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# An Interpretation of Recent Technological Innovation in Traditional Craft Industry in Japan

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***Abstract*—We propose a methodology for archiving technological knowledge based on a methodology of knowledge integration and creation called the "Knowledge Pentagram System" or the "*i*-System" to pass down to future generations information and experience-based knowledge about past technical innovation. In this paper, we propose an approach to interpret experience-based knowledge and information about technological innovation by the methodology for archiving technological knowledge based on the *i*-System. We report the results of the interpretation of the technology development of the Kutani-ware industry.**

***Keywords*—interpretation, technological innovation, the *i*-System, knowledge base, knowledge synthesis**

## I. INTRODUCTION

In recent years, there are signs of a trend towards collecting knowledge on technological innovations, and passing down it to future generations [1]. Behind the trend is the fact that experience-based knowledge in technological innovations are rapidly being lost because of the retirement of technology developers who supported technological innovation from the postwar era down to the present.

For the miraculous economic growth in Japan after the Second World War, the role of technological innovation has been very important. More than half-a-century has passed since the war, and a huge number of technology developers who took part in technological innovation in Japan have retired from active duty. This means that Japan has been losing much wisdom of forerunners about experience-based knowledge in technological innovation. As a matter of course, a part of the wisdom of forerunners is saved by working papers or articles. But contents written in the working papers or articles are small portion of the technological innovation. That is, there were various twists and turns that are not written in the working papers or the articles to lead technological innovation. It is important to pass the experience-based knowledge that is not written in the working papers and the articles to future generations for technological innovation.

For all of these reasons, technological innovation in various fields such as optical industry, electric industry, steel industry, traditional craft industry, etc. are investigated in order to collect, analyze and interpret experience-based knowledge in technological innovation (knowledge base) [e.g., 2,3,4,5,6]. In addition, we are trying a knowledge base of the technological innovation in the traditional craft industries in Japan. In the next section, we describe the methodology.

## II. KNOWLEDGE BASE OF TECHNOLOGICAL INNOVATION IN THE TRADITIONAL CRAFT INDUSTRY

### A. Situation of Traditional Craft Industries in Japan

In addition to being important for regional economies, traditional craft industries have a high cultural value, as they involve techniques that are unique to the country where they are located. In August 2008, 210 items were designated as traditional craft items by the Minister of Economy, Trade and Industry (METI), and in 2006 the annual production value of traditional crafts was 177.3 billion JPY. However, in the 1980s the annual production of traditional crafts had maintained a value of about 500 billion JPY, so in a period of 20 years the production value decreased by less than half (see Fig. 1) [7].

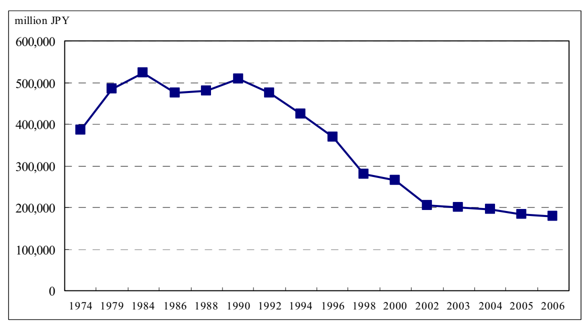


Figure 1. Annual production value of traditional craft industries in Japan

Seemingly, the traditional craft industry and technological innovations are unrelated. But the development of the traditional craft industry is not possible without the technology developers who have been supporting the production work of artisans and artists behind the scenes. In fact, various experience-based knowledge and information about the technological innovation in the traditional craft industry are certainly being lost by stagnation of the traditional craft industry. Thus, it is necessary to emphasize that we collect experience-based knowledge, and form a knowledge base while one has a chance. This is one of several ways to revive the flagging traditional craft industry.

### B. The i-System

When transferring experience in technological innovation of the 20th century to the 21st century, the problem of "what kind of data, information and knowledge to collect, organize and transmit, and how to go about it" arises. Therefore, we adapt the "*i*-System [8]" to the issue of the technological innovation in the traditional craft industry.

