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Researcher Column :

Studying Innovation for Cross-Disciplinary Projects

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Our Ongoing COE Program (**Technology Creation Based on Knowledge Science**) consists of the following four initiatives as sub-programs:

Sub-Program-1: Establishing Knowledge Science, and Tools for Its Application.

Sub-Program-2: Studying Innovation for Cross-Disciplinary Projects.

Sub-Program-3: Educating Innovative Knowledge Coordinators and Knowledge Creators.

Sub-Program-4: Forming "Center of Excellence" Organization with Its Infrastructure.

The idea that innovation is the key to revitalizing competitiveness has become a topical and widely accepted argument. And the sources of the competitiveness of a country, university, or company are advanced science and technology, for which this institute is named. This article explains Sub-Program-2, Studying Innovation for Cross-Disciplinary Projects.

The COE program is Japanese government-funded program to develop a competitive academic environment among Japanese universities, to elevate them to the world's highest echelons.

1. Design of the "Studying Innovation for Cross-Disciplinary Projects"

Sub-Program-2 aims to provide knowledge tools from the School of Knowledge Science and apply such tools to research work in laboratories of the School of Materials Science, to produce more creative and innovative research systems and findings[1]. This Sub-Program-2 consists of the following five projects as listed in Table-1, with 2～3 faculty members(professors, associate professors and researchers) and 2～3 students (Masters and PhD level students) per project.

2. Principle of Innovation [2]

The essence of innovation is the problem of mapping between a function space and an attribute space, as shown in Fig-1. Knowledge tools serve as seeds and as attributes. At the same time, the functions of research (labs) that require innovative improvement correspond to needs, located in the function space. The most successful project teams will be those that are able to discover the most important needs of labs and then quickly provide the labs with knowledge tools that have the attributes to fulfill these functions.

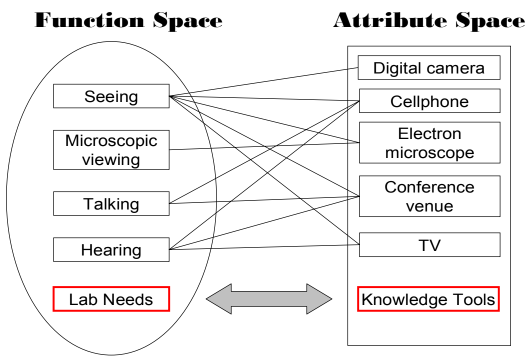

Fig-1 Principle of Innovation

Table-1 Projects in Sub-Program-2

No.	Project title
2A	Innovation for Polyolefin Chemical Industry as Mature Industry
2B	Scientific Research Philosophy
2C	Knowledge Representation Theory for Coordinators
2D	Laboratory Management Based on Cultural Anthropology
2E	Experimental Laboratory Management, using Mobile Blog Albums

3. How These Projects Have Proceeded;

3-1) Initially, when team members from the knowledge science side participated in the seminars of the materials science laboratories and took notes in the labs, this in itself caused a certain amount of suspicion and caution and an exclusionary reaction. As the projects were carried out, continuous efforts were made to reduce this sense of opposition. The projects started with proposals that the knowledge science side provided as knowledge tools.

3-2) However, whether or not cross-disciplinary research proceeds effectively towards its goal depends on whether there is a suitable match between the knowledge tools (seeds) and the needs of a laboratory, which leads to synergy. Success in such research depends on whether or not the final decisions are made on the function space side.

3-3) Ikujiro Nonaka, the first dean of the School of Knowledge Science at JAIST, has developed the SECI model describing the process of knowledge creation in Japanese companies. In his model, there are four modes of knowledge conversion. They are (1) socialization, (2) externalization, (3) combination, (4) internalization. Knowledge created through each of the four modes of knowledge conversion interacts in the spiral of knowledge creation in quadrant [3]. Making use of the SECI model, the current author delivered a presentation [4], which showed higher proportions of socialization and internalization in Japanese companies, when compared with Western companies, but lower proportions of externalization and combination, as illustrated in Fig-2.

