SPECIAL CONTRIBUTION

Methodology for Research Enabling

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1. Introduction

"What man of you, having a hundred sheep, if he loses one of them, does not leave the ninety-nine in the wilderness, and go after the one which is lost until he finds it?" Japanese literary critic Tsuneari Fukuda quoted these words of Jesus from Gospel Chapter 15 of according to Luke and continued by saying that politics is for the ninety-nine sheep, and literature is for the one lost sheep. Fukuda went on to comment that "bad politics mobilizes pens to serve itself and forces the scholarly to ignore the lost sheep" and "second-class literature wanders around the ninety-nine sheep in search of the one".

When we consider the form that research should take in modern industrial society, Fukuda's comments are thought-provoking and relevant. The ninety-nine sheep signify success in business, and the one lost sheep relates to the veneration of and yearning for knowledge. When the words 'development' and 'research' are compared in this context, it can be seen that 'development' calls for the mind to seek only the ninety-nine sheep but 'research calls' for the mind to seek the ninety-nine sheep and the one sheep simultaneously.

If research is understood as mentioned above, describing it as 'fundamental' or 'applied' is not particularly meaningful. Ever since the concept of engineering was created, research in engineering has been supported by minds in pursuing profit. If engineering research is conducted in focusing only on the one lost sheep, in other words, with a focus on understanding fundamental phenomena, it ought to be called 'fundamental' research at all times regardless of its stages, from research-theme establishment to applied research and ultimate development.

Research management is a concept that was introduced a few years ago, and it has since been provoking vigorous arguments on how to position research in social foundation establishment models and business models. Consequences of these arguments in Japan include the 'Frontier 21' program of the Ministry of Economy, Trade and Industry (METI) and the 'Center of Excellence' program of the Ministry of Education, Culture, Sports, Science, and Technology (MECSST). Both of these programs have the same key research management concepts: 'designation of core fields', 'shifts toward short-term programs', and 'partnership between industry, government, and academia'. Similar initiatives have been launched by private businesses. In Europe and the United States, research management arguments are taking place on most basic issues such as how to bridge the gap, the so-called 'valley of death' between fundamental research and ultimate commercialization, whether to model research as a survival-type model or as an advancement-type model, and on whether to have research organizations independent as central research laboratories or to disperse them among business divisions.

The mission of an enterprise is to offer value to customers by way of its products, and this value is perceived by customers in terms of differences from the products that they are currently using. Consequently, enterprises are forced to deny the value of the products and the technologies used in them they already have on the market and continue to offer new products and create new technologies. If repetition of this value denial and new creation cycle is defined as 'innovation', most of today's innovations are underpinned by new technological know-how in areas such as materials, processing methods, and information technology (although product planning and application of existing technologies are important processes in the creation of new value).

The role of research in enterprise lies in the building up of new technologies/knowledge and in finding ways to transfer the enterprises' accumulated technologies/knowledge into the value of products. What should not be forgotten with regard to these roles of research is that technologies and knowledge accumulated in enterprises are self-growing and enabling this self-growth is also an important role of research.

Various arguments on the roles of research can be simplified if we use the key word "techknowledge", which the author coined for this particular discussion by combining 'technology' and 'knowledge'. All these arguments should share the following premises:

(1) The sum of accumulated techknowledge within an enterprise is an important element of the value of that enterprise.
(2) Only techknowledge can create new techknowledge.
(3) Techknowledge is a uniquely human property.

The most important role of research management lies in creating a vision for the techknowledge that forms the value base of an enterprise and in creating a system that supports and maintains the process of continuous self-growth of techknowledge. Only a system based on this vision can create the value the enterprise it deserves. Since techknowledge is the result of a unique human process, making a system for techknowledge growth and self-growth is not an easy task. In an ideal system in which techknowledge is actively created and automatically develops, the vision for new techknowledge must be presented in a comprehensive man-

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ner. An environment rich in techknowledge resources must be created in accordance with that vision, and individual researchers working in the techknowledge-rich environment must have a strong sense that they are helping to raise that environment to an even higher level.

