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# Fostering a "Monozukuri (Manufacturing)" Organization Suitable for the 21st Century Digital Economy

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## 1. Introduction

The origins of Japanese "Monozukuri" (literally "making things") can be traced back to the history of Kyoto. For about 1,000 years, starting with the relocation of the capital from Tokyo in the year 749, Kyoto was the seat of government and the heart of Japanese culture, and became the birthplace of many industries. In the midst of this long history, even now, in the 21st century, Kyoto is the focus of attention from both inside and outside of Japan as a region where traditional industries that are representative of Japan coexist with industries at the cutting edge of the era. Many of the world's leading companies have established bases of operation in Kyoto, supported by advanced "Monozukuri" technologies.
Kyoto's industries have brought color to people's lives in all four seasons, for example through kimonos and various other crafts, as well as traditional foods. The "Monozukuri" industries of tradition and culture developed along with the community while forming social "division of labor" structure, functioning as the platform that gave rise to Japan's modern industry during the 20th century.

Fig. 1. Temple (Sanjusangen-do) and Sado(Ohara-Sanzenin) – Traditional Craftsmanship

Until the capital of Japan was relocated to Tokyo, Kyoto was called "Heian-kyo," and for about 1,000 years, it demonstrated continuity in Monozukuri even in the midst of war and great fires. It is important to think about what factors were behind this strength of continuity. One important factor was the history of Monozukuri, which fostered an original awareness of beauty that combined a different culture with natural laws, and a culture of craftsmanship that was passed on continuously across countless generations. These analog factors offer extremely important hints for modern men seeking out spiritual richness even now, in the 21st century, when lives are lived on a more digital social platform.

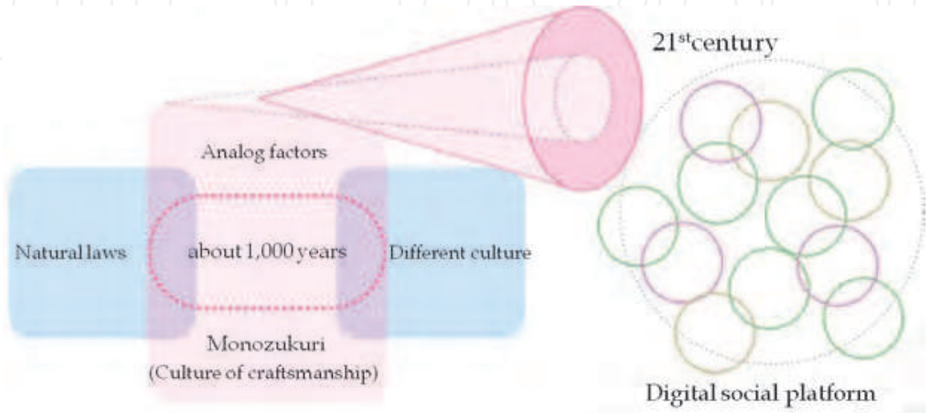


Fig. 2. 21st century, digital social platform

## 2. Japanese technology

The relocation of the capital from Kyoto to Tokyo, in what was called the Meiji Restoration, marked the beginning of modernization in Japan. At that time, railway, steamships, telegraphs, and other new technologies were purchased from the west, and then modified in a Japanese style. It is said that the strength of the Japanese manufacturing industry is in process innovation. In order to achieve its mission of creating more efficient, less expensive, higher quality products based on sciences and technologies born in the west, Japan made improvements and developed applications, and the innovations that arose through these processes were held in very high esteem in countries around the world.

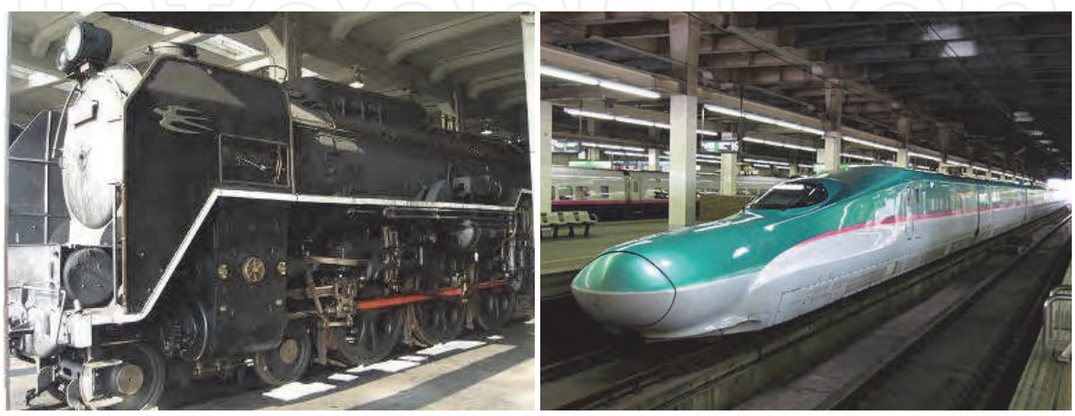

Fig. 3. Steam Locomotives and the Bullet Train (Hayabusa2011)


Fig. 4. 1901: Nippon Steel Yahata Works

The Meiji Restoration and the birth of modern Japan that followed were embodied by a catch phrase that could be translated as "National prosperity and a strong military"; in other words, the goal was to form a nation-state through the expansion of domestic production and the creation of military power. Based on this approach, the Meiji government built on the attempts at modernization in gun manufacturing initiated by the Bakufu government, established as an extension of the steel manufacturing and civil engineering technologies, and put railroads in place. Then, by establishing army and navy arsenals to introduce the latest military technologies, the government pushed forward in building platform technology industries introduced from European countries. In this way, Japan came through the Sino-Japanese War and the Russo-Japanese War to enter the ranks of the world's industrial states.

There has been an emphasis on the fact that Japan's sciences and technologies have been learned from the west since the Meiji Era, and there is a deeply rooted belief that Japan's society as a whole is an "imitation" or "borrowed" from the west. This has created a social environment in which it is difficult for Japanese people to assert with confidence that Japan has created its own original sciences and technologies. Monozukuri in Japan did not begin with the modernization seen in the Meiji Era; there was a foundation of Monozukuri that formed the base upon which that modernization and the advanced western technologies of that era could be assimilated, understood, and put into practice. This is origin of Kyoto's spirit of Monozukuri.

One of the reasons for Japan's successful modernization through rapid industrialization following the Meiji Restoration was that for around 1,000 years, mainly in Kyoto, people in all levels of society, particularly during the Edo period, had a high level of knowledge, and the literacy rate was also very high. In addition, the Japanese as a people had a strong interest in new technologies, an ability to absorb those technologies, and a desire to make things with their own hands.

In other words, it would have been impossible for Japan to achieve modernization of its domestic industries simply by introducing the sciences and technologies that were the fruits of modern civilization in the west. Japan, located in the easternmost part of Asia, was able to achieve a rapid penetration of modern technologies after the Meiji period that other countries in Asia failed to do, and to demonstrate substantial industrial and economic development after the 2nd World War as well. This achievement cannot be explained without the hypothesis that Japan already had outstanding social and technological

structures and systems even from before the Meiji period that acted as a platform for modernization. During the era before modern industrialization, for a period of more than 1,000 years, from the birth of Monozukuri centered in Kyoto to the Edo period, Japan's social systems and the foundations of Monozukuri played the role of an adhesive that enabled fundamentally different modern technologies to take root in Japan, and at the same time played an important role in promoting the understanding and acceptance of these technologies in Japanese society. In order to investigate the roots of the international competitive superiority of Japan's Monozukuri, we just reevaluate and reconfirm Japan's social climate, foundations, systems, and traditional technologies and techniques, from the perspective of creativity.
These foundations have been cultivated gradually up to today, though their forms have changed. Even today, Japan is capable of a creative Monozukuri that can respond to new requirements from the market or from the era in general.

## 3. Kyocera in Kyoto

The traditional technologies and techniques that live even today in modern advanced industrial fields are an important element in the formation of the creative and international superiority of Japan's Monozukuri. Based on this awareness, if we look closely at the cutting-edge industries and Monozukuri in our modern society, we will find that in a variety of industries and markets, Japan's traditional technologies and techniques, as well as traditional approaches based on original Japanese social climate and climate conditions, have all come into play. Here, we will describe one important case. In the field of ceramics technologies, it is easy to see that countless technologies and techniques cultivated through Japan's traditional industries are used in recent cutting-edge technology fields. The strong heat resistance and light weight of silicon nitride are used to increase engine response. The photo below is a cross-section of the engine from a Japanese sports car, the Nissan GTR. Using a new forming method developed by Kyocera in Kyoto that demonstrates outstanding precision and productivity, Nissan developed and manufactured a ceramic turbo charger rotor for its sports car engines. The development of this component brought about an innovation that enabled Japanese sports cars to compete with some of the top manufacturers in the world, including Porsche in Germany. Kyocera's outstanding technologies contributed to a 36% increase in response and a 34% improvement (reduction) in the moment of inertia.