“Ba”of Japanese Corporate Culture

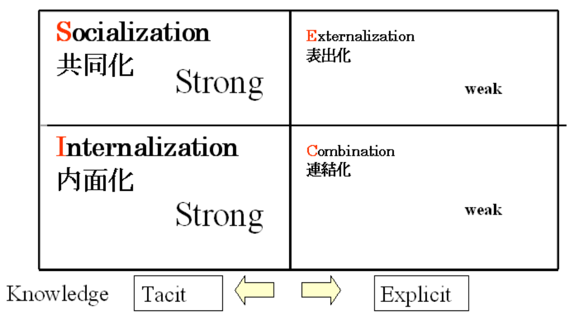

Fig-2 Features of Japanese Corporate Culture In the SECI Model

3-4) For Cross-disciplinary Projects, it is essential to have place and time (*ba*) for a certain duration for meetings that promote mutual respect and understanding between people from diverse disciplines. This intersecting place and time (*ba*) is required to make progress from step 3-1 to 3-2 above, which corresponds to socialization zone, in the SECI model.

3-5) To be successful at the intersecting place and time (*ba*), it is very important for all participants to have enough cross-cultural sensitivity to understand each other, in order to integrate diverse disciplines. Milton J. Bennett [5] has analyzed this cross-disciplinary sensitivity as six levels, as shown in Fig-4 below. The key participants should hopefully develop this sensitivity to the “integration” or “adaptation” level.

3-6) Fig-5 shows the process routes in the SECI model of our five cross-disciplinary projects until integration, where 2A～2E show their title No. listed in Table-1., In Fig-5, 2A-2 and 2D have started by providing knowledge tools to be applied in laboratory management in the SECI model, until needs would be fulfilled, while 2B, 2C-2 and 2E have started to identify the needs in the laboratory first, proceeding to the next step to find suitable knowledge tools, and then returning to laboratory management for fulfillment of needs in the SECI model.

3-6) Table-2 shows the combinations of research fields of laboratories and knowledge tools supplied from the Knowledge Science side, with integration results for each project.

4. Analysis of Cross-Disciplinary Innovation Projects

4-1) Fig-6 shows the three key factors for innovation analysis of the five Projects. Three innovation classification patterns have been applied to analyze each project: “type” [6], “focuses” [7] and “route” (Seeds push or Needs pull).

Types are categorized into four types of innovation for products, according to the MOT text book by Niwa [6], which enterprise plans to differentiate with their portfolio strategies. They are, (i) sustainable, (ii) disruptive, (iii) blue ocean, and (iv) revolutionary.

As shown in Table-3, the focus of innovation is categorized based on the famous Schumpeter model, which classified the focus of enterprise into one of five targets, ①New Goods, ②New Methods, ③New Channels, ④New Raw Materials and ⑤New Organization. In this relation, focus in laboratory can be identified, corresponding to the Schumpeter model, as ①Results,②Processes,③Markets, ④Feeds, ⑤Systems.

For the direction of innovation, as shown in Fig-5, Seeds Push means that the project started by offering knowledge tools (red arrow in Fig-5) first to be applied to laboratory management, and Needs Pull means that the project started first to identify the needs for innovation in laboratory (green arrow in Fig-5). Detailed description of this innovation analysis is referred to in other papers [2], [8].