To present this ideal system in a visible way to researchers, Mitsubishi Motors Corporation (MMC) has established subsidiary systems with the names 'House of Knowledge', 'Technology Database', 'Technology Trend Analysis Book', and 'Research Partnership'. This paper describes some of the fieldwork conducted by MMC to determine the orientation of these systems.

2. What is the current state of Japanese industries reflected by key performance indicators?

The hollowing-out of Japanese industry is widely recognized as the 'lost decade'. Many people seem to attach little importance to this phenomenon, seeing it as temporary and believing that the hollowed-out industries will eventually be restored. However, when the situation is examined via key performance indicators (KPIs), we find it extremely serious. They indicate that the rate of successful investment in research within Japan has been in continuous decline for the past decade. More important is that this trend is seen only in Japan. To deal with this situation, industry and government have been making significant investments in research (in terms of percentage of gross domestic product, these investments are greater than those made in the United States), but the situation shows no sign of improvement. Not one of the 38 epoch-making products recently listed in *Fortune* magazine was invented in Japan. Trade statistics including those for software and other intellectual property show considerable deficits. The number of patent applications per year made by universities in Japan is mere 206[(1)] compared with 5,591 in the United States and Europe.

There is a book entitled *Chuokenkyujo-jidai-no-shuen* (literal translation: The End of the Age of the Central Research Institutes), a translation published by Nikkei BP of a book originally entitled *Engines of Innovation*. That a negative-sounding title was chosen as a Japanese translation of the positive-sounding original title is indicative of the current environment of stagnation in Japan.

The 'valley of death' model has often been used to explain the current stagnation. Here, the 'valley of death' signifies the gap that must be crossed before fundamental technologies can be translated into actual products. According to one explanation of this model, the United States has an established industry-government-academia partnership system, has venture capital, and has major corporations that are keen to break into new fields. These mechanisms work successfully enough to cross the gap. Japan has none of these mechanisms and thus cannot cross the 'valley of death'. A number of political measures have been implemented in Japan to improve the situation, but they have led only to the marketing of products with limited applicability by small enterprises; Japan has yet to produce its own Intels or Microsofts. The 'valley of death' model assumes that, if help is given to cross the gap, unique products will be created. In other words, it assumes that Japan already has necessary fundamental technologies. The author feels this perception is wrong. What is lacking is a supply of new fundamental technologies; no innovative products can grow without new techknowledge.

3. In concepts, the key word is 'culture'.

Another explanation given for Japan's 'lost decade' is this: Japanese people were competent enough to achieve great economic growth by striving to catch up with the industrialized West, but they lacked the ability to subsequently pioneer new technological fields.

The author supposes that the key word underlying this explanation is 'culture'. During Japan's catch-up period, a profit-driven approach based on mass production and price competition was taken for the reason of by industrial needs. However, the end of that period saw a market where consumers possessed all the basic commodities necessary for daily life; apparently, their interest had already shifted to value-added products for a richer, more relaxing, more sophisticated way of life. In the author's view, industries in Japan, unlike those in the United States and Europe, failed to take this opportunity to mature the market culture into a richer one and hence were not able to create more intrinsically valuable products.

In today's Japan, there are a growing number of people who not only enjoy the physical benefits of an affluent society but also lead their life with a rich imagination. However, the ideas of these people seem to have little influence on Japan's industries. It is surely necessary to adopt product concepts that reflect today's popular culture no matter how juvenile they might appear.

The author believes that the concept of market culture must be given much higher importance, particularly in the automobile market. This is because today's culture with regard to automobiles is outdated compared with culture in other areas of daily life. The trend of residential interiors in homes is to conceal functional elements inside walls and create a simple appearance, but functional elements are most often exposed in automobile cabins. Drive controls and other control systems of automobiles are more complicated than home appliances, and their designs are far from standard. It is difficult to exchange or upgrade elements to suit different purposes because 'open architecture' is not yet an actual trend in the specifications of automobile electrical equipment.

