rational, explicit and intuitive, tacit. It is a duty of the coordinator and of all participants of a road-mapping process to search for relevant explicit information. In this task, the following methods of support could be helpful:

- *Scientific databases:* the access either to disciplinary or to general scientific databases such as Scopus, Science Direct, etc., can be very helpful for researchers to understand what has been done, that is being done, and what should be done.
- *Text mining tools:* the amount of scientific literature increases very fast, thus help in finding relevant explicit information is necessary.
- *Workshops:* in which menu experts are involved. Here some selected groupware, such as Pathmaker, could be applied to structure and manage discussions among experts.

In fact, the third method involves already some elements of intuitive or tacit knowledge of experts. But and important aspect of good intelligence is individual reflection on and interpretation of explicit information previously obtained.

Involvement is a dimension, related to two aspects: societal motivation and consensus building in the group is a consensus building process. This process might include many researchers, experts, and other stakeholders. There are following important aspects in this dimension.

- *Participation of administrative authorities and coordinators:* if administrative authorities are involved in the coordination of the road-mapping process, then this helps it to proceed smoothly.
- *Customized solutions:* preparing a template of a solution for the road-mapping process also helps it to proceed smoothly. There are many existing solutions that might serve as templates, such as T-plan [14], disruptive technology roadmaps [15], interactive planning solutions for personal research roadmaps [16], etc.
- *Internet-based groupware:* the use of internet-based groupware can contribute to involvement.

Imagination is needed during entire road-mapping process; it should help to create vision. Participants are encouraged to imagine the purposeful future where should we go and the means how to get there.

- *Graphical presentation tools:* Graphical presentation tools can help people to express and refine their imagination.
- *Simulations:* Simulations can enhance and stimulate imagination, especially concerning complex dynamic processes.
- *Critical debate:* this is probably the most fundamental way of promoting imagination.
- *Brainstorming:* Brainstorming is, in a sense, a counterpart of critical debate; it encourages people to generate and express diverse, even fantastic ideas, and is directly related to imagination.
- *Idealized design:* Idealized design is a unique and essential feature of interactive Planning approach [17][18][19] which is regarded as a basic method for solving creative problems.

Integration must be applied several times during road-mapping, at least when making a first-cut, refined, and the final version of roadmap. Integration includes all knowledge of the other four dimensions, thus is interdisciplinary and systemic. Diverse rational systemic approaches, such as analytical hierarchy Process (AHP) and meta-synthesis approach, see Gu and Tang [20], might be helpful. However, in order to be creative and visionary, integration cannot rely only on rational, explicit knowledge, must rely on preverbal, intuitive and emotional knowledge. Therefore, software with a heuristic interface and graphical representation tools are essential for help in this dimension. For example, the number of nodes and links in a roadmap might be large, difficult to master by an unaided human brain. A properly chosen perspective of graphical representation of the roadmap might be thus essential. In order to choose such perspective, a heuristic interface can be applied to infer the preferred features of graphical roadmaps.

4. The Triple Helix Model

The Triple Helix of a theory that normal process of knowledge creation at academic institutions (universities and academic research institutions) uses mostly three interrelated spirals of knowledge creation [7][8][9]. These three spirals are described shortly below.

The Hermeneutic EAIR Spiral of searching through rational heritage of humanity, interpreting it and reflecting on the object of student. This is the most fundamental and individual spiral that we illustrate on the example of research leading to a master of doctoral degree. After the suggestion of a topic given by the supervisor of a student, the student must check what was written on this topic in books, journals, etc., interpret what she/he has read, reflect on this material and try to generate further ideas.

The Experimental EEIS Spiral of verification and objectification of ideas through experiments. This is the basic objectifying spiral, necessary for hard sciences and technology: without testing experimentally, we cannot judge the validity of a theory in hard science, and we cannot evaluate the usefulness of tools created by technology. However, experimentation should be understood here even more broadly, including experiments used by some soft or social sciences when applying such tools as a questionnaire.

The Intersubjective EDIS Spiral of debating on ideas obtained from other spirals or through any other source of Enlightenment. This form of Intersubjective or group verification of ideas is fundamental for all sciences and technologies, with some specific distinctions. Humanities and soft sciences consider this as the fundamental form of interpersonal validation of ideas; part of them goes as far – in so called postmodern sociology of science – as to question the concept of objectivity, implying that objectivity is in fact only intersubjectivity. Hard science and technology use also interpersonal validation; they consider that objectivity (related to the experimental spiral) is necessary for the success of hard sciences and especially technology.

5. The Trefoil Model

This paper combines the ideas in th*e i-System* and the Triple Helix Model, and proposes a model named the Trefoil Model to evaluate knowledge creation environments as shown in Fig.1, and the following list of evaluation of scientific labs.