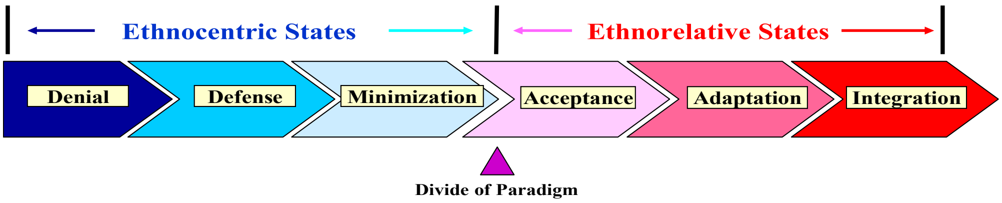

Fig-4 Participants' Cross-Cultural Sensitivity for Cross-Cultural Projects

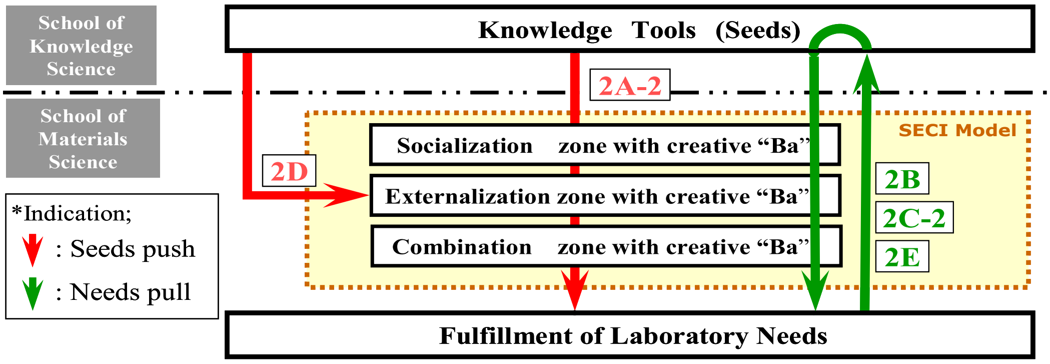

Fig-5 Process Routes in SECI model of Cross-Disciplinary Projects from Start to Target

Table-2. Combination of Research Fields and Knowledge Tools, with Integration Results

Item	Project Themes	Research System			Integration Results
		Subject	Research Fields	Knowledge Tools	
Common Themes	Cross-disciplinary Integration				Talented Innovators
2A-1	Polyolefin Chemical Industy	A Lab.	Polyolefin Research	･Innovation Theory	National Innovation System for Chem.Ind.
2A-2				･Road Map	Research Theme Map
2B	Scientific Research Philosophy	Research Life	Lab. Culture for High Quality Education	･All Liberal Arts, ･Knowledge Creation Theory	Philosophy to develop Excellent Researchers and Research Results
2C-1	Knowledge Representation Theory	Scientific Theory	The Essence of Science & Technology	･Understandable Presentation Method for Science	Method of Clear Presentation of Scientific Principles
2C-2		Animation	Physics Phenomena	･Animation Theory	Physics built-in Animation
2D	Lab.Management, based on Cultural Anthropology	D Lab.	Biochemistry Research	･Cultural Anthropology	Exploiting Laboratory Studies Based on Sociological Approach
2E	Lab. Management using Mobile blog albums	E Lab.	Surface Science	･Mobile blog albums (System for sharing of Tacit knowledge)	Organizing Lab. Identity ①Sociological ②Educational ③Lab. activation

A)The Types of Innovation (Niwa,2006)
- (i) Sustainable
- (ii) Disruptive
- (iii) Blue ocean
- (iv) Revolutionary

cf. C.M.Christensen, 2001

B)The Focus (Target) of Innovation (Schumpeter, 1926)
- ① New Goods
- ② New Process
- ③ New Market
- ④ New Supply Sources
- ⑤ New Organization

C)The Direction of Innovation (from MOT)
- (Technology Push) Seeds Push
- (Market Pull) Needs Pull

Fig-6 Three Innovation Classification (A, B, C) Patterns to Analyze Innovation

Table-3 Focus of Innovation for Labs, based on the Schumpeter Model

	Focus in Original Schumpeter Theory		⇒	**Focus, applied to Lab. Management**		
No.	**"Theory of Economic Development,Vol.1" by Schumpeter**	**Corporate activity**	**New combination (general)**	**Abbrev.**	**Application to lab. management**	**Focus of Lab. Applicability**
①	New Goods	Development of New Products	Delivered goods	①Results	･Results from research	Researchers, Research results, Papers, Research themes
②	New Production Methods	New Methods	Delivery method	②Process	･Process of producing results	Guidance by professors, Research management, Knowledge science. Research philosophy
③	New Sales Channels	New Markets	Delivery destination	③Market	･Beneficiaries of reseach	Potential employers, The Public, Organizations and Companies applying Research
④	New Raw Material(semi-finished products) Supply Sources	New Raw Material and Semi-finished Product Supply Sources	Resource acquisition methods	④Feed	･Raw materials and resources for producing results	Specimens,Social needs, Courses, Research training, Accumulated lab.knowledge
⑤	Establishment of New Organizations	New Forms of Oraganization	Resource utilization methods	⑤System	･Organization and systems for producing results, inside & outside	Supervising professors, Lab. organizations, Research support organizations (e.g. universities, academic

