On-site Knowledge Transfer in Agriculture: TalkingPot

Yosei Isoe
Graduate School of Science and Engineering
Ritsumeikan University
Shiga, Japan
cc001071@ed.ritsumei.ac.jp

Tomoko Izumi
College of Information Science and Engineering
Ritsumeikan University
Shiga, Japan
izumi-t@fc.ritsumei.ac.jp

Yoshio Nakatani
College of Information Science and Engineering
Ritsumeikan University
Shiga, Japan
nakatani@is.ritsumei.ac.jp

***Abstract*— Recently, the continuity of agricultural knowledge transfer has grown in importance because of a decrease in the number of agricultural workers. In agriculture, novice agricultural workers gain knowledge through on-site agricultural work. Therefore, on-site agricultural work is important for the transfer of knowledge in agriculture. This system targets the cultivation of potted plants and compares the user's history of agricultural work and experts' history of agricultural work. The system constructs the rules of the user's failure habits and the plant pot communicates with the user based on these rules. This enables the user to obtain knowledge directly in on-site agricultural work.**

Keywords-Knowledge transfer, agriculture, tacit knowledge, explicit knowledge, SECI model.

I. INTRODUCTION

Knowledge transfer is currently a very important theme in business and education, and has been the subject of a great deal of attention [1]. The issue of knowledge transfer is being tackled in a variety of contexts, for example, system engineering, artificial intelligence, and so on. However, these approaches involve a number of problems. This study tackles the problem of transferring knowledge in agriculture. Agriculture is not corporatized in Japan, and hence, has typically been transferred through direct communication from parents to their children or senior farmers to juniors over long periods of time. In recent years, however, the number of people who have been changing jobs from corporate employees to farmers has been increasing. In addition, the number of expert agriculture workers has been decreasing rapidly [2][3]. Thus, the opportunities for novice agriculture workers to directly learn from experts have also decreased. As a result, the need for agricultural knowledge to be transferred to inexperienced workers has increased as well. On the other hand, with the increase of home gardens allowing the cultivation of crops, a gardening boom has taken place among people young and old in Japan, and the need for agricultural knowledge to be transferred to such people is also increasing.

However, as such trends are relatively recent, the newly increased needs for the transfer of agricultural knowledge have been satisfied via the trial and error process until now. In the agricultural field, transferring or acquiring knowledge is problematic because appropriate cultivation methods vary according to various environments. Thus, it is difficult for novice agriculture workers to acquire customized knowledge only through standardized manuals. Recently, the possibility of global knowledge sharing through the new ubiquitous network architecture has arisen. This study proposes a framework by which novice agricultural workers can access the knowledge of experienced agricultural workers via a network. In particular, this study targets the cultivation of potted plants. The plant pot communicates with a novice agriculture worker, considering the differences between the experiences of the novice and experts. Through the dialogue with plant pots, the novice agricultural workers can learn useful practical knowledge on-site during agricultural work. There have been a number of studies and support systems aimed at enabling objects to provide information to users, and this study is characterized by the changing nature of plants and their environments.

Section II describes related concepts and some agricultural studies. Next, we introduce the previous study and its problems in Section III, and describe the proposed system in Section IV. Finally, we examine the prototype system in Section V and discuss our conclusion and future work in Section VI.

II. RELATED CONCEPTS

A. Tacit Knowledge

Nonaka and Takeuchi defined tacit knowledge to be "knowledge gained from individual experiences or specific situations, which can include intangible elements such as beliefs, views, value systems, and so on" [4]. This concept was a refinement of Michael Polanyi's concept of tacit knowledge [5]. Agricultural knowledge regarding necessary tasks, know-how, and experience gained from failures could be classified as tacit knowledge.

B. SECI Model

The SECI model was defined by Nonaka and Takeuchi as a knowledge acquisition process used to share tacit knowledge within a company. This model repeats 4 processes, which are given below.

i . Tacit to Tacit (Socialization)
ii . Tacit to Explicit (Externalization)
iii . Explicit to Explicit (Combination)
iv . Explicit to Tacit (Internalization)

Figure 1 shows the flow of the SECI model.