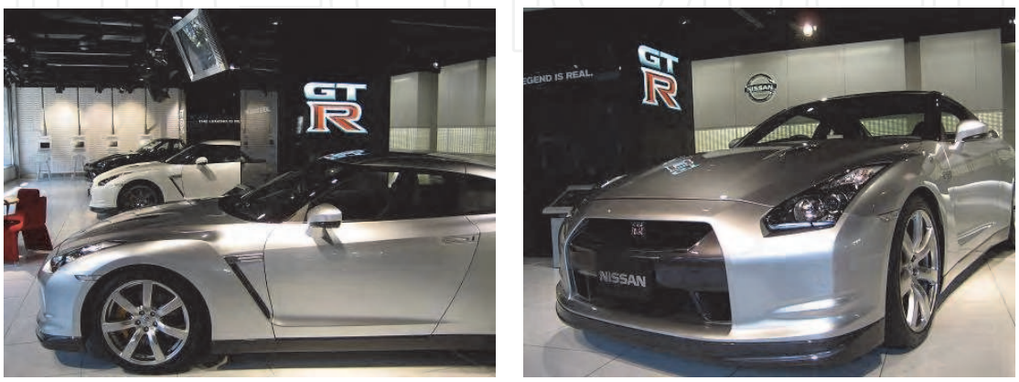


Fig. 5. NISSAN GTR body-Premium Super Sport Car

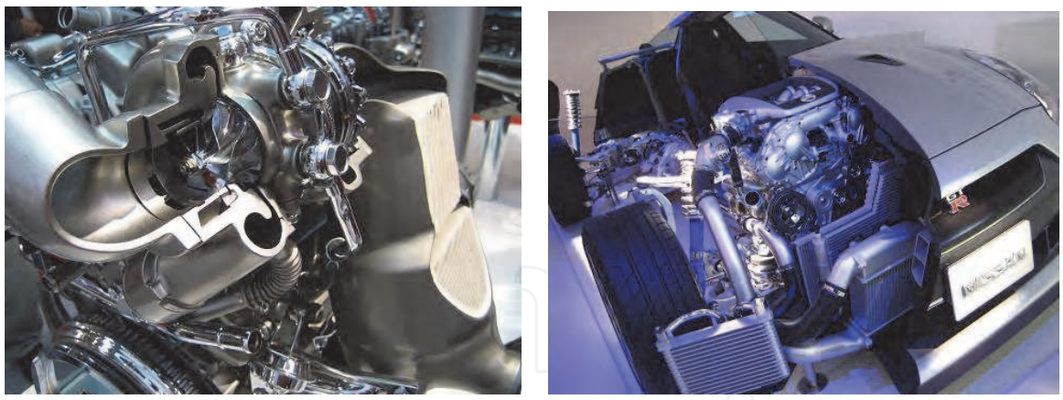

Fig. 6. Kyocera Ceramic Turbo Fin in the NISSAN GTR engine

Kyocera has other ceramic ECU technologies that are closely related to the application of IT in automobiles. ECU modules using multi-layered ceramic substrates required advanced mounting technologies. Development was achieved using Kyocera's extensive experience and data based on an unparalleled knowledge of the unique characteristics of these multi-layered ceramic substrates. Automotive components also require a high degree of reliability. Kyocera's automotive materials are developed based on diverse forms and technologies accumulated over many years; they have an outstanding track record of automotive applications, and have contributed to the increased export of Japanese automobiles overseas. Kyocera is involved in a wide range of fields, from solar power generation systems and substrate materials, components, and devices to integrated systems, and has contributed to the development of everyday social infrastructures, mostly related to the automotive field, based on communication technologies.
In this way, Kyocera's Monozukuri has accumulated many forms and places an emphasis on the relationship with the surrounding circumstances. Each type of Monozukuri has a different definition depending on the form and circumstances, and companies are the shared embodiment of Monozukuri.

## 4. "Form," learning + obedience - breakdown – breakaway

Regarding "Form," if the basic form has not been mastered, then subsequent changes cannot be expected. The training of manpower for handling form requires "circumstances," and the structures involved here involve knowledge that is the result of accumulated human experience and learning. Knowledge is an important asset that is obtained through a long process of trial and error, and which is communicated through the medium of "circumstances" in a specific "form." The "form" of a company contains formless elements such as corporate culture and tradition. If knowledge is a "form" that is acquired by humans through a long history, then in the beginning, then in the beginning, it is essential to learn the initial "form," and Japanese people have practices this for about 1,000 years. Form changes through "learning + obedience - breakdown - breakaway." In other words, form is similar to the teachings of "obedience - breakdown - breakaway," which can be found in the traditional Japanese martial arts and "Sado," the art of tea. "Form" is learned even before the process of "obedience - breakdown - breakaway," so it is important to begin one's studies from this process of "learning + obedience - breakdown - breakaway." The Meiji Restoration, which was the embodiment of Japanese modernization 100 years ago, was not

an imitation of the west, but learning from it. The 20 year period from the introduction of IT and the Internet into Japan during the latter half of the 20th century was a period of "learning + obedience - breakdown - breakaway."


Fig. 7. Knowledge is a "form"

The concept of "obedience - breakdown - breakaway" was born from Higashiyama Culture (the era of the Shogun Ashikaga Yoshimasa); it rippled outward from Noh theater (the actor Kanami) to the art of tea, and from there was adopted by masters of the martial arts. This spirit was also passed on from the Edo era to the modern day in Japan through the apprenticeship system in Monozukuri. Following is a summary of the description of "obedience - breakdown - breakaway" as found in the journals of Yamanoue Soji, on the art of tea:

15-30 years of age: The period of obedience. The student follows the teacher's instructions, and focuses on the practice of being obedient to these teachings.

30-40 years of age: The first stage of "breakdown." The student begins to find his own approach, accounting for about 50% of the whole.

40-50 years of age: The second stage of "breakdown." The student strives to apply new and creative approaches (using methods that may be completely at odds with the teacher's).

50-60 years of age: The final stage of "breakdown." The student carefully studies and reexamines the master's works, and prepares for the next stage; that of "breakaway."

70 years of age: The stage of "breakaway" is a result not only of spiritual effort, but of an inborn talent; this stage only occurs rarely, when the student has reached the level of the master, who himself has achieved breakaway.

In the case of traditional Japanese Monozukuri, the most fundamental items are thoroughly learned during the "obedience" stage of "obedience - breakdown - breakaway," but the truly important thing is not simply to learn from the teacher, but to be obedient to the process of feeling, thinking, and learning for oneself. Right now, Monozukuri in the backdrop of Japanese IT is in this "obedience" stage.

"Circumstances" are required to change "form," and these circumstances could be thought of as transcending time and space. In terms of "transcending time," we can "interact" with Christ by reading the bible, and similarly interact with Socrates or Buddha through their teachings. Today, one example of "transcending space" is that through the Internet and ICT (information and telecommunication technologies), we can interact with and learn from people anywhere in the world. In this sense, circumstances transcend both time and space.

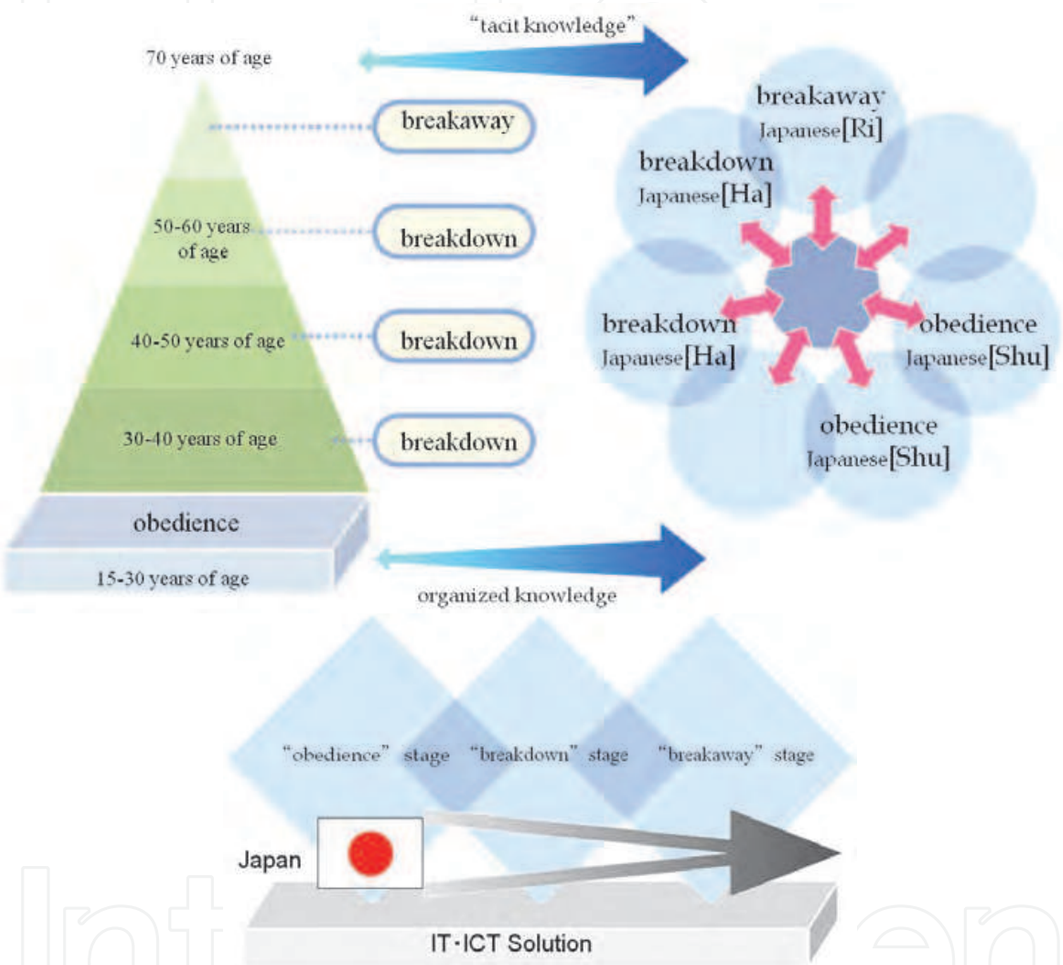


Fig. 8. Obedience - breakdown – breakaway

Human capabilities are based on our capacity to take "tacit knowledge" and express it as "organized knowledge." Knowledge is expressed and shared to become organized knowledge, and this in turn become the practical knowledge of companies. As long as knowledge exists only on an individual level, it is not shared. The cultivation of tacit knowledge is related to both an internal and a cultural aspect, so it is necessary to develop original learning curriculums that are suited to the climate and characteristics of each country and its people. In other words, if knowledge does not become organized knowledge, then individual tacit knowledge cannot become the assets of an organization. In a company, it is important to provide the circumstances in which individual tacit knowledge can be expressed and shared in order to become organized knowledge. Even if those

"circumstances" do not have a formal structure, in Japan, one can see cases in which meetings take place at drinking establishments every day after work, where colleagues gather to exchange opinions. In the west, meetings after 5pm would no doubt be criticized. In order for "forms" to improve, there must be circumstances that allow those forms to compete and mutually develop. Forms change by competing in these circumstances. Meetings at drinking establishments promote common understanding through mutual exchanges of information, and through the generation of a psychological energy, they promote collaborative work with other persons and other companies. They also promote learning for the future. In this way, through a process of improving output, these informal meetings act as the circumstances that can be expected to further assist in mutual exchanges of information.