Table-4 Results of Project Integration, with Analysis of Innovation and Expecting Output

Item	**Project Themes**	**Integration Results**	**Analisis of Innovation**			**Output**
			Type by Niwa Model	**Focus in Schumpeter Model**	**Innovation Direction Model**	
Common themes	Innovation by Cross-disciplinary Integration					Knowledge Innovator Theory
2A-1	Innovation for the Polyolefin Chemical Industry	Innovation System for Chemical Industry	(iv)Revolu-tionary	②Process ⑤System	Needs Pull	National Innovation System for Chemical Industry
2A-2		Research Theme Map	(i)Sustainable (iii)Blue ocean	②Process ④Feed	Seeds Push	Research Road Mapping
2B	Scientific Research Philosophy	Philosophy to develop Excellent Researchers and Research Results	(i)Sustainable (iii)Blue ocean	①Results ②Process ⑤System	Needs Pull	Philosophy for Innovative Researchers and Reseach Results(Findings)
2C-1	Knowledge Representation Theory	Clear Representation Methods for Scientific Phenomena	(iv)Revolu-tionary	①Results	Seeds Push	Presentation Methods for Representing Scientific Theory
2C-2		Physics built-in Animation	(iv)Revolu-tionary	①Results	Needs Pull	Physics built-in Animation
2D	Lab.Management, based on Cultural Anthropology	Exploiting Laboratory Studies Based on Sociological Approach	(iv)Revolu-tionary	②Process ⑤System	Seeds Push	Theory of Innovative Research supported by Sociological Approach
2E	Lab. Management, using Mobile Blog Albums	Organizing Lab. Identity ①Sociological ②Educational ③Lab activation	(iv)Revolu-tionary	②Process ④Feed	Needs Pull	IT Network System for Tacit Knowledge Externalization in Experimental Laboratory

5. Conclusion

5-1) For cross-disciplinary projects, it is important for participants to have great eagerness for the integration of diverse disciplines, to have the highest possible cross-cultural sensitivity , and to have a good socialization "S" zone to start with, with respect for each other and broad-minded sensitivity , in order to fulfill the project goals, while appreciating the real difficulty of meeting these goals. From this viewpoint, we can conclude that our COE projects have been very valuable to learn about and strengthen our research structures.

Through this program, the professors and students have acquired considerable integration skills for multidisciplinary research work, and they can be expected to be active cross-disciplinary coordinators and creators of innovation from now on. Especially, through this project activity, one of the postdoctoral researchers disclosed that he established his guiding principles, and felt confidence in becoming an excellent researcher in the future.

5-2) Table 4 summarizes the innovations that we tried to develop in the process of pursuing each project, based on the above understanding of innovation. This analysis is organized by the Niwa, Schumpeter, and Innovation Direction models, which are outlined above. This Niwa model corresponds to the Roman numerals(orange in Fig-6 and Table-4), the Schumpeter model (blue in Fig-6 and Table-4) corresponds to the circled Arabic numerals in Abbrev. column for focus of lab. management in Table−3, and the Innovation Direction model (purple in Fig-6 and Table-4) corresponds to the direction of seeds-push or needs-pull, in Fig-5. In the right column of Table-4, output by integration are listed.

5-3) Among five Projects, the most well-integrated cases are, the ones having good S zone in SECI at first, and these successful Projects proceeded, pulled by needs.

5-4) For the university culture of the SECI model (in Fig-7), to organize intersecting time and space (*ba*) as socialization zone in activities has been a very important point in these five cross-disciplinary innovation projects.