The *i*-System is a "methodology for synthesizing, integrating and creating knowledge", which integrates the "structure-capability paradigm of the West" and the "dialectic thinking of the East". It consists of the fronts of "cognitive-mental", "social-relational" and "scientific-actual". In each front, there are actors with the capabilities of "intelligence", "imagination" and "involvement", respectively. The methodology unifies "Intervention" and "Integration", the abilities of leaders and analysts to take action and to integrate their knowledge are inseparable (see Fig. 2).

As shown in Fig. 2, the *i*-System consists of five subsystems or requests five capabilities [9]:

- Intervention: For a problem to face, it is considered to solve a problem (problem establishment) that what kind of knowledge is necessary. Then, three subsystems (Imagination, Involvement, Intelligence) are asked to collect those knowledge.
- Imagination: Personal feeling and experience for the problem create ideas and hints.
- Involvement: The situation of the social and cultural background and opinions of people are collected by a meeting and an interview.
- Intelligence: Findings of scientific problems solving is created by an objective data collection and analysis.
- Integration: Findings of three capabilities (Imagination, Involvement, Intelligence) are integrated, and the result is evaluated.

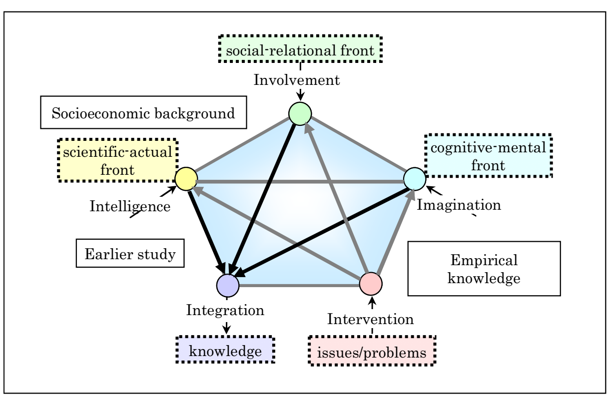


Figure 2. Conceptual diagram showing the *i*-System

We applied a systems methodology for the *i*-System to try to collect and organize information and experience-based knowledge about technical innovation in order to form a knowledge base of technology innovation in the traditional craft industry [10,11].

### C. A Methodology for Archiving Technological Knowledge

We investigated from what kind of resource we should collect knowledge with the use of the *i*-System. In the following three subsystems: Imagination, Involvement, Intelligence play a key role.

- Intervention: Here we collect information for problem establishment about technological innovation.
- Imagination: We interview persons who have been involved in technical development for many years. They might tell us about what they have focused on while engaged in technical development, and their ideals and thoughts. This enables us to gather knowledge to carry out the technological innovation.
- Involvement: To obtain information about individual technological innovation, previous research and case examples are investigated through the use of literature and interviews with people involved in the industry. The mutual relationship between society and culture is also focused on.
- Intelligence: Here we collect information mainly from articles and working papers about technological innovation. We collect and organize information such as experiment contents or results.
- Integration: Here we summarize collected knowledge and information. In each subsystem of the *i*-System, we consider above from what kind of resource we should collect knowledge.

However, just clearing up the target is not enough to solve the problem of "what kind of data, information and knowledge to collect, organize and transmit, and how to go about it". That is to say, we have to investigate what kind of information we collect in each subsystem of the *i*-System. We first carried out a brainstorming to consider concretely what kind of experience-based knowledge and information we collect in each subsystem of the *i*-System. As a result of the brainstorming, subsystem for Intervention 16 words, for Imagination 13 words, for Involvement 12 words, for Intelligence 12 words, and for Integration 15 words were obtained.