In Japan, the METI a few years ago designated the key promotion fields of technological development as the manufacturing technologies that yield added intellectual value, technologies that address the needs of an aging society, technologies that address aesthetic needs, and complex systems technologies. In the

author's view, this move was intended to invigorate Japan's industries with a focus on people and culture. However, the METI's new Frontier 21 program seems to have shifted the development promotion fields toward fundamental technologies.

4. In technologies, the key phrase is 'bottom-up vision'.

The Frontier 21 project designated the following four key promotion fields of technological development:

(1) Biotechnology and life science technology field
(2) Information technology and telecommunications technology field
(3) Nanotechnology and material technology field
(4) Environment field

Among these four fields, the environment field seems incongruous. While the first three are associated with distinct technical fields and there exist corresponding industries and scholastic fields, the environment field is conceived from the objective and does not correspond to independent technical fields.

In 2003, the MECSST selected several universities in Japan as 'centers of excellence for research' according to the key promotion fields of technological development it had designated. A large number of research themes were selected for the technical fields (1) to (3), but few were selected for the environment field.

The above disparity can be explained by this: While fields (1) to (3) are selected by 'bottom-up vision' (or inductive vision), field (4) is selected by 'top-down vision' (or deductive vision). When technologies and technological fields exist and research themes are selected based on concepts that are born from them, such a selection is made by 'bottom-up vision'. When the selection of research themes is made based on the concepts created from the objectives, such a selection is made by 'top-down vision'. The author has heard that many universities, selected as centers of excellence for the environment field, were given themes that either lacked concreteness in terms of achievement methods and content of research or, conversely, were too specifically defined.

Where selection of fundamental research themes is concerned, therefore, the important vision is 'bottom-up vision' rather than 'top-down vision'. In fact, the themes selected in the environment field for the 2004 financial year in the Frontier 21 project included carbon-nano-tubes and liquid-crystal-display technologies, which should all have been classified in the nanotechnology and material technology fields. This fact also highlights the validity of the bottom-up approach for research theme selection.

Techknowledge and mathematical theories about molecules, atoms, and other objects and phenomena lies at the base of the bottom-up approach. For example, with regard to research themes in the biotechnology and life science technology field and in the nanotechnology and material technology field, the techknowledge should be about molecules and atoms; for the information technology and telecommunications technology field, it should be about voice recognition, image recognition and encryption technologies in addition to molecules and atoms. Most of the innovative inventions announced recently are supported by new material technologies derived from techknowledge about molecules and atoms and by new data processing technologies supported by mathematical theories.

Research in the product development area requires market knowledge, technological knowledge, and business knowledge[(2)]. The approach market knowledge is playing a role in research theme is a top-down approach which requires identification of latent needs and a search to realize its technology.

Technological knowledge, on the other hand, should be given for its role a bottom-up thinking approach through which new base technologies are discovered and applications for them are sought. Needless to say, top-down and bottom-up approaches are both predicated upon techknowledge that has been accumulated and enriched within the organization. It is also needless to say that it is business knowledge that enables the final evaluation of the advantages and disadvantages of launching any new product.

5. The significance of research by enterprises is now being re-evaluated.

Today's business managers seem to have left behind conventional straightforward thinking about the role of research in technological innovation. Some seek ways to cut investment in research as a way to cut costs, thinking ahead to keep a cost model, while others look for research to play a pivotal role in overcoming the dilemma of competition. Positions vary widely, but every manager is striving to better understand the form that research should take.

Business models in which survival is pursued through improvement of existing products and manufacturing methods in order to reduce research costs are not successful because they preclude creation of the new value demanded by customers. The 'quickly making the second from the first' model is also difficult to use successfully because the lifecycles of products acceptable to customers are becoming shorter. Also business models that focus on research do not always work effectively. They may be seriously compromised by the scarcity of research themes that have been successfully commercialized and by the existence of continued research whose link to needs has already been lost or whose feasibility of being seeds of future research is virtually zero.

The author does not think it effective to analyze model-based arguments of the above mentioned types and become involved in them for better understanding of the expectable future form of research, because most of these arguments do not seem to have direct connection to the purpose.