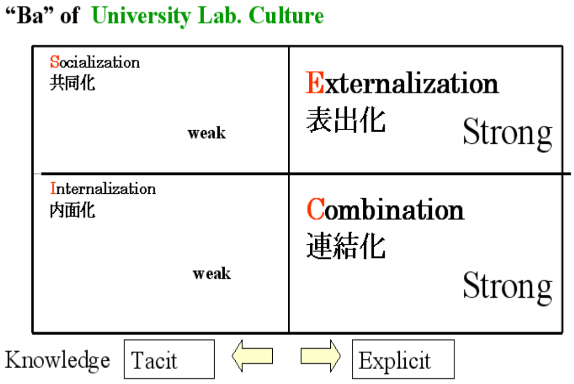

Fig-7 Features of University Culture
In the SECI Model

That is why, until now, integration has seldom occurred in cross-faculty activities inside universities, and in activities outside the university in conjunction with society. In JAIST, thanks to this COE activity, our COE center (Center for Strategic Development of Science and Technology) is now playing the role of a socialization zone, for an interactive interface for cross-faculty activities and with the local community.

At the same time, if the socialization zone could be developed more in the personal activities of each professor, then cross-disciplinary projects might become much easier from now on.

All the participants, students and researchers, also could develop new sensors to diverse disciplines, through this COE activity, which will enhance their sensitivity for integrating network of wider fields, not only in Materials Science and Knowledge Science, but also in other disciplines.

5-5) The purpose of the pursuit of learning is to shape the future of society. In terms of integration, some of these projects were able to achieve sufficient integration, while others were not. Some projects failed to reach integration because the participants pushed their own particular scholastic frameworks too heavily.

We thus conclude that construction of a laboratory culture aiming for cross-disciplinary and innovative research will promote enhanced competitive edges in advanced science and technology fields.

6. Final Comment

It is said that "innovation system shifting to front runner type" for new advanced technological development is essential, to cope with rapidly globalizing business competition. To implement this kind of development, the role of cross-disciplinary innovation management is most important.

In 7 years in the 21st century, GDP(growth % over 7 years) is 23.5% for the world average, 12.2% for Japan and 90.3% for China. As a manufacturing-oriented country, Japan is confident that our "cross-disciplinary" and "innovation creation" experiences in these Projects can contribute to enhance efficiency of combining diverse disciplines and creating innovation in advanced science and technology development, to stimulate national competitiveness, which is the final target of our COE program. We highly appreciate all participants' contributions to this COE program.

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The Bird's Eye Report of the International Conference KSS2007

As the world is entering into the era of the knowledge economy, the significance of developing knowledge has grown to a level where it is coming to dominate other socio-economic factors. The recent developments challenge many of institutions to understand the nature of knowledge and its role in applications, to effectively utilize knowledge for improving corporate competitive advantage and national strength, as well as establishing development of knowledge sciences. The First International Symposium on Knowledge and System Sciences was held in Ishikawa, Japan in 2000 to start some recombination of different ideas and opinions, methods and technologies, schools and disciplines, theorists and practitioners, which aim to develop knowledge science from a systemic perspective, and may be regarded as use of meta-synthesis system methodologies toward complex problem solving. After 8years of work, the 8th International Symposium on Knowledge and Systems Sciences (KSS2007), jointly with the 2nd International Conference on Knowledge, Information and Creativity Support Systems (KICSS2007), took place in Japan on November 5-7 to show some new achievements and prospects for continuous thinking and studying, especially to observe the power of synthesis in knowledge creation. During the conference, a total of 64 papers were presented. The participants came from about 17 countries and regions including Australia, Austria, Canada, China, Czech, Germany, Ireland, Japan, Korea, New Zealand, Poland, Russia, Slovenia, South Africa, United Kingdom, and Taiwan. Those papers are roughly grouped into 10 categories, Knowledge Management in Academia, Intelligent Knowledge Management Systems, Intelligent Computing, Knowledge Representation, Knowledge Coordination, Ontology, Organizational Knowledge, Prediction and Planning, Knowledge Science, and Management Of Technology, which cover the highlighted topics of theory and practice of knowledge and systems sciences, and reflect the continuum of thinking and understanding about the scope of knowledge science.

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