## 5. "Group" common body of practice

The term "company" is used now, but the common bodies that have practiced Monozukuri in Japan for the past 1,000 years share the same concept as that espoused by Wenger, the Swiss knife manufacturer. This common body of practice is a group of people who share an interest in a given theme, related problems, enthusiasm, and other factors, and deepen their knowledge and skills in that field through continual mutual interactions.

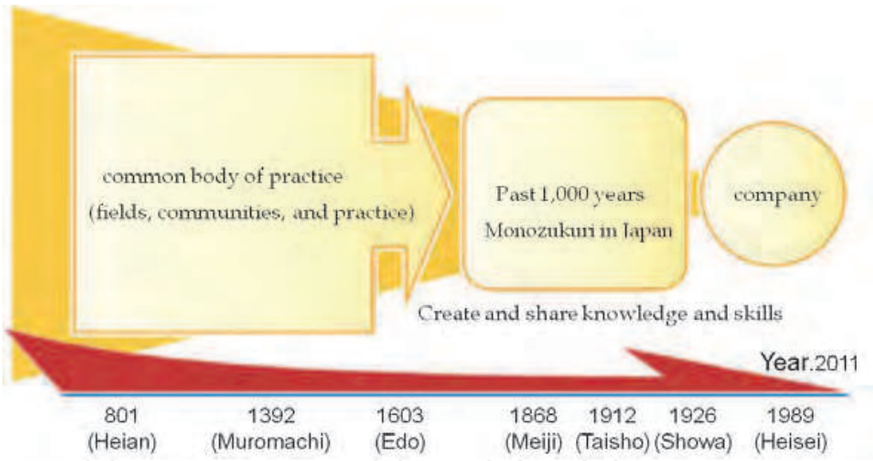


Fig. 9. Common body of practice

The common bodies of practice create and share knowledge and skills, and as a result the design of learning in those common bodies of practice defines levels of participation; for example, participation (or lack thereof) in the common body, creative action, and interactions or collaborations with parties outside of the common body. The common body of practice also has component elements: fields, communities, and practice. The most notable of these is "fields"; as in the case of specialized fields, there are common characteristics such as: Creating a common platform among the members to create a sense of unity; securing a promise from the members and other related parties regarding the community's goals and values, and justifying the community; and inducing contributions and participation from the members, leading in learning, and giving meaning to action.
Thinking about it in this way, compared to "circumstances," the "common body of practice" is a more specific concept, and can be thought of as a connotation of circumstances. The

common body of practice is a concept that further narrows down the focus on learning and knowledge sharing. Particularly given the approach of being obedient to and evolving "form," it is important to use the knowledge of the common body of practice more effectively. The knowledge base in traditional Kyoto crafts provides important hints regarding the synergistic effects of Japanese Monozukuri. In the orthodox participation in the common body of practice by others as seen in Monozukuri (e.g., in traditional crafts), skills are acquired simultaneously with participation in the common body that possesses those skills. It is necessary to deepen the degree of participation on those common bodies, and to increase involvement. First of all, participation in the common body is a process of learning, and at the same time, it promotes the construction of identity as a member of that body. In this way, the framework of orthodox participation by others can be seen as a kind of trinity: an acquisition of knowledge and skills; participation in the common body; and the construction of an identity as a component member. Each of these three elements affects the other, creating a synergistic effect. If the acquisition of form transcends simply learning skills and knowledge, then this is the result of the synergistic effect. The acquisition of "form" could thus be seen as a result of participating in the common body, and learning the history that is incidental to those skills and knowledge, the learner's own approaches and beliefs with regard to his or her skills, and the overall skills that are supported by these other elements. Automakers such as Honda and Toyota are participating in this type of common body of practice.

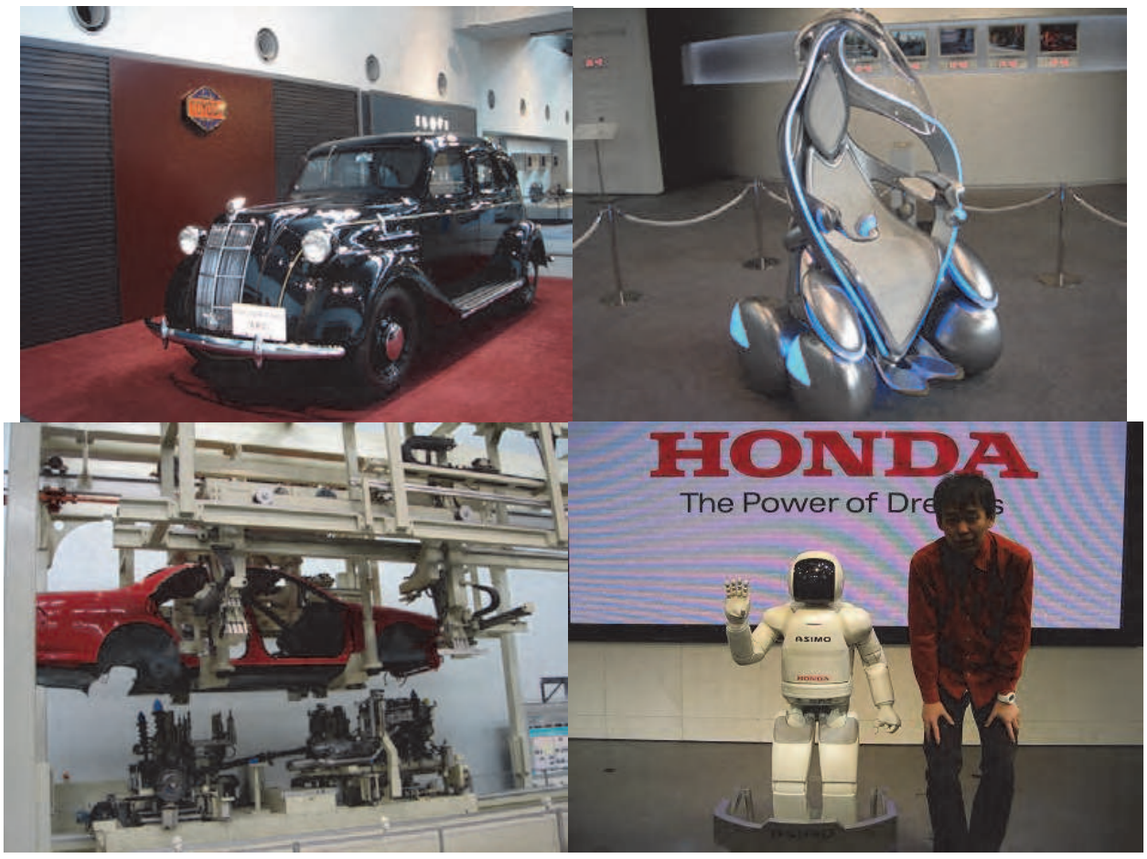


Fig. 10. Car and Robotics (TOYOTA Type-AA, i-unit , product-robot and Ashimo)

## 6. Knowledge creation

Japanese companies have succeeded thanks to the skills and technologies of organized knowledge creation in the company as a whole, based on participation in the common body of practice which forms small organizational frameworks. Organizational knowledge creation refers to the capacity of the organization as a whole to create new knowledge, spread it out across the entire organization, and give it concrete form as a product, service, or operating system.

Japanese traditional Monozukuri is carried out in the context of "transmission." In the midst of this transmission, only the best information, which has endured the tests of time, is selected. In western Monozukuri in recent years, however, the mainstream approach is the dialectic method, involving debates in a dialog format. In the world of the dialectic method, sound arguments sometimes lose to sophistry, and in order to rectify this, Socrates's student Plato introduced the theory of ideas. In the field of natural sciences, the dialectic method functions correctly because ideas are embodied in the subject nature itself, but in the fields of social sciences or human sciences, if the dialectic method is applied without discussing the ideas, then a mistaken conclusion may result. This is because in corporate management, the corporate philosophy is considered important. In order to form a rich pool of tacit knowledge, it is necessary to circulate both the world of transmission and the world of the dialectic method.

