Establishment and Utilization of Technological Knowledge Global Sharing System

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In OMRON's factory automation business, engineers around the world provide effective technical solutions to address customer manufacturing issues, in order to bring more value to customers. For further acceleration, we built a system to formalize the technical know-how and to share and to utilize globally, which beforehand, remained within individual engineers or within each region. We setup and classified technological knowledge as the outcome of engineers' activities, such as technology developments, feasibility studies, verifications, and operational manuals, in order to lessen the burden of engineers and lead to continuous increase of technological accumulation. As for the global sharing system, we developed a mechanism for users to access technological knowledge that they can freely utilize without the worry of handling of technologies such as export control. The amount of technological knowledge accesses between regions increased 2.8 times from the first month of release because of this mechanism and the extensive information sharing through the steady increase in technological knowledge. Furthermore, as the results above, two years after the system release, customer deployment cases have increased 3.0 times from the initial month of release, which reflects the contribution to customer issue resolutions and OMRON's factory automation business.

1. Introduction

Recently in the manufacturing industry, sustainable productivity improvement and quality improvement are promoted while addressing the social requirements and issues of the diversity of consumer needs, carbon neutral, and labor shortage due to the decreasing birth rate and aging population. For these issues in the manufacturing site, the Industrial Automation Business Company of OMRON provides the technological solutions for solving the manufacturing site issues of individual customers assisted by the large accumulation of over 200,000 product items. Specifically, engineers deployed in six global areas (Japan, China, Korea, Asia Pacific, America, and Europe) where the locations are close to manufacturing sites of customers and provide solutions for the issues specific to the industry and producing items or the issues of the improvement of tact time in manufacturing processes and equipment and the improvement of inspection performance to individual customers by combining the wide range of products, such as sensors, PLC, drives, and robots, and the technology, such as control, AI and IoT[1].

In addition, the solutions of issues of customer and the enlargement of the OMRON's factory automation business is aimed by globally accelerating the quality, the quantity, and the speed of providing these solutions.

1.1 Definition of technological knowledge

Knowledge is defined by the Merriam-Webster[2] Dictionary as follows:

(1) The fact or condition of knowing something with familiarity gained through experience or association.
(2) Acquaintance with or understanding of a science, art, or technique.

Along with the definition of the above dictionary, this paper assumes the technological knowledge as "knowledge and understanding acquired through experience using technology" documented to the format deployable to others having similar knowledge and skill.

2. Issues

Solutions for issues in the manufacturing sites of customers require the algorithm using high level technology of control, motion, image processing, AI, and robotics and the utilization technology of a product or multiple products. Sharing of this

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technological knowledge by the engineers deployed towards each area prevents double development, and the acquisition of rich findings enables the improvement of quality by providing solutions and improvements in efficiency. Issues and measure policy for globally deployed technological knowledge and sharing between engineers are shown in Table 1.

Table 1 Issues and measure policies

Issue	Explanation	Measure policy
(1) Turn technology, knowledge and skill possessed by engineer into explicit knowledge	Since technological knowledge so far remains in individual engineers and areas, the clarification in what form and content it should be verbalized is required.	Systemize in form that has light burden for user who registers technological knowledge and that corresponds to role and activity.
(2) Create mechanism for globally sharing technological knowledge	Construction and operation of information system that holds and shares technological knowledge between engineers who are globally enrolled are required.	• Realize system configuration and function corresponding to the above issue (1). • Since laws and regulations regarding intellectual property right and export control are different depending on regions and countries, possession, and control should belong to each area. • Technological knowledge can be unitarily utilized from the system without burden of user side for dealing with compliance for convenience of user and without being aware of sharing inside and outside the area.

Hereafter, measures for issues (1) and (2), especially issue (2) for which the measure has high degree of difficulty, are described in detail.

3. Measures

3.1 Turning technological knowledge possessed by engineer into explicit knowledge

Approaches for turning into technological knowledge were so far implemented in multiple areas and turning into explicit knowledge was promoted by summarizing those methods.