 ISBN: 978-1-61208-232-5

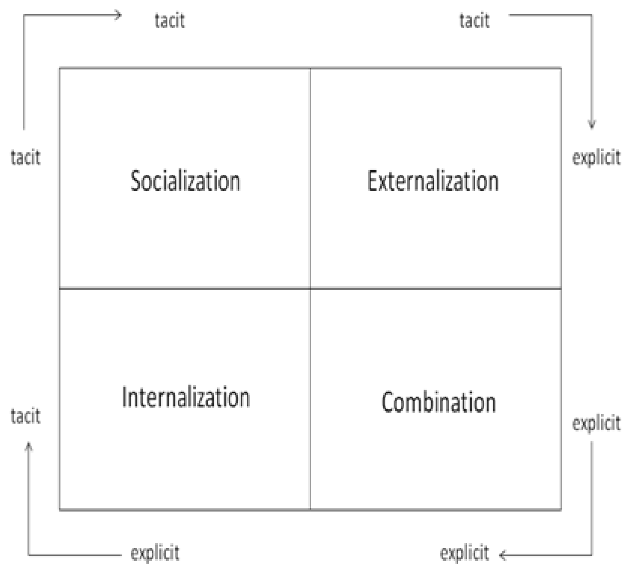

Figure 1. Flow of SECI model.

These four processes lead to the creation of new knowledge. The transfer of agricultural knowledge can also be classified into the four steps of the SECI model, with examples of each step being as follows.

i . Socialization

Novice agricultural workers work together with experienced agricultural workers. Novice agricultural workers can thus observe them, and then imitate them, learning the techniques of experienced agricultural workers.

ii . Externalization

Novice agricultural workers and experienced agricultural workers note down their observations during agricultural work.

iii . Combination

Novice agricultural workers summarize what they have noted down. In addition, novice agricultural workers also transcribe what was noted down by experienced agricultural workers.

iv . Internalization

Novice agricultural workers work alone without the help of the experienced agricultural workers.

Several studies have been conducted on agricultural support, but have been inadequate thus far. Examples include "Cloud Computing Applied for Agriculture and Other Fields" [6], which uses the cloud service of Fujitsu, and "PotPet: pet-like flowerpot robot" [7]. However, these support systems or studies place importance on product management and enjoyment of cultivation. Thus, it is difficult for a novice agricultural worker to learn directly from their experiences on-site. In addition, there have been almost no support systems from the aspect of "objects that can provide information to people".

III. Previous Study

A. *Agricultural Knowledge Transfer*

This study is based on our previous research, titled "Agricultural Knowledge Transfer based on Experience from Failures" [8]. The previous system aimed to support the transfer of knowledge that is deemed necessary as a result of failure experience, using the SECI model.

B. *Construction of Previous System*

The flow of the previous system involves 5 main functions. An explanation of each function and the corresponding SECI model process are given below.

i. Retrieval of Failure Experience (Socialization)
ii. Recommendation of Relevant Failure Experience (Socialization)
iii. Registration of Failure Experience (Externalization)
iv. Construct rules (Combination)
v. Information (Combination)

The system does not actually implement the Internalization part of the SECI model; instead, novice agricultural workers have to select the right choice before doing the actual work, which therefore plays the role of Internalization in the SECI model.

Figure 2 shows an image of the previous system, and Figure 3 shows the main screen of the previous system.

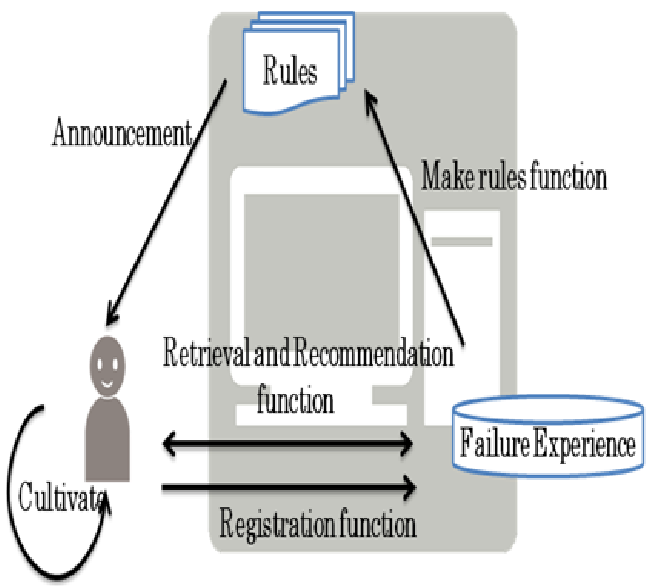

Figure 2. Image of the previous system.