Then, we classified words obtained by the brainstorming with the KJ method [12]. According to the procedure of the KJ method, the close words are compiled in one place. We gave a category name for the set of words collected in one place. The following are the results of KJ method (see also Fig. 3) :

- In the subsystem Intervention, 16 words were divided into three categories. We named them "Spontaneous undertaking", "Requests from outside", and "Establishment of the problem".
- In the subsystem Imagination, 13 words were divided into three categories. We named them "Hints/Ideas", "Difficulties", "Thoughts about research and development".
- In the subsystem Involvement, 15 words were divided into four categories. We named them "Budget",

“Collaboration”, “Industry situation”, “Social/Cultural background”.

- In the subsystem Intelligence, 12 words were divided into three categories. We named them “Research content”, “Research equipment”, “Previous research”.
- In the subsystem Integration, 15 words were divided into five categories. We named them “Research results”, “Discussion of results”, “Evaluation”, “Discontinuation”, “Practical application”.

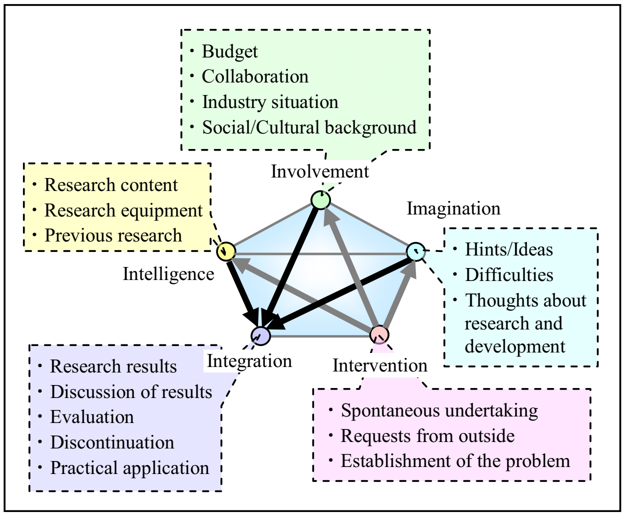


Figure 3. Specific expressions used for each front

Based on the above result, we collected and organized experience-based knowledge and information about technological innovation in the traditional craft industry, and formed a knowledge base.

*D. Knowledge base of technological innovation in the Kutani-ware industry*

The traditional craft industry used as the subject of the survey was Ishikawa Prefecture’s Kutani-ware industry. The reason for this is that Ishikawa is home to the Kutani-Ware Research Center of the Industrial Research Institute of Ishikawa (the former Kutani-Ware Research Institute), a public organization that specializes in giving technical support to the Kutani-ware industry. There are very few such public institutions with a traditional craft in their name in other traditional craft production areas-an indication that the Kutani Ware Research Center is likely to have a lot of information on technological innovation.

In order to form a knowledge base of technological innovation in the Kutani-ware industry, we carried out collection of working papers from the Kutani-Ware Research Center, and interview survey to technology developers using the methodology for archiving technological knowledge based on the *i*-System. The subjects of the survey were eight people involved with technical development in the Kutani-ware industry, who belonged to public organizations in Ishikawa Prefecture.

The interview started with basic, easy questions pertaining to the person’s personal history (number of years of work experience, job description, area of specialization), the trigger for starting the research, the production area’s needs in terms of research, information on the production area and the flow of the research. It continued with questions that gradually zeroed in on the essence of the research-about ways of solving problems that arise, the situation in terms of collaborators and cooperating organizations, the influence of research results on the production area, and thoughts about the research and changes in feelings at various stages. Questions tailored to each research project were added to these basic questions.

After being transcribed, the interview data is classified and organized according to the methodology for archiving technological knowledge based on the *i*-System that we proposed. As for the specific method of organization, the time-line for the technology development process was set as (1) Research trigger and background, (2) Study, (3) Research into practical applications, (4) Commercialization and (5) Improvement. The collected data for each stage was classified into the five subsystems of “Intervention”, “Imagination”, “Involvement”, “Intelligence” and “Integration”.

Part of collected and organized result pertaining to knowledge of the technological innovation in the Kutani-ware industry based on our methodology is shown in Fig. 4 and Fig. 5. Knowledge of the technological innovation is part of “the development of translucent porcelain” here. Due to space limitations the development of translucent porcelain is only partially reported on here.