To have a long-term vision of research, one must do a large amount of work to process a virtual matrix focusing on the future. Many people support the short-

term, intensive research as a survival strategy but they do so simply because they find it difficult to predict the future. At the same time, though, many people argue that a long-term research strategy is necessary for advancement but they often lack solid belief or vision and insist on long-term research simply to counter an ambiguous fear of competition or simply as a form of insurance.

Needless to say, the most desirable stance when thinking about research is to keep one's eyes on the future and devise strategies for advancement while accepting that creating new knowledge is accompanied by significant risk. The important question is how to minimize the risk.

6. Can knowledge be managed?

Not only enterprises, but universities and research institutes seem to have also come to realize that they must evaluate the processes and results of knowledge creation. Knowledge management requires politics that seek the ninety-nine sheep. In reality, however, people responsible for knowledge management depend mostly on easy-to-acquire information and concentrate only on making tools, failing to achieve the true objective of knowledge management effectively.

They may think like this: Creation of knowledge is associated with human nature, and the very concept of knowledge management and its quantification may be beyond human capability.

Recently, Professor Ikujiro Nonaka of Hitotsubashi University and co-authors presented the concept of "knowledge enabling" in a book[3]. This approach seeks the ninety-nine sheep and one sheep simultaneously and seems to be very useful when applied to the execution of research. The concept is based on the following three assumptions:

(1) Knowledge is a distinct conviction that has been justified and has an individual aspect and a social aspect as well as a tacit aspect and an explicit aspect.
(2) Knowledge depends on the perspective of individuals.
(3) Knowledge creation is a craft work, not a science.

The concept of knowledge enabling begins with the assumption that organizations cannot manage knowledge. Organizations are seen to be only capable of enabling knowledge. After defining that enabling knowledge is the key factor for enterprises to continuously achieve knowledge creation, Nonaka et al. proposed knowledge enablers, knowledge activists, and other specific methods for enabling knowledge. Knowledge creation always occurs in an environment where everyone is accepting each other. When members of the organization establish such an environment by proactively accepting the ideas of others, a source for higher creativity becomes available. The roles of the knowledge enablers and knowledge activists are to distribute information throughout the organization and remove obstacles to communication.

The concept presented by Professor Nonaka and his co-authors in the book offers its main values in the support for creation of knowledge and in the realization of the created knowledge in the form of products. The author would like to add to these values another value that lies in activity in which individuals study and then share the results of their studies as knowledge throughout the organization.

What should an organization do for systematic knowledge creation? Richard Saul Wurman answers this question with a key word 'study'[4]:

(1) If one plans to use a wonderful original idea to build a business, one must build a company culture that values study.
(2) If one hopes to be given a responsible job and advance one's career, one must continue to have a strong desire to study.
(3) The most important point is to work in an organization that continues to provide opportunities for study.

In fact, it is actually relatively easy for an organization to achieve the above. The only thing the organization needs to do is to declare a corporate culture that values study. Humans innately seek the one lost sheep; we instinctively want to solve worthwhile puzzles when we encounter them, or more generally expressed, we have awe and adoration for knowledge. Simply enabling this mindset leads naturally to a corporate culture that values study. The results of study are accumulated within individuals. Individuals in an organization instinctively want to contribute to the organization and to the organization's output. Providing just a modicum of support leads the knowledge accumulated within the individuals to be naturally spreads into the organization.

7. Research management can provide certain support to knowledge creation.

It seems reasonable to think that research management is able to fulfill a certain support function in order to enable study and the creation of knowledge through study. Frameworks for this support include MMC's recently introduced 'House of Knowledge', 'Technology Database', 'Technology Trend Analysis Book', and 'Research Partnership' systems.

Since knowledge creation is vulnerable, its achievement requires careful support through various organizational activities that are devised to overcome various obstacles. 'House of Knowledge' is an organizational concept that MMC has introduced as its declaration of a corporate culture that values study.