In the case of Japanese technologies, which are good at imitation and good at creating, the speed of catching up is important. The speed of catching up is not limited only the Japanese manufacturing industry after the war, since 1945; as indicated by the Great Buddha of Nara and the manufacture of guns, when Japanese come in contact with advanced civilization and culture, they are able to evaluate them honestly and incorporate them with a great determination. What was the secret that made this incredible speed of catching up possible? States simply, Japan already had the groundwork – the potential capability 0 to accept and absorb new technologies. For example, in the case of firearms, Japan had already accumulated advanced metal processing technologies, even before guns arrived in the country.

When examining Japan's speed of catching up from the perspective of this process of "obedience - breakdown - breakaway," for example, in the front lines of technologies possessed by the world's artisans, for generations, the work always involved participation in a common body of practice (a group). In that context, when one person mastered a new skill, the others all imitated it. During the teaching process, rather than having the teacher do all the work, the student was set free in the workplace and told to pick up on skills independently: "Rather than learning, just get used to it," or "watch and steal what you see." In other words, the learning process was a process of thorough imitation.

Even in the case of the arts in Kyoto, the concept of "obedience - breakdown - breakaway" has been around for many generations. First of all, the students learned the old traditional approaches, being thoroughly obedience to them. Then, once the students had sufficiently mastered the basic skills, they would gradually break down the old traditions, eventually breaking away from what they had learned, establishing completely original methods, in the form of a new "school."

Japanese people have thus adopted a stance that thorough imitation means learning, and have a history in which the adoption of this stance is a major premise behind demonstrating true creativity. In our modern world, this has come to be misunderstood – imitation is seen

as a lack of creativity – but this is only because the people who say this do not clearly understand the distinction of "breakdown" and "breakaway" in the process of "obedience - breakdown - breakaway." When "form" is established and recognized by people, after a time, people forget who it was that created the form in question, and it permeates through the culture. Still, the nature of that form as a model never disappears. People look up to that model, imitate it and learn from it, and practice so that they can make that form a part of their being. But this is more than just a simple imitation. Zeami Motokiyo, a Japanese actor, playwright, and drama theorist who lived in the 15th century, taught students to "learn well from the teacher and imitate him." Once the student has transcended that stage of learning, however, the goal is to transcend imitation: "Reach a level that is not imitation; if you become that thing, then there is no desire to imitate." The poet Matsuo Basho said of this process, "Enter that rank, and then leave it," and Kawakami Fuhaku of the Edosenke school named this process "obedience - breakdown - breakaway [Shu-ha-ri]." If we look back to our original theme, the students of Noh theater begin by using this form as a model, practicing and training while following the teacher; later, they will separate themselves from that form, eventually reaching a state where they are able to form their own style, based on their own free performance. This process of assimilating form was dubbed [Shu-ha-ri]; this "form learning" then became the pattern for practical education in the context of Japanese culture. In the backdrop of obedience - breakdown - breakaway [Shu-ha-ri], "Form" has many characteristics, including functionality, rationality, stability, continuity, and an artistic character. In the context of Japanese Monozukuri, form has the nature of a model and a standard, and has a dramatic effect on social and economic structures as the foundations of modern IT.

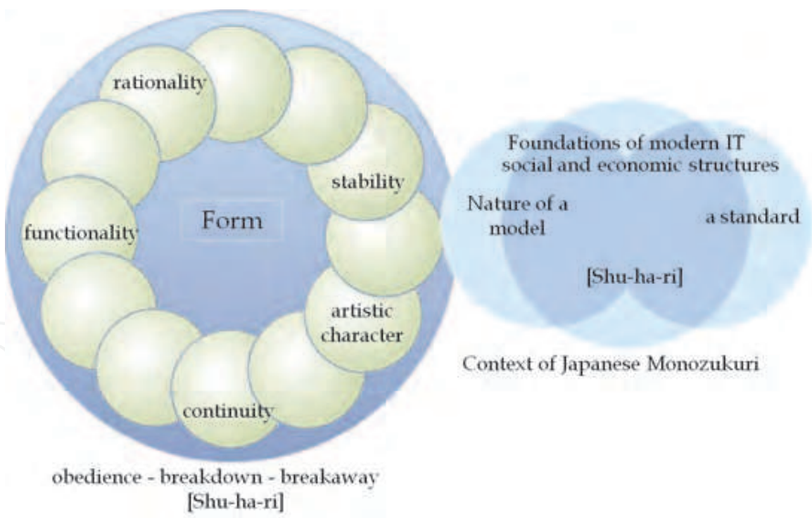


Fig. 11. Shu-ha-ri

## 7. Modern Monozukuri -software design

In modern Japan, the Internet and other information technologies were introduced from the west about 15 years ago, and have developed at a rapid pace. Both common bodies of practice and ICT are involved in fostering Monozukuri organizations that are suited to the digital economics of the 21st century. For people studying modern Monozukuri (software

design) in a school or a workplace, it is valuable to learn from examples of failure in order to resolve a variety of problems. Our goal will be to achieve more creative design by building a database of various failure examples, and present resolution measures to the organization.

## 8. ICT solutions

The first decade of the 21st century has passed. During this period, the key word of "economy" has undergone a transformation throughout the world. Over these first ten years, in the foreground of global economics and management, computer networks are now being used proactively. Information and knowledge obtained through these networks are creating new values and generating wealth in the world economy and indicating the need for ICT in economic strategies. In order to remain competitive in the current global market, ICT frameworks are imperatives as the era has arrived where we now need ICT to obtain new values and wealth. This way, ICT is becoming requisite in global environment and human resource to create the ICT is required. In Japan, in 2003, the subject of "Information" became compulsory, as one of the changes in educational policy for secondary education. This policy is one of the new cornerstones of human resource development, and Japan implemented the policy with the foresight to establish an on-coming ICT-supported knowledge-based society, of which, ICT was indispensable. As a system possessing the full adaptation of the organizational characteristics of Japanese cultural and traditional manufacturing, "*monozukuri*", human computing instruction system is important. In this field, it is necessary to incorporate so-called humanistic elements to understand human being, like creating elaborate traditional craftwork. Elaboration in *monozukuri* (manufacturing) has always been of the most significant for many Japanese products. By adapting ICT to these traditional concepts, the utmost of the elaboration is being asked for. To achieve the utmost in elaboration, the development of human resources is unarguably vital. Schools and business enterprises are now seeking to develop human resource capable of designing and developing integral products based on Japanese tradition.

Fig. 12. Study of Computing Science in University(Kushiro Public University)

This integration is truly an epoch-making idea for many multilateral issues and requires organizational communication to elaborately and seamlessly affix surfaces. Business enterprises attempting epoch-making ideas for the introduction of new strategies or problem solving procedures are making investments with futuristic perspectives, by foreseeing prospective changes expected to happen in mid-to-long terms, instead of making investment with traditional perspectives of thinking what to do for its products or management from analysis of its current situations. An example of this can be clearly seen with the development and introduction of a new IC card boarding system for Highway, railways and airlines in Japan. In adding a new service to a traditional service structure, and foreseeing profits in the future, a large investment was required for the development of ICT. This is genuinely a digital economic strategy.


Fig. 13. IC card boarding system(Airport Check-in and Highway payment system: ETC)

## 9. Young people education for digital economy strategies

In traditional economic strategies, it was believed that one could remain dominant for the long term. However, in the present world, a company's competitiveness in any given market is extremely short. For this reason, companies place importance on the generation of as many new ideas as possible; ideas such as those for services to generate profits or create values, and companies foster human resource to create these values.

In a knowledge-based society, a digital economy cannot be realized just by introducing computers to old structures. At least for the realization of the digital economy, organizations to materialize epoch-making ideas and success of information education to support new ideas are inevitable as premises.

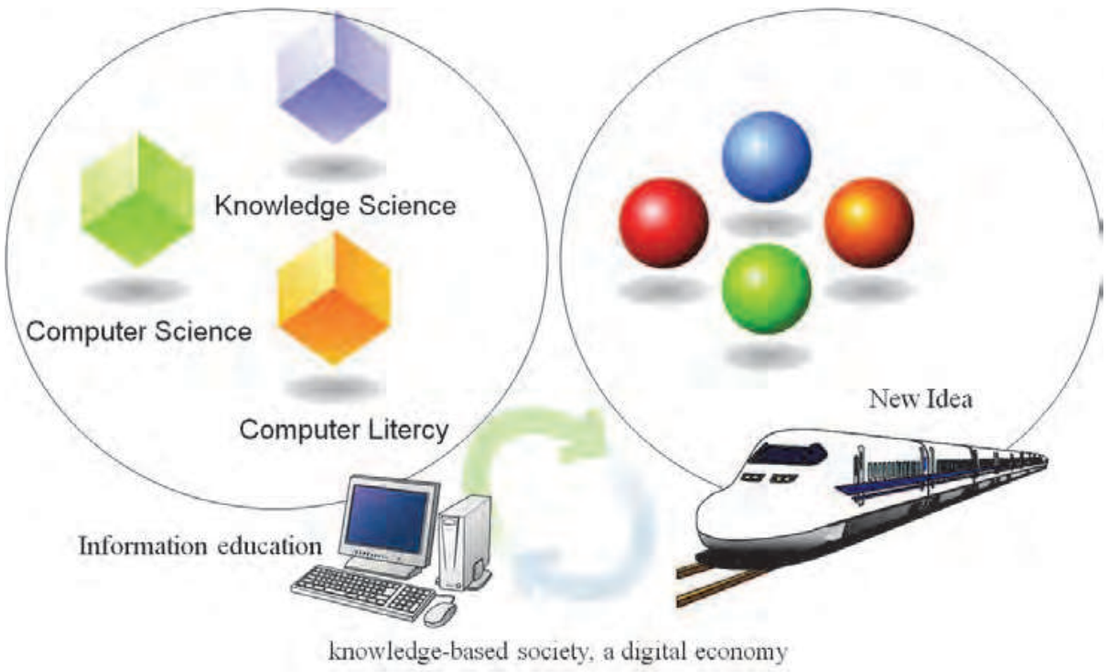


Fig. 14. Knowledge-based society Supported by epoch-making

Social science departments at universities in Japan have begun to admit the difficulty in solving issues in global competitions solely through the economic and management theoretical system called the old economy. Universities are now actively providing education to create digital economic business models with an emphasis on ICT. Recently, even in other fields, new value creations through the addition of ICT to traditional structures and systems has been sought and developed. It can be considered that whether or not to success in introduction of IT is leading actual economy in Japan. Since there are complex and multilateral issues regarding the direction to which the international society is heading, the necessity to create epoch-making values through the utilization of ICT is of extreme importance. After a decade in the new century and going through necessary revisions, high schools have also moved toward fostering human resources with the ability to create values by utilizing ICT through the introduction of "Society and information" and "Information science", and aim to create knowledge-based societies being asked for. The following section illustrates two examples of the fostering of human resources for a knowledge-based society.