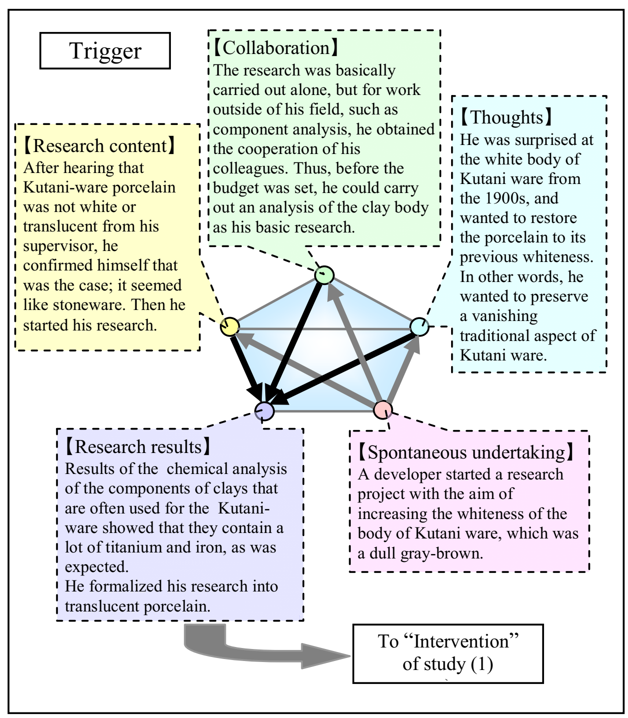


Figure 4. Trigger for development of translucent porcelain

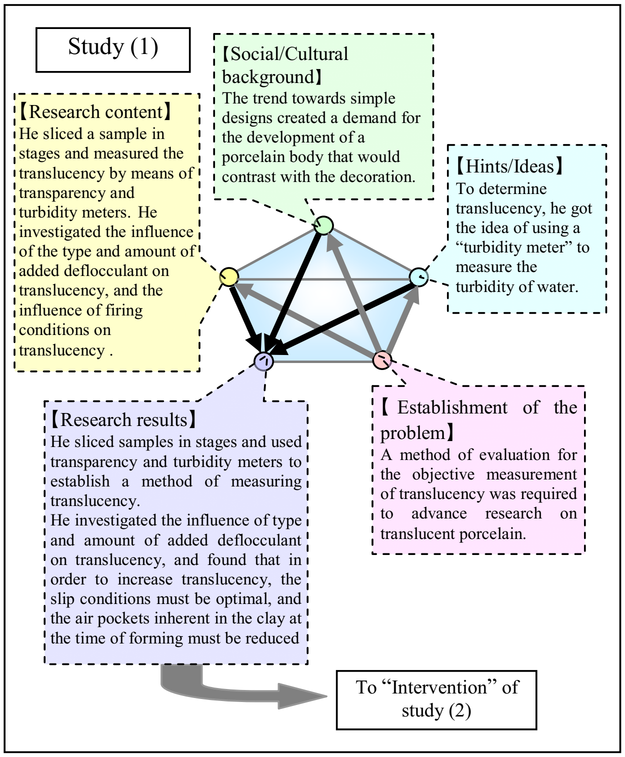


Figure 5. Research and development of translucent porcelain (1)

## III. THE PURPOSE OF THIS STUDY

We proposed a methodology for archiving technological knowledge based on the *i*-System to form a knowledge base of the technological innovation. We also formed a knowledge base of the technological innovation in the Kutani-ware industry based on the methodology that we proposed.

However, this methodology was confined to only the collection and organization of experience-based knowledge and information about the technological innovation. It is necessary for the collected and organized experience-based knowledge and information about the technological innovation to add an interpretation.

Therefore, in this study, we propose an approach to interpret the collected and organized experience-based knowledge and information about the technological innovation using the methodology for archiving technological knowledge based on the *i*-System.