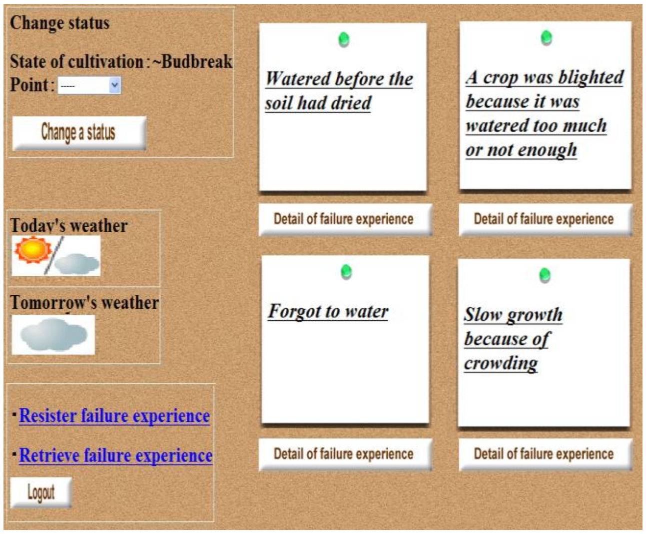

Figure 3. Main screen of the previous system.

C. *Evaluation of Previous System*

An evaluation experiment was conducted on the previous system. The purpose of this evaluation was confirming whether the subjects actually learned from experienced agriculture workers and their own experiences. In addition, the system also confirmed whether or not the subjects were able to gain individual knowledge. Before the evaluation, a questionnaire was provided on their knowledge of agriculture, with 29 university students from a Social Communication Laboratory completing the questionnaire form. 6 subjects who gave the same answers to the questionnaire were then selected because of the assumption that their knowledge of agriculture would be basically the same. The evaluation involved the method of cultivation being classified into 3 patterns, the results of which were then compared. The 3 patterns were:

i. Pattern where nothing was utilized
ii. Pattern where a manual was utilized
iii. Pattern where our system was utilized

The results of interviews were classified into three kinds of knowledge and experience, with the classified knowledge “Knowledge the subjects learned from this system or a manual”, “Knowledge the subjects learned via experience” and “Chores the subjects experienced”. One of the results of the interviews is given below, which is based on the above classification.

TABLE I. RESULT OF “USING NOTHING AT ALL”

< Knowledge the subjects learned from this system or a manual> Nothing in particular
< Knowledge the subjects learned via experience > Don't plant too many seeds at one time
< Chores the subjects experienced > Planted a little less seeds / Watered the crop everyday / Watered the crop using a glass container and tap

TABLE II. RESULT OF “USING A MANUAL”

< Knowledge the subjects learned from this system or a manual> Water the crops carefully / Don't overwater
< Knowledge the subjects learned via experience > Nothing in particular
< Chores the subjects experienced > Planted seeds in a line / Watered the crop carefully / Watered the crop using the right amount

TABLE III. RESULT OF “USING THIS SYSTEM”

< Knowledge the subjects learned from this system or a manual> Narrowly-spaced planting results in slow growth The crop can be blighted because of being watered too many times or not watered enough
< Knowledge the subjects learned via experience > Mizuna seeds are very small / Take care not to plant seeds too close to each other / Mizuna leaves are not very big
< Chores the subjects experienced > Planted seeds at appropriate spacing / Didn’t plant one seed per space but instead two

The subjects cultivated mizuna (*Brassica rapa nipposinica*) in pots for a month, then they were interviewed, and the results of the 3 patterns were then compared.