## 10. Education1

The first example presents the education of human resources for the purpose of leading a knowledge-based society. The title of the research is Programming Through the Transferring of Skills to Non-Computer Science Majors from a research called establishment

of creative programming class environment and practices. For information education at universities, the introduction of standard curriculum for information-related departments is being discussed mainly for students with a Computer Science major. For non-CS majors, such as those majoring in the social sciences or teacher training, the introduction of standard information curriculum is not being discussed. From a global perspective, as issues for programming classes for students with non-CS majors, the followings can be included: the necessity for specific class structure while taking less background knowledge, interest, or eagerness of non-CS major students than CS major students or consideration for practical class development within limited time frame. This research proposes a methodology for the programming of classes for non-CS major students, and indicates its effectiveness through the comparison of results obtained from actual practices of the method over the past 3 years with those from earlier studies. The programming class is one of the few practical training classes for non-CS majors, and presents an opportunity for the students to experience and practice system establishment (*monozukuri* (manufacturing)).

In support of the classes, from the last school year, post-process related files created by students over the previous 2 years, including system source code, and class and Readme files, can be accessed on an exclusive server for the programming class. With this system, failed source code Tips for the past 2 years can be viewed and executed so that students can trace programming to date. Failed source code Tips which cannot be executed are offered together with Readme files attached filled with the know-how of the previous students.

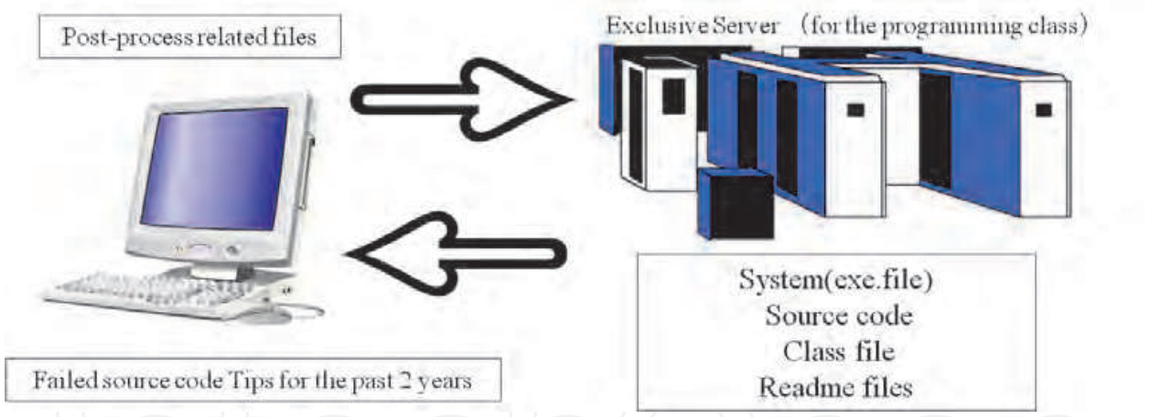


Fig. 15. Failed source code Tips view system

Preceding process and post-process are 2 divisions of the software development process, with the line which divides the two not clearly visible. In these two processes, knowledge spiral phenomena are anticipated when writing programs. In dividing the process in two, we considered that learning support methods for students would be different for the two processes. In other words, the learning of "precise sample codes for the description of classes" will be the preceding process, while the utilization of failed source codes of students in the past will be the post-process.

This division is related to characteristics of programming classes and also similar to the transferring methods for Japanese *monozukuri* (manufacturing) technologies.

This problem solving through education means that a high percentage of software development in Japan is being outsourced not only to western countries but also to Asian countries and that human resources to promote *monozukuri* (manufacturing) are not being

fostered in Japan. However, when actually practicing an educational method proposed in this research by commanding Java or C# language, it can be expected that even non-CS major students can obtain conception ability and achieve skilled *monozukuri* (manufacturing).

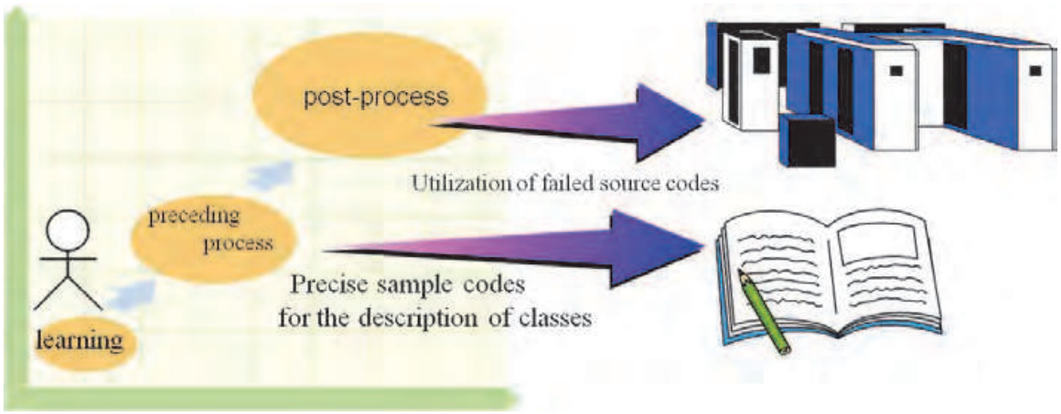


Fig. 16. Post-process and preceding process

Fig. 17. Class(Final Presentation) of non-CS major students

## 11. Education2

The second example is the establishment of a class environment through the utilization of SECI model theory with a method by clarifying weak points (WP) in learning. In this research, by focusing attention on the weak points (WP) of students in programming classes, we established a learning support environment and system to overcome those weak points (Anti Weak Point). Effective lecturing and a positive learning environment were realized by having students identifying their weak points (WP) by themselves to overcome them on 3 levels: as an individual, as a group, and as an organization.

Lectures on programming consist from 2 parts: teachers explaining the grammars of programming to students, and students learning these grammars. As can be seen in text examples published in the world, including Japan and western countries, a systematic understanding of these grammars consists of sections, including an overview of the program development environment, the kinds of variables, and the control statement.