In each area, there are roughly two types of engineers. First, they are engineers whose roles are to provide solutions to the manufacturing sites of customers utilizing technology, and they are called FEs (field engineers). Second, they are engineers whose roles are to possess and develop technology or to perform the technological rear assistance for FEs, and they are called AEs (Application Engineers).

In order to turn technological knowledge into explicit knowledge, the systemization was performed from the viewpoint in line with the role and the activity of the above engineers, and the documentation of the results of their business activities as technological knowledge was enabled. These are specifically shown in Table 2.

Table 2 Types of technological knowledge to be turned into explicit knowledge

Types of technological knowledge	Specific technological knowledge
Technological knowledge relating to technological development and technological assistance (mainly role for AE)	Explanation of technological outline
	Materials for training
	Program operation manual
	Sample program
	Sample of technological proposal
	Utilization know-how, procedure and precautions
Technological knowledge relating to technological utilization and proposal of solution (mainly role for FE)	Results of demonstration experiment
	Results and cases of introduction
	Utilization know-how, procedure and precautions

Furthermore, the above types and contents were shown to engineers as guides in order to address operations, and the preparation and the sharing of technological knowledge without a burden to engineers were enabled under normal business operations. In addition, among technological knowledge, the template of technological knowledge items that have high commonality in technological outline explanations and introduction case results and that positively promote the utilization by users was created so as to enable the easy description of the same level by creating a template.

3.2 Mechanism of global sharing of technological knowledge
3.2.1 System configuration
Advantages for system development were utilized through the optimization of the construction of a library and data list, a certain guarantee of information security, and the availability of all user accounts by using OMRON's standard IT infrastructure Microsoft Office 365, SharePoint Online[3], as the system platform.

In order to reflect the technological knowledge control in the individual areas, it was decided to configure as other site collections separated for each area and decided to store the technological knowledge limited inside an area and the technological knowledge capable of sharing all areas for dispatching from the area concerned regarding the entity of technological knowledge (file, folder, and property information, such as an author, a creation date, a technology type that are associated with them). The home site is positioned as the portal, and it is used only for the publication of the news articles, announcements from the system administrator, and the manual to be utilized. The general configuration is shown in Fig. 1. In addition, the storage of documentation was facilitated by arranging libraries, such as Software, Training, Technical Notes, Feasibility Studies, and Success Stories, based on technological knowledge on the site of each area.

This configuration, as the system, clarified the control

category by each area. It was decided that the Technological Development Division as the supervisor is in charge of the total system and the home site. In addition, the area representative is selected in each area to be in charge of administration of its own area site and utilization promotion. This enabled in each area to easily and flexibly manage technological knowledge , administer users, and perform area-specific utilization method.
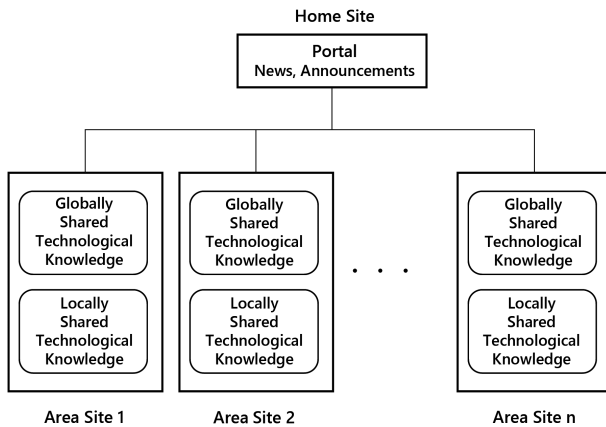
Home Site

Fig. 1 Configuration of global technological knowledge system

3.2.2 Range of disclosure of technological knowledge

It is preferrable for technological knowledge to be shared and utilized across areas. On the other hand, as mentioned in the chapter on issues, there is some technological knowledge where the range of disclosure cannot avoid being limited from the viewpoint of intellectual property or export control depending on the technological characteristics, and its range setting will be based on the judgment of the area that publishes the technological knowledge. Furthermore, it is desirable that the technological knowledge that the user can access be utilizable without being aware of the range of disclosure and compliance realization.