List 1: On Growth of Students

A1: Are you satisfied with your abilities of research planning and explaining your research activities rationally?

A2: Do you thing that your investigation of the disciplinary status and perspective related to your research plan is sufficient and gives satisfactory result?

A3: When you have a research result or research idea, is it easy for you to explain its disciplinary importance (validity, uniqueness, etc.)? Or do you have confidence and intuition to explain this importance?

A4: Do you think that your investigation of the social importance of your research theme(social contribution, ripple effect, etc.) is sufficient and gives satisfactory results?

A5: When you have a research result or research idea, is it easy for you to explain its social importance? Or do you have confidence and intuition to explain this importance?

A6: Do you think that your abilities in carrying out experiments(or investigation, data analysis, etc.) are sufficient and give satisfactory results?

A7: When you have experimental results or data, is it easy for you to interpret them, derive conclusions, explain their importance? Or do you have confidence and intuition to interpret them and explain their importance?

A8: When you have a new research result, is it easy to understand its overall (disciplinary, social, experimental) importance and its implications for further, new research? Or do you have confidence and intuition to discover new research themes, to design new experiments, formulate new ideas?

For each question, the subject is asked to answer her/ his satisfaction level and importance level for her/his research life.

Unsatisfied 1 2 3 4 5 Satisfied

Unimportant 1 2 3 4 5 Important

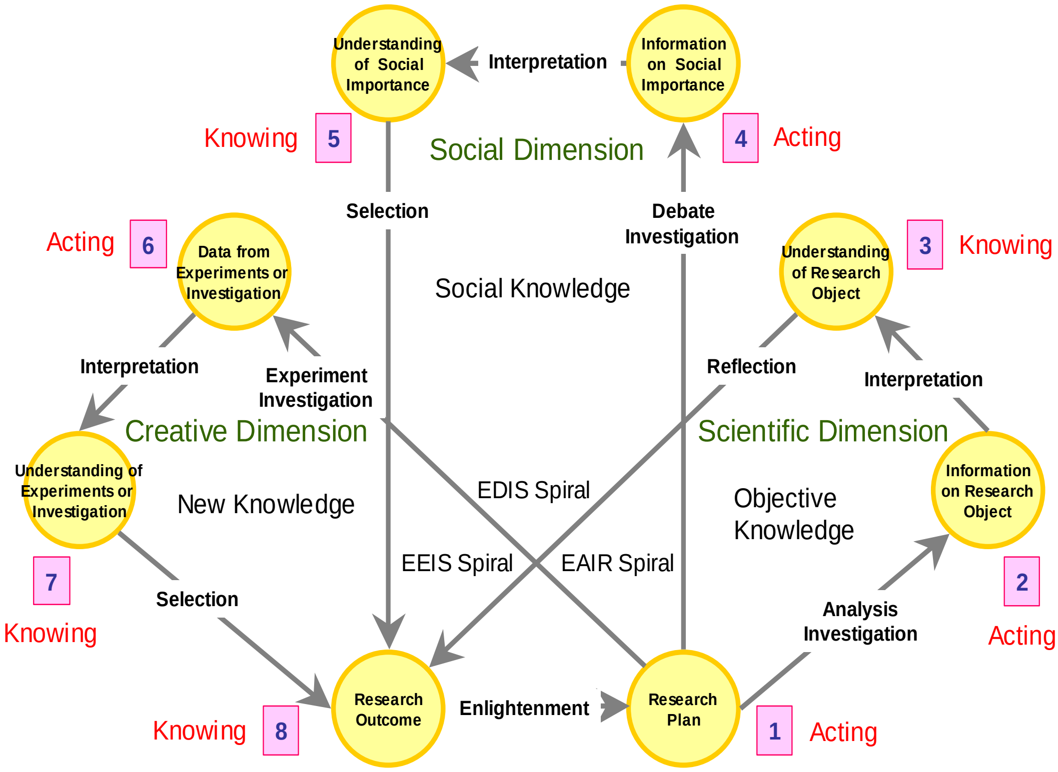

Fig.1. An Evaluation Model for Knowledge Creation Environments in Academia.

List 2: On Research Environments

B1: When preparing a research plan, do you receive sufficient guidance from your supervisors or seniors?

B2: Is the availability of written research materials for your research theme (books, papers, research results of your supervisors and seniors, both on papers and in electronic forms) food and satisfactory in your lab and at the university?

B3: Are discussions and guidance related to the disciplinary status of your research good and satisfactory in your lab?

B4: Is the information related to the social importance of your research good and satisfactory in your lab and at the university?

B5: Are discussions and guidance related to the social importance of your research good and satisfactory in your lab?

B6: Is the equipment and funds for carrying out experiments (investigation, data analysis, etc.) good and satisfactory in your lab?