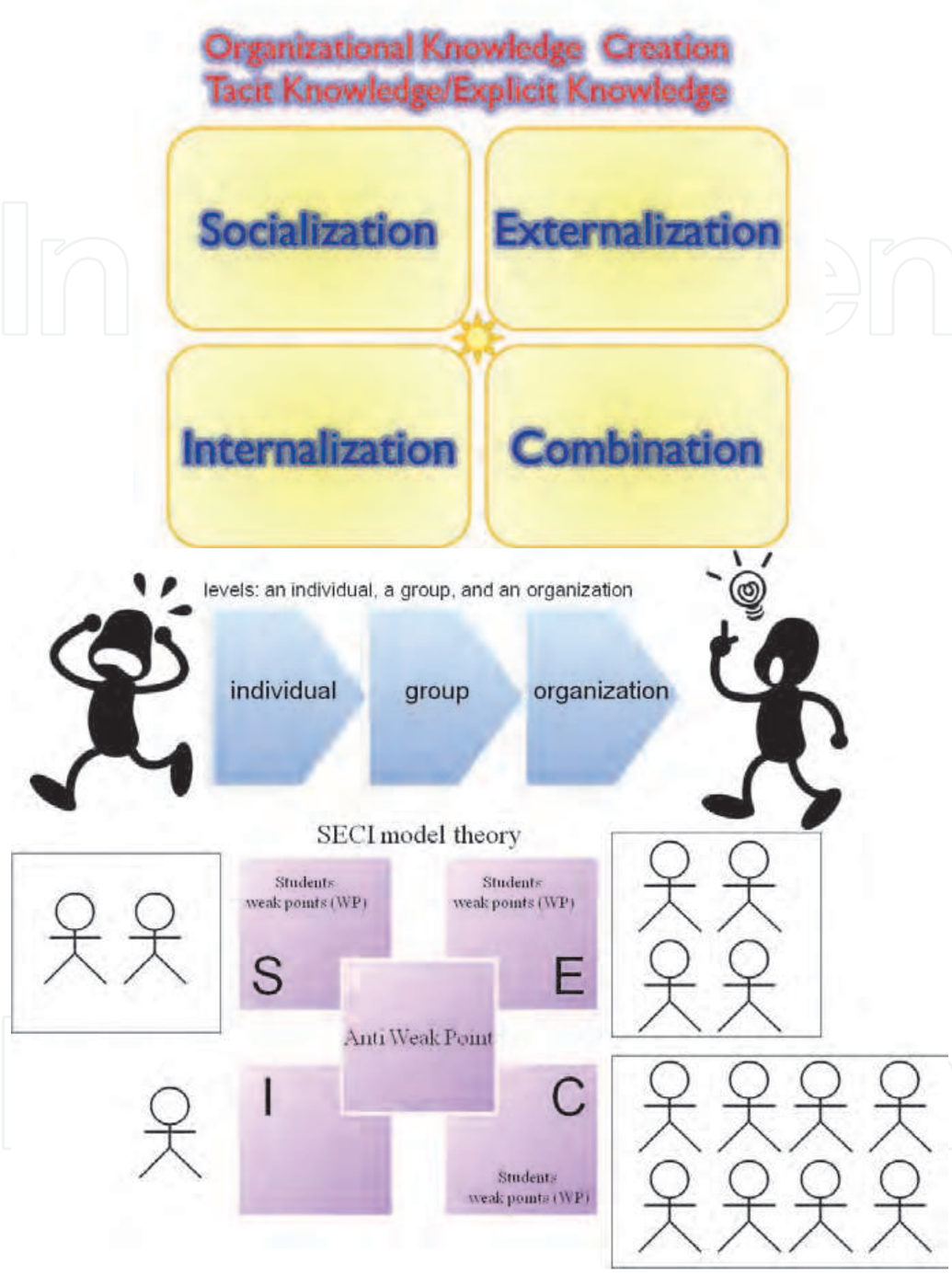


Fig. 18. SECI model theory with a method by clarifying weak points (WP) in learning

Without consecutively "combining" knowledge obtained in preceding sections with that to be obtained in sections to come, and "internalizing" the obtained knowledge as one's own, students cannot truly understand and apply the programming skills. In other words, understanding obtained from lectures should become each individual student's internalized knowledge. In understanding the contents of each section of lectures, each individual

student's capability varies in their extraction of meta-knowledge. Additionally, each student's knowledge is delivered from the lecture as explicit knowledge, and while some students are able to "combine" the explicit knowledge of each section of the lectures and obtain true knowledge, or tacit knowledge, others are only able to obtain explicit knowledge. Without being able to combine the various fragments of learning obtained from each lectures for tacit knowledge, students cannot write programs. Knowledge can be considered combinations of explicit knowledge obtained from lectures. While some students can combine the explicit knowledge from each lecture by themselves, others need groups or organizations for peer teaching to "socialize" and "combine" the explicit knowledge. In this research, we focused on the latter group of students, formulating a hypothesis, testing the hypothesis and studying the results.

In this research, we hypothesized that knowledge can be obtained by converting explicit knowledge to tacit knowledge. Based on this assumption, we supported the attainment of tacit knowledge to support programming ideas or creation as an organization.

The explicit knowledge obtained from lectures includes many weak points (WP) for students. Traditionally, group learning and quizzes have been used to solve these weak points of students but outcomes were not satisfactory. For instance, since questions in quizzes are fragmented parts of explicit knowledge from lectures and cannot be comprehensive, students cannot obtain the epoch-making knowledge (tacit knowledge) needed to write a program. Therefore, as a method to support the attainment of tacit knowledge, we clarified the students' weak points (WP) and had the students discuss the essential parts of the explicit knowledge in groups and an organization.

In the process to lead from descriptions of lectures to student understanding, knowledge is delivered from the instructor to students as explicit knowledge, which will then be converted to tacit knowledge. Students who cannot combine the explicit knowledge from each lecture by themselves often feel difficulties in understanding. In this research, we distributed record cards so that students could freely document their weak points (WP). We called these cards Weak Point Cards (WPC), and at the end of each lecture in the first and second half of the course, students were given approximately 5 minutes to write their weak points in the following manner: a maximum 150 Japanese characters divided into 5 points (no more than 30 characters for each point within 1 minute), leaving each comment short like a whisper. Writing WPC briefly can be used effectively as a metaphor to promote conversion of knowledge when communicating each student's murmuring of distress in learning at a later date. To actively promote understanding of descriptions and discussions in groups or organizations with the metaphors, we set a rule not to write their weak points in detail. Using the writing of WPCs as a starting point for the "socialization" of each student's tacit knowledge, by exchanging each other's WPC, students could often obtain ad-hoc opportunities to communicate with other students outside the classroom.

The explicit knowledge provided from instructors in lectures is merely understanding at one point. To promote socialization and the externalization of tacit knowledge among students, we had students write WPC at the end of each lecture of the course (a total of 12 lectures). For the "conceptualization" of weak points (WP), group participation is needed. Consequently, we divided students into groups of 4 to discuss and conceptualize their weak points for presentation. After presentation, groups are disbanded. In the second half of the course (classes 7-12), new groups of 4 members are created to further develop a system to overcome weak points (WP).

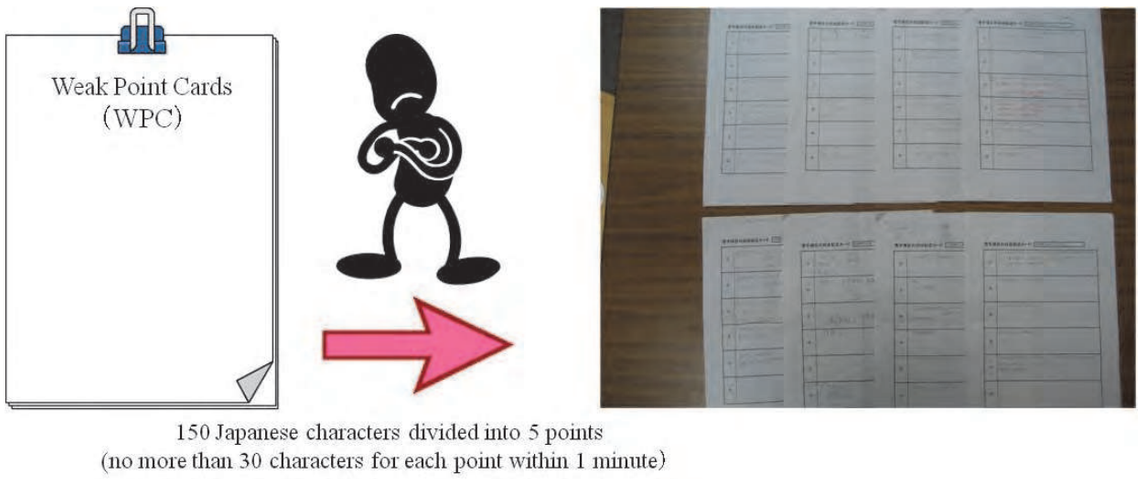


Fig. 19. Weak Point Cards

In writing WPCs as a method to find and record weak points (WP), as described previously, each student's weak points (WP) for each lecture are clarified as points for homework or review. However, to further utilize WPC, without socialization and externalization of tacit knowledge and exchanging WPC with others, new tacit knowledge cannot be obtained.

After every lecture, within limited number of characters, weak points (WP) of students were listed as "a whisper" on the WPCs. Examples of such whispers include: "2nd lecture; for sample codes and practice exercises, locations to designate local variables torture me (29 characters)" or "5th lecture; conditional branching processing of list contents. No, No, No (18 characters)".

By distributing WPC twice, once each for the first half and the second half of the course in order to supplement the argument in Figures, tacit knowledge can be obtained. The 1st attainment of tacit knowledge from WPC is as follows: In the middle of the course (in the 5th or the 6th class), WPCs are collected and groups of 4 students are created by randomly drawing cards. By exchanging WPCs with others and using metaphors for weak points (WP) to allow for a free discussion, students will obtain as much tacit knowledge as possible.

Utilizing WPCs in the latter part of the course (the 11th or the 12th class), an organization (in the beginning, an assembly like a group) to develop a learning support system to overcome weak points (WP), promotes the combination and externalization of knowledge obtained from WPC. As a general rule, groups of 4 members should be different for the first group in the first half of the course and the second group for the second half of the course. The new group of 4 persons will decide support targets to overcome the weak points (WP). To decide the groups, the instructor randomly picks a number of WPCs (the total number of WPCs divided by 4 equals the number of cards chosen). The first student chosen by the instructor will pick the 2nd member by looking at the back of their cards, each card with different pictures on it. This process continues until the last of the 4 members is picked in this manner. Pictures on the back of the cards used for the second half of the course are to maximize the chance of choosing different members for the first and second half of the course. When all of the members of a group are chosen, the 4 members will externalize and combine their WPCs to review and plan learning support measures to conquer their weak points (WP). Then, prior to their presentation, using Visual Studio ASP .NET C#, a system

development tool, students decide the name of their system, and create a flow chart and an image of their system to be developed by using a designer function of the development tool. Approximately four weeks later, after making any necessary adjustments after their presentation, students complete the assignment of developing a learning support system to overcome weak points (WP) for learning programming.

While WPCs were used to write down the weak points (WP) of each student, they were also used to convert the tacit knowledge of weak points (WP) to explicit knowledge, and help students obtain new tacit knowledge. Each WPC of 4 group members helped to clarify weak points (WP), review conceptual design to support overcoming the weak points, and obtain tacit knowledge which will be a structure for the learning support system. The conquering of weak points (Anti Weak Point System; AWPS) is to notice one's weak points (WP) and to support to create knowledge for learning support (Creativity Support System; CSS) to help students understand. For this reason, we named the system "CSS on the AWPS". With this system, while sharing one's weak points (WP) with others, and undergoing discussions in an organization and actual programming process, each student is able to obtain operational knowledge (new tacit knowledge) while overcoming his or her weak points (WP) in programming. Practicing with WPCs and actual system development process assists in the identification and clarification of weak points (WP) and tacit knowledge through creative planning and development, mainly brought about through the externalization and combination phases of explicit knowledge.