In order to deal with these factors, individual technological knowledge was provided with the property of the range of disclosure, and the function that controls access according to the set range of disclosure was realized. Mechanisms for setting the range of disclosure for storing technological knowledge in the system and enabling the access corresponding to the range of disclosure is as follows:

Mechanism for registering range of disclosure

(1) System setting in advance
  ▪ Set four types of authority group consisting of "Local AE," "Local FE," "AE of other area," and "FE of other area" in the site of each area.
  ▪ Register AE and FE members belonging to local area in each site in "Local AE" and "Local FE," respectively, and

AE and FE members of other area in "AE of other area" and "FE of other area," respectively. For example, When three areas X, Y, and Z exist, user registration is performed at each site as shown in Table 3.

Table 3 Examples of setting authority groups in each area

Authority group and area	Area X	Area Y	Area Z
Local AE	AE user of area X	AE user of area Y	AE user of area Z
Local FE	FE user of area X	FE user of area Y	FE user of area Z
AE of other area	AE user of areas Y and Z	AE user of areas X and Z	AE user of areas X and Y
FE of other area	FE user of areas Y and Z	FE user of areas X and Z	FE user of areas X and Y

▪ Three types of range of disclosure for technological knowledge defined
  ▪ "Local 1" is technological knowledge shared between AE members, such as technology under development, and its range of disclosure is limited to local AE users.
  ▪ "Local 2" is technological knowledge limited to sharing inside the area from the viewpoint of laws of intellectual property and export control, and only the users of local AE and local FE have access to it.
  ▪ "Global" is technological knowledge without legal limitations and deployable, and all the users have access to it.

These disclosure ranges and typical characteristics of technological knowledge shared in that range are summarized in Table 4.

Table 4 Range of disclosure and characteristics of technological knowledge

Disclosure range	User with accessibility	Characteristics of technological knowledge
Local 1	Local AE user	Technology under development
Local 2	Local AE and local FE users	Technology with legal limitation
Global	All users	Deployable technology including legally

(2) Registration of technological knowledge by user
When registering technological knowledge, the user sets one of the ranges of disclosure from the above three types corresponding to its characteristic. Furthermore, it is decided that the area representative who is the user with privileges for the area concerned approves the operation.

(3) Disclosure range setting by system
Entity of technological knowledge, specifically one item of SharePoint Online, is provided with the access authority corresponding to the property of the disclosure range setting and is stored in the site of the local area.

3.2.3 Access range setting in technological knowledge within global disclosure range

Although the users of their own area naturally have access to technological knowledge if it is within the global disclosure range, the users of other areas also have access. However, there are cases in which the ability to deploy or the necessity to do so differs depending on technological knowledge, such as the technological knowledge having the risk of insufficient support because technology not possessed by AE that is rear assistance troop is used, and technological knowledge that has low marketability because it is technology for the specific industry. It is necessary that AEs can judge and set the deployment of such technological knowledge to their own area. Therefore, we realized the following mechanism for this issue:

- Only the user having the AE user authority group of another area can have access to the initial condition of the information globally disclosed.
- When the user who has access to technological knowledge judges that it is deployable after checking the contents, the disclosure setting is performed. Furthermore, the representative of the area who is a privileged user of the area concerned makes the decision to perform the disclosure setting operation.
- The system performs processing to allow the FE member of only the area concerned access to technological knowledge by checking the area to which the user belongs.

For example, the disclosure range setting for technological knowledge in area X and the procedure of accessing to it in areas X, Y and Z are as follows:

- User of area X registers technological knowledge prepared in area X within the global disclosure range. Under this condition, the AE and FE users of area X and the AE users of areas Y and Z can have access to it.
- The AE members in area Y check the content of technological knowledge, judge that it is deployable in area Y, and perform the disclosure operation.
- The system provides the access right also to the FE members belonging to area Y to allow them access to it.

Four types of access of disclosure setting for (1) Local 1, (2) Local 2, (3) Global, and (4) Global and area Y in the technological knowledge registered in area X according to the above disclosure range setting are shown in Table 5.