The results led to the following discoveries:

<Pattern where nothing was utilized>
Subjects gained knowledge from experience.

<Pattern where a manual was utilized>
Subjects gained knowledge from the system or a manual.

<Pattern where the system was utilized>
Subjects gained knowledge not only from the system or a manual but also from actual experience.

The traditional transfer of agricultural knowledge has involved a method in which experienced agriculture workers provide novice agriculture workers with knowledge and experience, and the novice agriculture workers then gain individual knowledge via actual experience. These steps are typically used to transfer agricultural knowledge. The pattern that uses our system is thus fairly similar to these steps when compared to the other 2 patterns.

The system can therefore be used to efficiently transfer agricultural knowledge.

D. *Problems*

In the previous study, transferring agricultural knowledge was proved to be effective through the use of failure experience and the SECI model. However, agricultural work was assumed to be done after referring to the failure experience information in front of a computer. In the transfer of agricultural knowledge, it is typical that knowledge is shared and exchanged between people. Using the system via a computer therefore appears somewhat unnatural, and using the computer and doing the agricultural work will be recognized as two unrelated things. Moreover, it will be difficult for users to relate knowledge acquired during agricultural work to knowledge acquired from the system, because they would appear to be separate processes. In addition, the failure experiences registered by users are “noticed failure experiences.” Thus, the system cannot provide any useful knowledge about failures that novice agriculture workers do not notice. The present study, therefore, suggests a framework that users can use to aid the face-to-face transfer of agricultural knowledge during actual agricultural work.

IV. Proposed System

A. Media Equation

The Media Equation involves a "person corresponding unconsciously and socially in treatment of an object" [9]. This suggests that a user can treat an object in the same way as treating a person.

An example of a study using the Media Equation is “Clothes Which Propose Fashion Coordinate Based on the Previous Experience” [10]. The current study uses this theory in aiming to aid knowledge transfer.

B. System Approach

This system attempts to rectify problems in the previous research through the “Media Equation”. In addition, we propose a framework to help the user gain knowledge with the same feeling as when the user works with a real person. A method in which a plant pot provides information while talking to the user during agricultural work, in particular, is used. This results in the user feeling that they are working together with another person, because the plant pot provides a form of communication. In addition, the user can act according to the information provided by the plant pot. Thus, the user can learn know-how from the plant pot and do the agricultural work at the same time. Moreover, the plant pot provides information based on the agricultural work. Thus, the user can acquire knowledge about “unnoticed failure experiences”. Figure 4 illustrates the concept of this system.

Figure 4. Image of the proposed system.

C. System Flow

The proposed system is based on the approach written in the preceding section. The system flow is described below.

i. Acquires basic data of the cultivation situation and the details of agricultural work by using various sensors.
ii. Stores the basic data as the cultivation history of a novice agriculture worker.
iii. Compares the cultivation history of the novice agriculture worker and the registered expert agriculture workers.
iv. Based on this comparison, detects wrong or problematic cultivation methodology and stores these as rules.
v. Monitors agricultural work by the novice agriculture worker based on these rules.
vi. If problematic behavior is detected, the plant pot communicates this to the worker based on the relevant rule.
vii. Repeats “i” to “vi” processes.

Figure 5 shows the composition of this system.

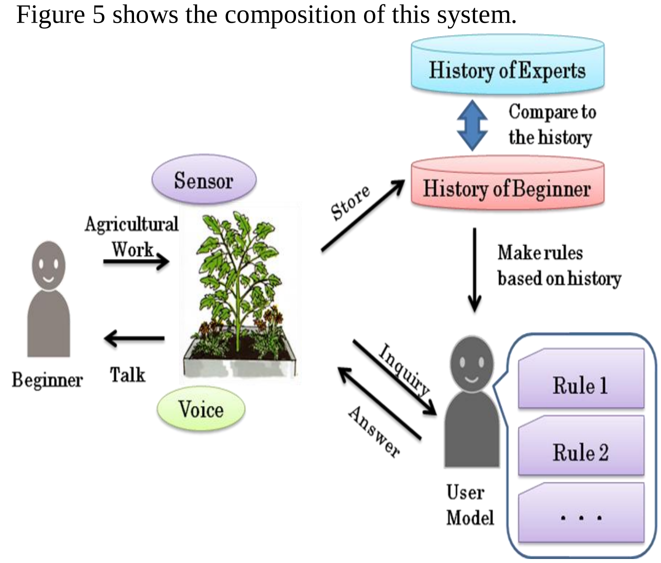

Figure 5. Composition of the proposed system.