For the weak points (WP) of individual students in the first half of the course, (as described in Ⅰ, Ⅱ, Ⅲ, and Ⅳ), WPCs are utilized to write down each student's weak points in order to "socialize" the individual knowledge with a group. In the group, knowledge is "externalized" and "combined" to clearly "conceptualize" the whispered metaphors of the weak points (WP). In this process, each metaphor from the WPC triggers a topic for group discussion; a discussion starting from the socialization of knowledge by 2 or more members freely talking as individuals. Later, in the 5th or 6th lecture, discussions continue within the group as an "externalization" of knowledge. In the 11th or 12th lecture, discussions continue in new groups of 4 members in order to combine knowledge as an organization consisted of groups. Through this method, from our observations, it became obvious that relationships are formed for mutual learning. In this process of mutual learning, metaphors of weak points (WP) on WPCs are sometimes easily solved through the sharing of knowledge with others. In this combining of knowledge, weak points (WP) are found for "socialization", extracted for "externalization", and then "combined". The weak points are then converted into practical knowledge of programming (as internalized knowledge). The transition from WPC input to conceptualization of weak points (WP) to a development of learning support system clearly indicates that by organizing students, operational knowledge is created.

Though these 4 processes are based on our research practices in a programming course, this is similar to one of the theories for the creation of organizational knowledge. In this theory, Ⅱ and Ⅲ of Figure , a transition period can be described as follows: (Ⅱ) "a learning period through dialogues and actions" and "a period of knowledge spiral and changing of its contents". In this period, conceptual knowledge can be obtained from the externalization of weak points (WP) on WPCs. In Ⅲ and Ⅳ, through the organization of students, systematic knowledge is obtained by combining knowledge, and operational knowledge is obtained for the planning and development of learning support measures to overcome weak points (WP).

These illustrate a starting point for a SECI theory of socializing tacit knowledge to make it into explicit knowledge of weak points (WP) for discussion. It is necessary to set an opportunity for socialization and externalization in order to transform tacit knowledge to explicit knowledge by combining WPCs with others. In the first half of the course, WPCs are utilized to emphasize the socialization and externalization of weak points (WP) in shifting focus from the individual to the group as shown in Figure

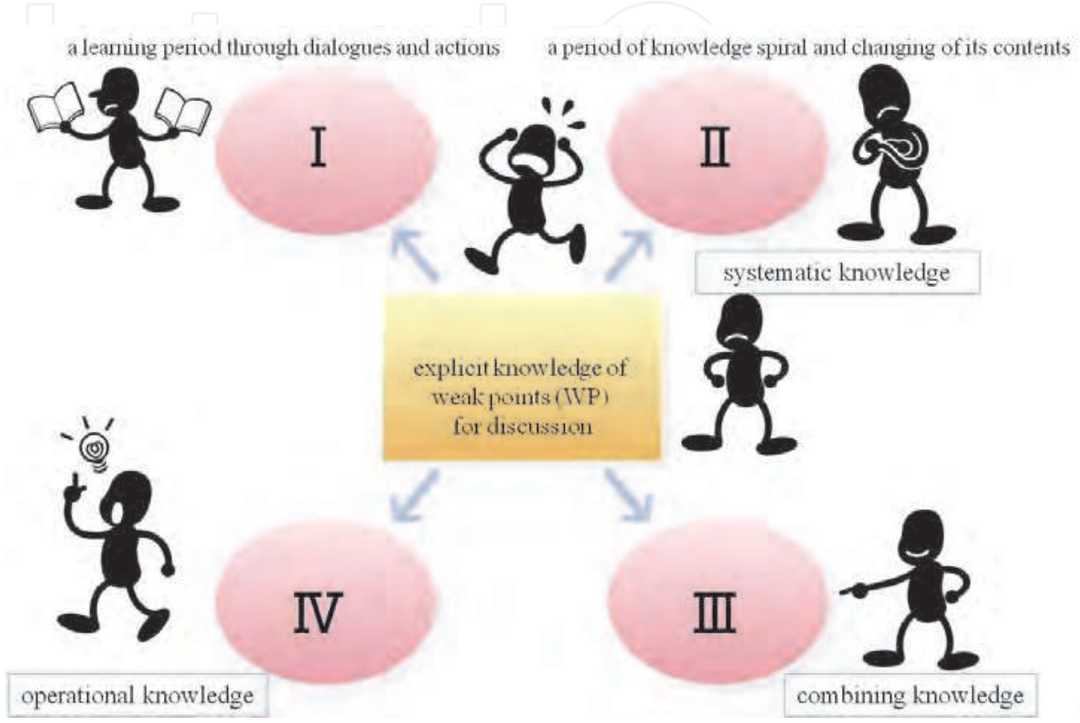


Fig. 20. Metaphors of weak points (WP) on WPCs

In the second half of the course, the WPCs from a wide range of students are utilized in the Combination and Internalization phases in order to combine explicit knowledge in an organization. Through Combination and Internalization, the conceptualization of weak points (WP) is promoted, and by investigating learning support measures, system design drawings were created. In the planning and development of AWPS, as for the shift from the group to the organization, since members are adjusted so that students can obtain operational knowledge of weak points (WP) of individuals by SECI theory, in the second half of the course, WPCs were utilized to obtain operational knowledge (tacit knowledge) from the organizational spiral as follows: the WPC allowed for the progression from sympathetic knowledge to conceptual knowledge, and then to systematic knowledge. As a result, AWPS was completed through phases of creating organizational knowledge. While learning with feedback involves the application of one's results to improve upon them, with AWPS, by reviewing the weak points (WP) of prior students, and by understanding potential drawbacks, students can make adjustments for the acquisition of skills to exert programming language. In this way, AWPS can provide feed-forward type learning control support. For use in the coming school year, in order to provide a feed-forward type learning support system with emphasis on prior course preparation by students to provide weak points (WP) and problem solving support beforehand, AWPSs will be gathered at the

interface. In this way, AWPS developed by students this year can be utilized by students in subsequent years.

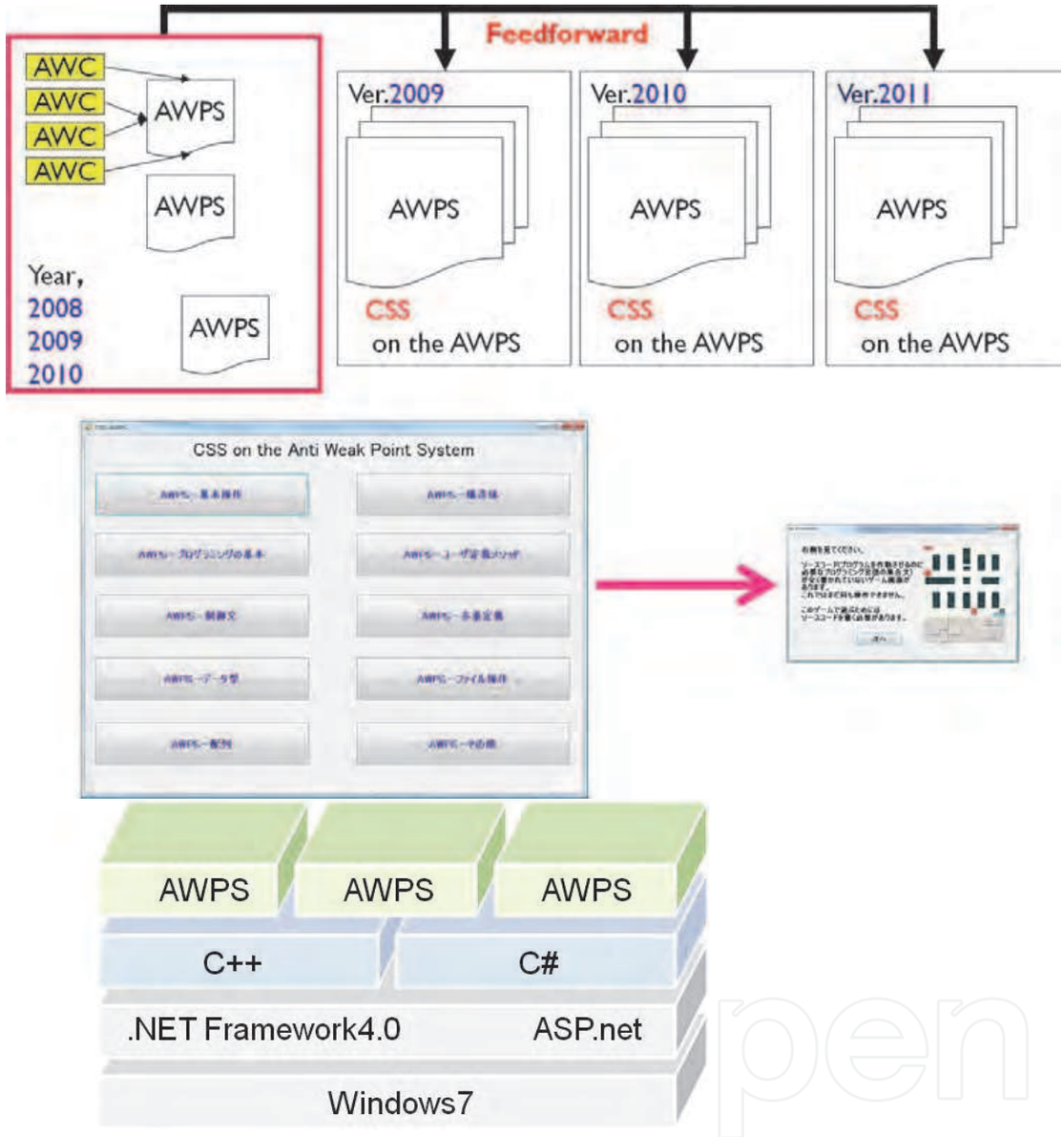


Fig. 21. AWPS system Window

For learning support to overcome weak points (WP), each student needs to combine the tacit knowledge of each class and convert the knowledge. This research showed that as a method to acquire knowledge, SECI theory in knowledge management is effective. In order to overcome weak points (WP) through an organizational knowledge spiral, this research indicated that by dividing the utilization of WPCs between the first and second half of the course, individual tacit knowledge steadily shifted to fit the SECI model. Though SECI theory is widely known, there are no reports of properly fitting the theory into corporate or educational learning environments.