Table 5 Accessibility of area user to technological knowledge in disclosure range setting

Area user/ disclosure range	Local 1	Local 2	Global	Global (Area Y disclosure)
AE at area X	Accessible	Accessible	Accessible	Accessible
FE at area X	Not accessible			
AE at area Y				
FE at area Y		Not accessible	Not accessible	
AE at area Z			Accessible	
FE at area Z			Not accessible	Not accessible

In addition, the system compares the disclosure range setting provided to the registered technological knowledge (visibility column in an example of diagram below) with the area disclosure setting (shared with FEs column in an example of diagram below) corresponding to the authority group to which the user belongs, and only technological knowledge within the accessible range for the user is displayed. The display results of technological knowledge in the real system corresponding to the authority group to which the user belongs are shown in Figs. 2–5. Furthermore, the diagrams below are the illustrations of examples where disclosure setting processing is performed only for the FE users in Area Y, and even if the FE user in an area other than Y attempts to gain access, nothing is displayed.

As mentioned above, in order to register technological knowledge, the setting of the appropriate disclosure range corresponding to the characteristic of that technology is required.

However, comparing the disclosure range setting with the area disclosure setting like this allowed user to realize the convenience to freely utilize technological knowledge in the accessible range.

4. Results and consideration

4.1 Results

Two years elapsed since the formal release of the system, and the achievement of the cumulative amount of technological knowledge and the number of accesses between areas (relative comparison with the first month of release, respectively) are satisfactory as shown in Figs. 6 and 7. Moreover, the cumulative amount of technological knowledge in the initial month is the amount of globally deployed technological knowledge that was shared within the local area so far.

4.2 Consideration of technological knowledge accumulation

The system has grown so that it can share the cumulative amount of technological knowledge 2.8 times in comparison with the amount in the start month. We consider the reason as follows:

Name ∨	Description ∨	Shared with FEs	Visibility ∨
Global Knowledge B	Global, accessible to Area Y FE and other area AE	Site Y	Public global
Global Knowledge A	Global, accessible to other area AE		Public global
Local2 Knowledge	Accessible to Area Y AE and FE		Public to AE and FE
Local1 Knowledge	Accessible to Area Y AE only		Public to AE

Fig. 2 Accessible range of area X AE user

Name ∨	Description ∨	Shared with FEs	Visibility ∨
Global Knowledge B	Global, accessible to Area Y FE and other area AE	Site Y	Public global
Global Knowledge A	Global, accessible to other area AE		Public global
Local2 Knowledge	Accessible to Area Y AE and FE		Public to AE and FE

Fig. 3 Accessible range of area X FE user

Name ∨	Description ∨	Shared with FEs	Visibility ∨
Global Knowledge B	Global, accessible to Area Y FE and other area AE	Site Y	Public global
Global Knowledge A	Global, accessible to other area AE		Public global

Fig. 4 Accessible range of other area AE user

Name ∨	Description ∨	Shared with FEs	Visibility ∨
Global Knowledge B	Global, accessible to Area Y FE and other area AE	Site Y	Public global

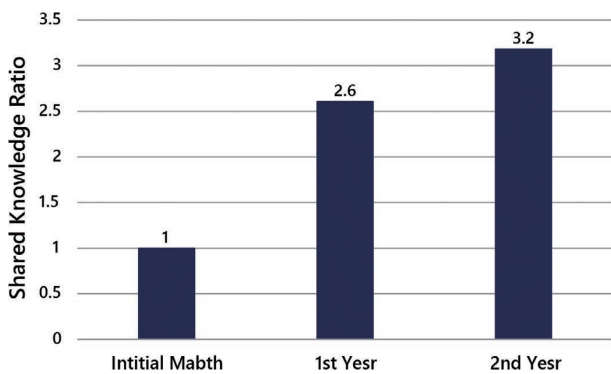**Fig. 5** Accessible range of area Y FE user