## IV. THE INTERPRETATION APPROACH

We proceed with forming a knowledge base of the technological innovation in the Kutani-ware industry using the methodology for archiving technological knowledge based on the *i*-System. In the result, the process of most research and development was a linear model (see Fig. 6). At the time of research into practical applications, as a matter of course, technology developers cooperate with Kutani-ware companies. The process of this research and development may be a characteristic one of the technology development in the traditional craft industry.

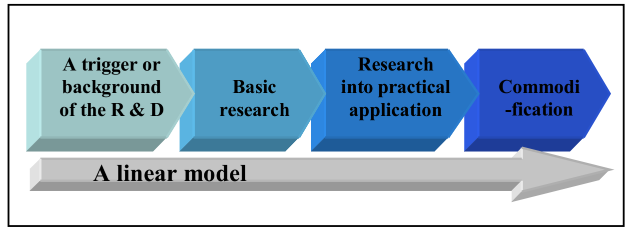


Figure 6. Characteristic of technology development in the traditional craft industry

In fact, the process of research and development on reflection corresponds to five subsystems of the *i*-System. That is, the correspondence of the process and five subsystems of the *i*-System is as follows:

- A trigger or background of the research and development: Intervention, Imagination, Intelligence, and Involvement.
- Basic research: Intelligence.
- Research into practical application: Intelligence and Involvement.
- Commodification: Integration.

Therefore, in this study, we apply each research and development process to subsystems of the *i*-System, and make a reconstruction in one the *i*-System. Then we try to interpret the research and development (see Fig. 7).

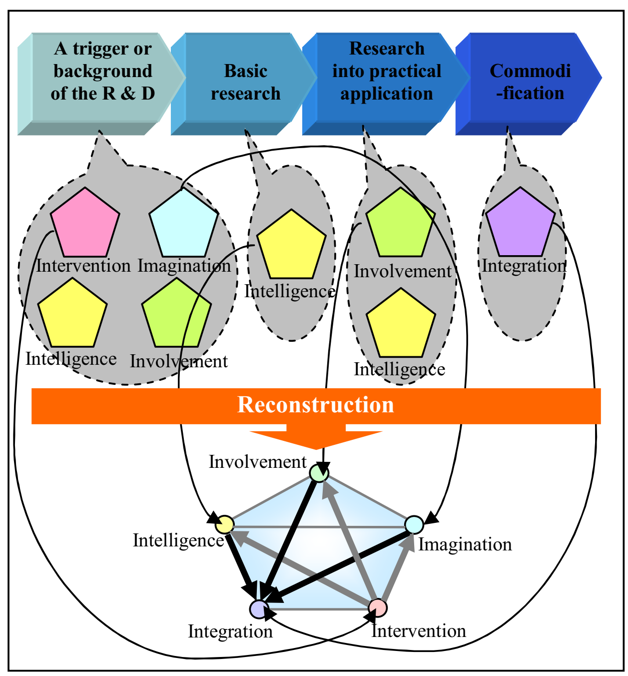


Figure 7. Concept of the interpretation approach

## V. Results of the Study

In this instance, we interpret the development of translucent porcelain as an example using the approach that we proposed. In addition, experience-based knowledge and information about the development of translucent porcelain was collected and organized using the methodology for archiving technological knowledge based on the *i*-System. The development of translucent porcelain was divided broadly into five researches and development processes. That is, the process of the development of translucent porcelain is a trigger of the research and development, basic research, research into practical applications and commodification. We investigated which five subsystems of the *i*-System corresponded to the research and development processes. the results are shown in Fig. 8. In addition, the interpretation of the development of translucent porcelain is shown in Fig. 9.