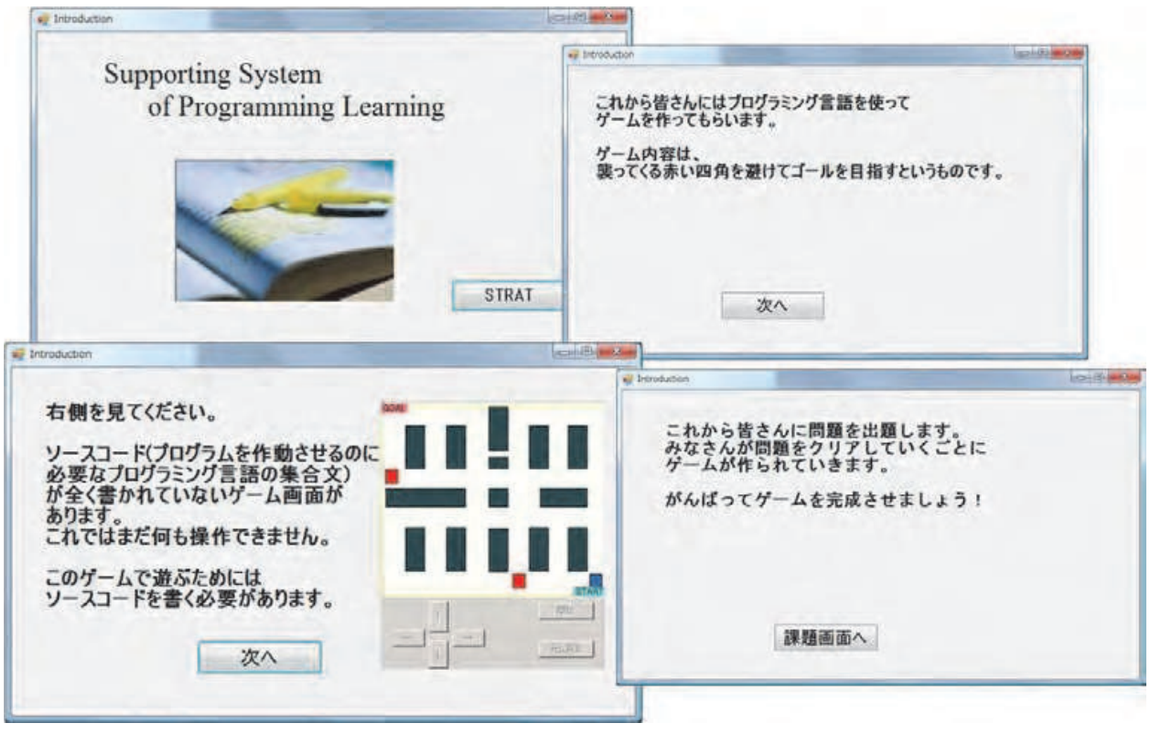


Fig. 22. AWPS contents(example)

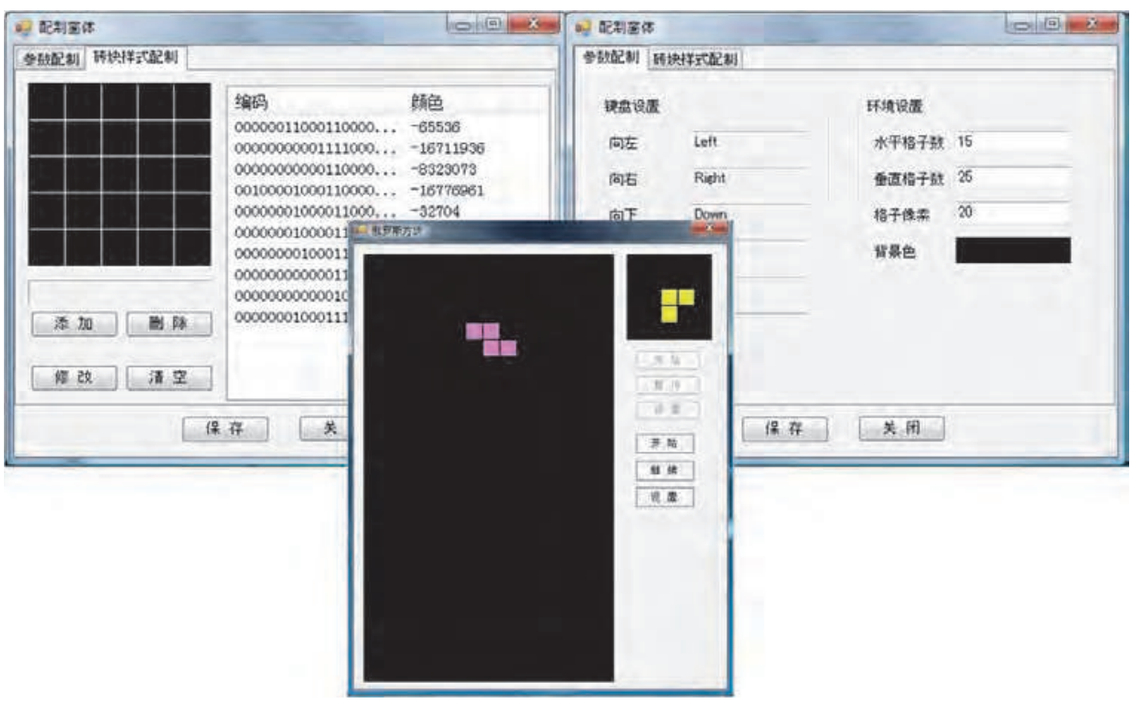


Fig. 23. AWPS contents(example2)

The procedure of whispering of weak points on WPCs after each class quite effectively fit into the S-E process. In the second half of the course, WPC metaphors effectively activated

the knowledge spiral during the C-I process. As a result, we concluded that our shuffling of members two times during the course, group knowledge was effectively converted to operational knowledge (internalization) as organizational knowledge. In the planning and development of the system, students derived (converted) knowledge to solve their weak points (WP), and systemized the knowledge to overcome weak points (WP) with the tacit knowledge for the learning support of others. Having students from subsequent years utilize the system, the creation of a knowledge bank to conquer weak points (WP) in programming learning can be utilized for a long time.

Fig. 24. The Sanzenin in Autumn (The leaves change color.)

Basically, educational and corporate organizations must play their respective roles, and must work together to promote activities related to the following items:

1. Maintain and pass on traditional technologies and skills, and foster the individuals who will be responsible for the next generation of traditional and cultural Monozukuri industries
2. Leverage traditional materials, technologies, and craftsmanship, and combine these with IT and other advanced technologies, to promote a new form of Monozukuri that is adapted to the changes in the times.

## 12. Conclusion

The traditional and cultural Monozukuri industries of Kyoto maintain and pass on traditional technologies and skills, while developing as industries that create lifestyle cultures that embody those traditions. At the same time, these industries promote a new form of Monozukuri that adapts to the changes in the times by combining traditional technologies with advanced technologies. In this way, they are expected to play a major role in achieving a richer cultural society. Furthermore, traditional and cultural Monozukuri industries will continue to be a target of admiration for people around the world, and this will contribute dramatically to increasing the appeal of Kyoto in the context of international society.

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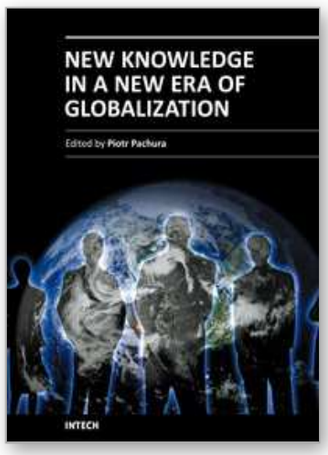


**New Knowledge in a New Era of Globalization**

Edited by Prof. Piotr Pachura

ISBN 978-953-307-501-3
Hard cover, 354 pages
**Publisher** InTech
**Published online** 01, August, 2011
**Published in print edition** August, 2011

To better understand the contemporary world, the world of innovation and technology, science should try to synthesize and assimilate social science in the development of our civilization. Does the new era require new knowledge? Does the age of globalization demand new education, new human attitudes? This books tries to clarify these questions. The book New Knowledge in a New Era of Globalization consists of 16 chapters divided into three sections: Globalization and Education; Globalization and Human Being; Globalization and Space. The Authors of respective chapters represent a great diversity of disciplines and methodological approaches as well as a variety of academic culture. This book is a valuable contribution and it will certainly be appreciated by a global community of scholars.




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