V. Prototype System

A prototype system is currently under development according to the system flow described above. The prototype system focuses especially on watering. Watering crops is an essential part of agricultural work. In addition, it tends to rely on personal experience and almost all manuals fail to specify precise quantities of water. Thus, the act of watering contains many kinds of failure experiences that agricultural workers do not notice.

A. Data Acquisition Method

In the prototype system, 3 kinds of data relating to watering are obtained.

i. Watering quantity
ii. Watering interval
iii. Watering date and time

Sensors are used to obtain these data. In the case of "i", the system uses the weight sensor to measure the weight of the plant pot. Then, it compares the weight before watering and after watering. Thus, the system can obtain the data relating to the quantity of watering.

In the case of "ii", the system uses the soil moisture sensor to measure the degree of soil moisture. Thus, the system can obtain the data relating to the interval of watering.

In the case of "iii", the system connects to the network and obtains the date and time of watering.

B. Rule Construction

This system uses the "MT method" [11] to construct rules. The MT method is used to determine tendencies such as, for example, whether a person has a propensity to cancer or not. Using this method, the system determines whether the agricultural work will fail or not. In the prototype system, we used 4 kinds of data relationship: "water quantity and temperature", "water quantity and soil moisture", "water quantity and temperature difference from previous day" and "water quantity and soil moisture difference from previous day". The flow of the rule construction is described below. This is based on the relationship of "water quantity and temperature" and sample data relating to watering.

i. Determine the central point of the unit space consisting of the experts' data of water quantity and temperature.
ii. Divide into 4 groups (A,B,C,D) based on the central point, classify the novice worker's data (X).
iii. Determine the distance (R) from the central point of the experts' data to the novice's data.
iv. Construct rule based on the classified group and the distance. In this example, Rule 4 will be made.

Figure 6 shows an example of the central point of the data relating to water quantity and temperature, Figure 7 shows an example of classified novice's data based on the central point, Figure 8 shows an example of the distance from the central point to the novice's data and Table 1 shows an example of rules relating to water quantity and temperature.

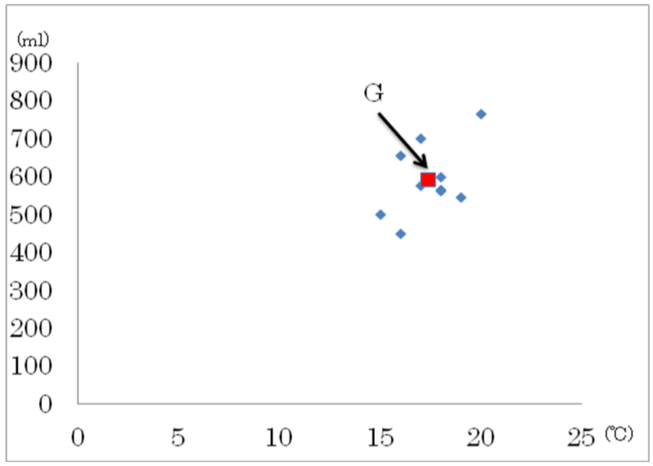

Figure 6. Example of the central point of the data relating to water quantity and temperature.