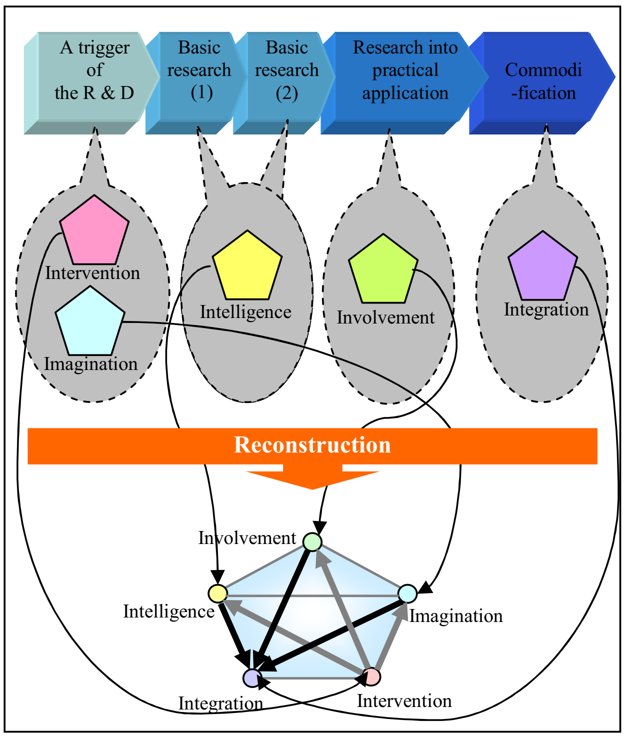


Figure 8. The development of translucent porcelain was divided into five subsystems of the *i*-System

At a gathering in Tokyo for a traditional craftsmen's exam, the technology developer's supervisor at the time was told by people from other traditional crafts production areas that the Kutani-ware was not porcelain. After hearing this from his supervisor, he looked up information on porcelain, and learned that porcelain is white in color and has some transparency. When he looked objectively at the body of Kutani-ware of that time, which was very argilliferous and of a dingy gray color, he felt that it was not porcelain. In this development of translucent porcelain, he was surprised at the white body of Kutani-ware from the 1900s (Meiji and Taisho periods), and wanted to restore the porcelain to its previous whiteness. In other words, he wanted to preserve a vanishing traditional aspect of the Kutani-ware. He started a research project with the aim of increasing the whiteness of the body of the Kutani-ware, which was a dull gray-brown.

An evaluation method to measure translucency objectively was necessary to proceed with the development of translucent porcelain. He got the idea of using a “turbidity meter” to measure the turbidity of water. Then, he sliced samples in stages and used transparency and turbidity meters to establish a method of measuring translucency. Next, since he knew from analytical research that had been carried out up until the previous fiscal year that the components causing the dull gray-brown color were iron and titanium, he researched materials that did not contain those components. He changed the ratio of the formulation many times and carried out repeated tests. The procedure for the tests was as follows. (Analysis → Formulation → Pulverization → Forming → Firing → Evaluation of translucency and whiteness → back to analysis) As the test results approached his objective, he greatly increased the amount of materials used, and carried out productivity (mass production) tests.

After a presentation on translucent porcelain by the Kutani-Ware Research Institute for the Kutani-ware industry, the technology developer's personal connections made it possible for a company of Kutani-ware to ask if they could use the material that he had developed for their white porcelain to be supplied to the Imperial Household Agency. In addition, among 300 submissions form companies all over Japan, translucent porcelain tableware by the company of Kutani-ware was selected for the Imperial Household Agency to commemorate the coronation ceremony, and the company of Kutani-ware received an order. The product development for the Imperial Household Agency was the first step in the commercialization of translucent porcelain.

In the result of Involvement, Imagination and Intelligence were integrated, the production technologies (roller machine forming, pressure casting, slip casting and wheel throwing) for translucent porcelain manufacturing was established and transferred to clay companies in the Kutani-ware industry. Then, companies began to commercialize products made of translucent porcelain. Taking advantage of the characteristics of whiteness and translucency, they developed and commercialized lighting fixtures (lamps, gatepost lighting, etc.). Simple designs and decorations that took advantage of the whiteness of the ceramic body started to be used.