B7: Are discussions and guidance related to experiments (investigation, data analysis, etc.) and their results good and satisfactory in your lab?

B8: Are discussions and guidance related to summing up your research and designing new research themes good and satisfactory in your lab?

For each question, the subject is asked to answer sufficient level and necessity level of her/his research environment:

Insufficient 1 2 3 4 5 Sufficient
Unnecessary 1 2 3 4 5 Necessary

6. Survey

We have carried out a survey for seven supervisors who manage the laboratories and educate their graduate students in the school of material science at Japan Advanced Institute of Science and Technology.

We asked supervisors to evaluate the importance of such activity and the necessity of such environment for their researches to graduate students in their laboratories.

Figure 2 shows results of the average from the supervisors. Here items of A1-A8 mean importance of their activities and B1-B8 mean necessary of their environments.

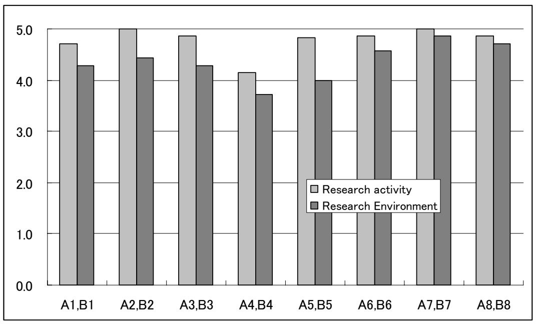

Fig.2 Evaluation of the supervisors: the importance of students activity, A and the necessity of students environment, B.

From Fig.2 the value of A2 and A7 are very high, which mean supervisors think information on research object and understanding of experiments of investigation are very important to graduate students for their researches.

On the other hand, the correlations between A4 and B4 are relatively low. It means that supervisors think the information on social importance and supporting this environment are not important for student activity, relatively.

And we have carried out a survey for doctoral students. The number of them who answer the question is 25.

Figure 3 shows the results of the average from the students. Here, each value of the environment B2, B3, B5 and B7 is higher than each activity. But in Fig.2 by supervisors, the value of the environments is lower than the activities. They may think the environment is more important for research activities.

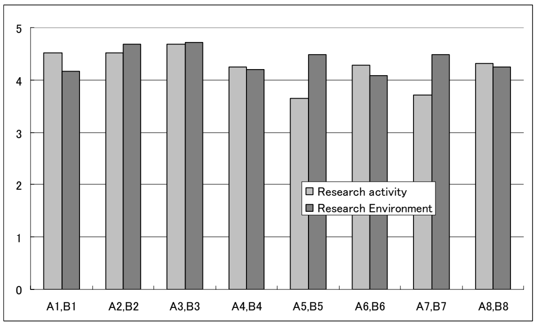

Fig.3 Evaluation of the doctoral students: the importance of students activity, A and the necessity of students environment, B.

In Fig.2 and Fig.3 the difference is found in the items related to activity A5, A7. It means students think the understanding of social importance and understanding of experiments or investigation are not so important than supervisor thinking. These items may be education points for supervisors to graduate students.

On the other hand, we have carried out a survey for the public research laboratories on material science fields in Japan. The number of research leaders who answered the questionnaires is 21.

Figure 4 shows the results of the average from research leaders.

Here we can see the research leaders think almost activities are important.

From Fig.4 the value of A6 A7 and A8 are high. It means the data from experiments or investigation and understanding of experiments or investigation and research outcome are important for their researches.

But, the value of A4 and A5 are relatively low. It means information on social importance and understanding of social importance are not important relatively. And it is similar to evaluation in Academia

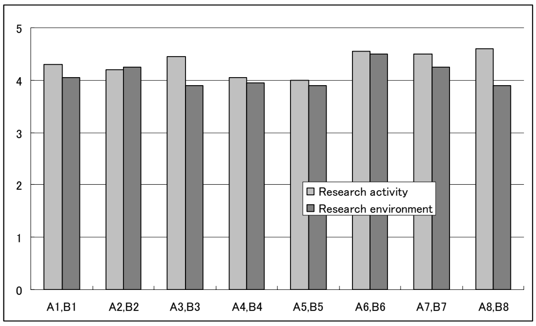

Fig.4 Evaluation of the supervisors: the importance of students activity, A and the necessity of students environment, B.

.7. Conclusion

This paper proposed an evaluation morel on knowledge creation environments in academia and a checklist of evaluating the capabilities of students and research environments, and introduced an actual questionnaire survey on the research capabilities and environments of the graduate students in the research fields of material science.

From the survey we found that the support to understand the social importance of research and to understand the result is weak in this material science fields. Generally, students require more help in doing research in almost all aspects.

Future work should include: to carry out survey for other fields of students and compare these data to understand how different in knowledge management in different fields.

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