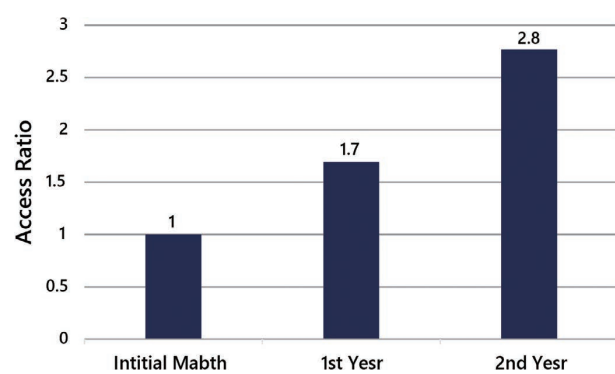**Fig. 6** Cumulative number ratio of technological knowledge

Fig. 7 Access ratio of technological knowledge between areas

- Since the technological knowledge documents the outcome of the normal business operations of engineers, it could be prepared without an excessive burden.
- The documentation of technological knowledge that individual engineers turned into tacit knowledge was promoted by systemizing technological knowledge to be documented and showing it as the guide.

- The voluntary accumulation in each area was promoted by the operation that controls technological knowledge in each area. Specifically, the operation that relates the number of registrations of this technological knowledge system to the achievement evaluation of engineers was performed in some areas.

4.3 Consideration in access between areas

We consider the reason of having realized the active access between areas as follows:

- The mechanism where technological knowledge accessible by each user can be freely utilized without worrying about the restrictions concerning dealing with compliance was realized.
- The technological knowledge normally used by engineers was unified into this system.
- The satisfactory increase of technological knowledge enabled access to technological knowledge that was always fresh.

In the cases of the introduction by customers created as the outcome of providing solutions to customers, the number of introductions by customers having the effects of the value provided to customers 3.0 times the number of introductions in comparison with that of the initial month was obtained by these synergistic effects for the original purpose of sharing technological knowledge as shown in Fig. 8.
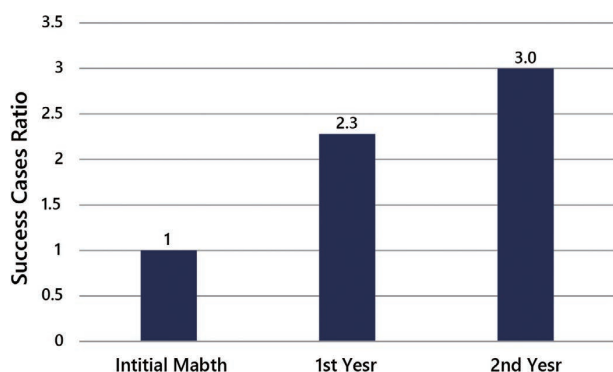

Fig. 8 Ratio of the number of cumulative cases of introduction by customers

5. Conclusions

The issues in the acceleration of providing technological solution corresponding to the issue of the manufacturing site of the customer are (1) to turn the technological knowledge and skill possessed by engineers in each area into explicit knowledge and (2) to create the mechanism for globally sharing the technological knowledge that was turned into explicit knowledge. We constructed the system for sharing and utilizing knowledge between engineers who are deployed globally by making technological knowledge have the form with a low burden for the user who registers technological knowledge and corresponding to the role as the measure for these. As a result, the accumulation and the sharing of technological knowledge were promoted, and the acceleration of providing solutions to customers was realized.

At present, this technological knowledge system is positioned as one of the important IT infrastructures on the medium- and long-term management strategy in the factory automation business, and the response to the enlargement and deepening is required. In addition, technological knowledge not conforming to the initially set system is emerging because a few years elapsed from the first operation. The realization of the renewal of the technological knowledge system, classification and system configuration and the sharing of more efficient technological knowledge is required considering these. Furthermore, we intend to contribute to the acceleration of solution for the issues of customers and to OMRON's factory automation business by constructing the mechanism enabling the identification of effects, the analysis and the improvement of technological knowledge by means of making this system cooperate with CRM (customer relationship management), feeding forward technological knowledge to CRM, and feeding back the information on the utilization to the proposal of customer, the acceleration of successful business negotiation, the successful business negotiation ratio, and the sales amount.

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