The above is an interpretation of the development of translucent porcelain. Furthermore, we can suppose success factors of the development of translucent porcelain as “strong thought for the research and development of the technology developer”, “a collaborative relationship with the company of Kutani-ware”, “the establishment of a new study method”. There is a possibility that the successful research and development uses the five subsystems of the *i*-System properly. If this hypothesis is right, a technology developer can know which subsystems of the *i*-system are not enough when the research and development does not go well. Verification of this hypothesis is a future work.

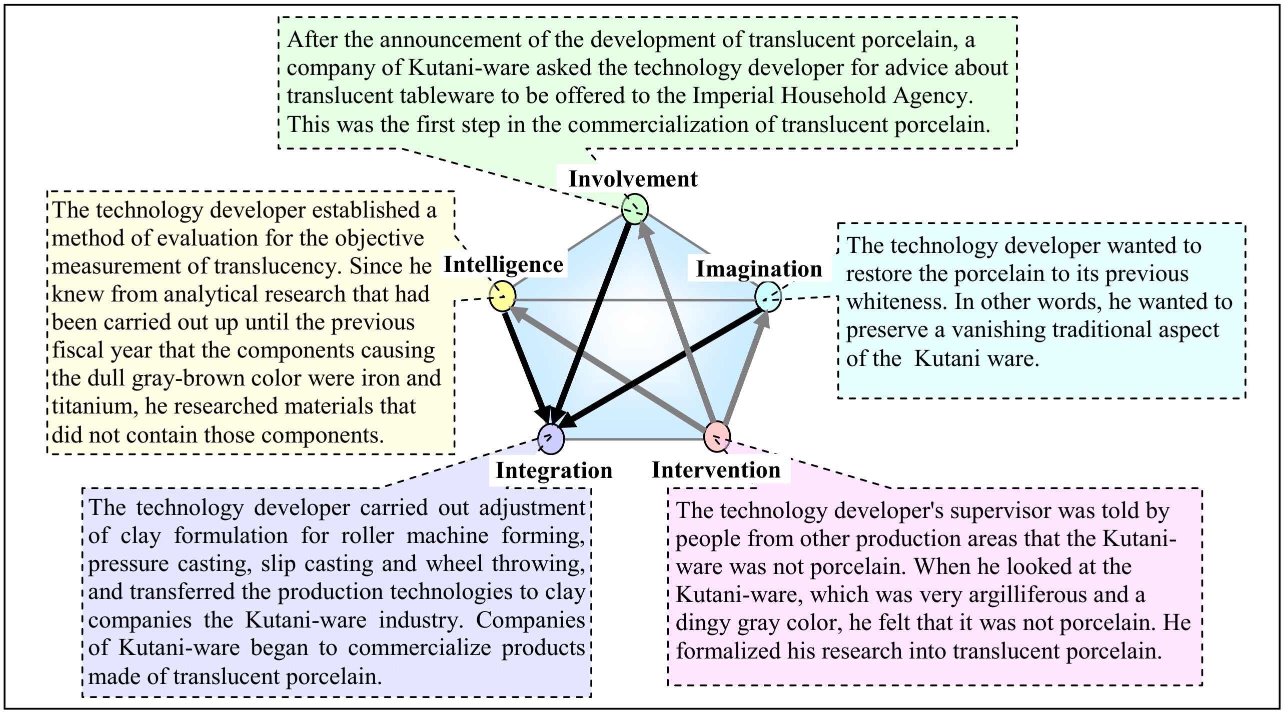


Figure 9. The interpretation of the development of translucent porcelain

## VI. CONCLUSION

We proposed a methodology for archiving technological knowledge based on the *i*-System to pass down to future generations experience-based knowledge and information about past technical innovation. We also formed a knowledge base of technological innovation in the Kutani-ware industry based on this methodology. In addition, we proposed an approach to interpret experience-based knowledge and information about the technological innovation collected and organized by the methodology for archiving technological knowledge based on the *i*-System. Then, we carried out an interpretation about the development of translucent porcelain using this interpretation approach. In the future, we carry out an interpretation with the same approach for other research and the development of the Kutani-ware industry. Furthermore, we try to determinate whether successful research and development used the five subsystems of the *i*-System properly.

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