Required for next knowledge creation is a clearly presented research vision. An example of a vision presenting method is a portfolio system with a coordinate chart in which the X-axis shows the time, the Y-axis shows the value, and key words for technologies expected to emerge at different timings are plotted against the two axis. It is desirable that the technologies to which this method is applied are of the bottom-up vision nature. An inevitable characteristic of the technology of bottom-up vision nature is the branching

of extremely numerous subfields and an extremely large number of key words needed to be plotted. Research vision presentation with this method should ideally be conducted by management while researchers add the results of their studies into the portfolio. This is the role of 'Technology Trend Analysis Book'.

It is also important for research management to establish a knowledge database as a knowledge creation support function. Currently most research time is spent on reaching information. If the information that individual researchers have acquired is collected in a database, the time can be shortened. This is the role of 'Technology Database'.

The greatest support that research management can provide to knowledge creation comes from the promotion of joint research. Taking material technologies (the most important technologies of the bottom-up vision nature) by way of example, we see that the latest research efforts involve materials design where researchers handle individual molecules. It is impossible for a single company to implement such high-level technology in all fields. In such a case, it is effective for the company to form tie-ups with leading researchers in different fields. In the tie-up forming, the company presents the theme selected based on top-down vision to researchers of the field concerned. This necessitates clear explanation of the value of the technologies under research, past performance and future obstacles all in the language of the technological fields of those who undertake the research of the selected theme. It is the role of research management to locate the most suitable specialists and start communication with them using the most appropriate language. This is the role of the 'Research Partnership'.

8. Ultimately, communication is key.

Knowledge is an attribute of individuals. It can become significant only when it is communicated. Many reports indicate, however, that this quite natural mechanism often does not work within companies. Researchers, who have the seeds (knowledge), believe that their responsibility has been fulfilled when they file and register the knowledge in the database, thinking that it is the designers' responsibility to access the knowledge. The designers, on the other hand, believe that the researcher's responsibility is to provide the knowledge in a language understandable to them.

It would be easy to say that such problems do not arise if communication is conducted properly. In reality, however, conflicts of this kind have been frequently occurring in a large number of enterprises, which allows one to infer that they are innately inevitable. Based on this inference, Professor Nonaka and his co-authors propose to add "support" to the evaluation items for researchers in addition to "trust". How much a researcher is responding to a request for support, how long a researcher is spending on listening to the desires of others and looking for a solution, how long a researcher is spending on transferring his/her knowledge to others, and how long a researcher is spending on helping to put the knowledge of others in a clearly understandable form; these would all be indicated in specific indexes.

The author believes that the most practical form of knowledge transfer system from knowledge creators to knowledge users is a system in which knowledge creators are obliged to give support to knowledge users and knowledge users indicate demand for such support on their own initiative.

9. Conclusion

Research managers want to contribute to their organizations through research. For this reason, they wish to recruit researchers with better capabilities than themselves. If they cannot recruit such competent researchers, they seek to empower the pride latent within their subordinates, give them incentives to do higher-level work, and nurture them to become researchers with better capabilities than themselves.

It is easy for research managers to force researchers to conduct research, but it is not possible for them to force researchers to create something. All they can do is to pray that the god of creation may smile on the researchers. But a prayer alone is not sufficient. It is necessary for them to establish an environment that attracts the god of creation. It is possible for them to create a corporate culture that attaches value to study and provide a modicum of support to maintain that environment.

Continuing research and maintaining knowledge at a cutting-edge level is a painstaking job. Researchers sometimes worry about whether they are working in fields where solutions do not exist. The way to remove this anxiety is to broaden fields of activity through study. There is also anxiety about when the next brainchild will emerge. The way for a researcher to escape from this anxiety is to have an excellent research theme for which a solution is really wanted. To this end, it is effective for them to continue studying in a knowledge-filled environment. Studies not only solve problems but also present more research themes.

References

(1) Manabu Akaike: "The Latest Low-Tech Is Far Greater Than High-Tech", Wedge
(2) William L. Mirrer, Langdon Morris: "Fourth Generation R&D"
(3) Georg Von Krough, Kazuo Ichijo, Ikujiro Nonaka: "Enabling Knowledge Creation", Oxford University Press, Inc.
(4) Richard Saul Wurman: "Information Anxiety 2", Macmillan Computer Publishing

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