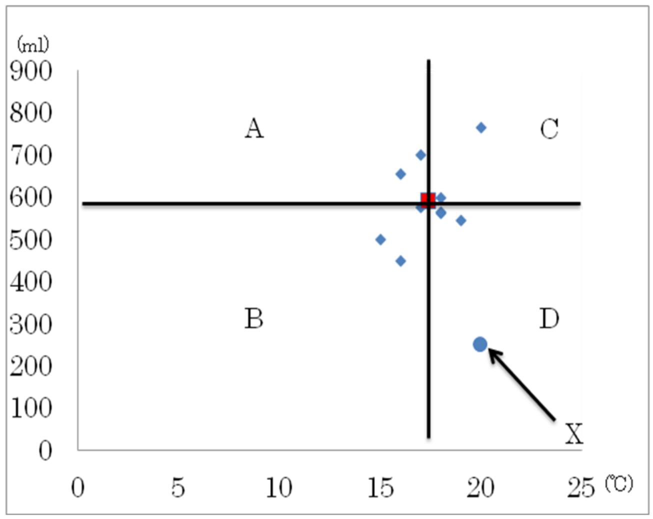

Figure 7. Example of classified novice's data based on the central point.

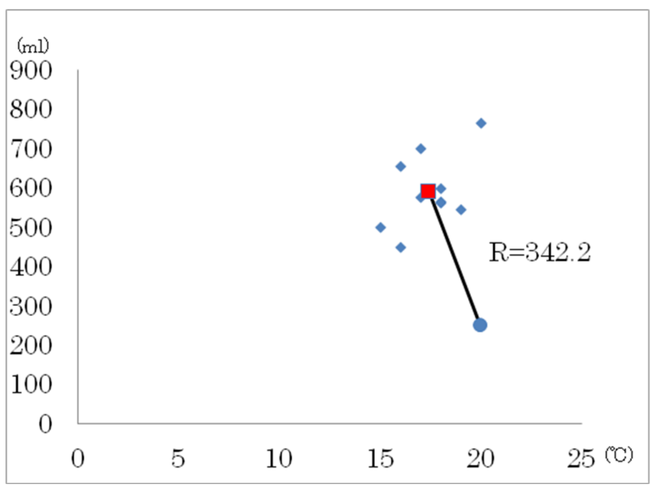

Figure 8. Example of the distance from the central point to the novice's data.

TABLE IV. EXAMPLE OF RULES RELATING TO WATER QUANTITY AND TEMPERATURE

If (group=A and R>300)
Then make Rule 1
"Higher quantity of water when temperature is low"

If (group=B and R>300)
Then make Rule 2
"Lower quantity of water when temperature is low"

If (group=C and R>300)
Then make Rule 3
"Higher quantity of water when temperature is high"

If (group=D and R>300)
Then make Rule 4
"Lower quantity of water when temperature is high"

The system constructs rules according to these algorithms. Rules made by the system are based on the novice's agricultural work. In addition, the rules contain knowledge about "unnoticed failure experiences". Thus, even if the novice does not notice a problematic behavior, the system would make and store the rule automatically and communicate to the novice. Finally, the novice can obtain knowledge about "unnoticed failure experiences" by communicating with the plant pot based on the rule.

VI. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a framework to help the transfer of agricultural knowledge via communication with plant pots, which stores the data of expert agricultural workers. The next step will be to conduct evaluation on the use of these data and on the prototype system. In this evaluation, we will compare the watering data of the novice worker with and without using the prototype system. We will then confirm whether the distance from the central point of the experts' data to the novice's data is shorter when using the system. By using this method, we will be able to confirm the efficiency of the prototype system.

REFERENCES

[1] Miyajima, S., Zukai 2007 nen mondai no subete ga wakaru (Understand all the issues of 2007). Gijutsu-Hyohron Co., Ltd. Tokyo, Japan. 2006.

[2] Ministry of Agriculture, Forestry and Fisheries of Japan, The 84TH Statistical Yearbook of Ministry of Agriculture, Forestry and Fisheries 2008-2009.
http://www.maff.go.jp/e/tokei/kikaku/nenji_e/other/n045.xls
[retrieved: 11, 2012]

[3] Ministry of Agriculture, Forestry and Fisheries of Japan, The 85TH Statistical Yearbook of Ministry of Agriculture, Forestry and Fisheries 2009-2010.
http://www.maff.go.jp/e/tokei/kikaku/other/n045.xls
[retrieved: 11, 2012]

[4] Nonaka, I and Takeuchi, H., *The Knowledge Creating Company.* Oxford University Press, Oxford, England. 1995.

[5] Polanyi, M., *The Tacit Dimension.* University of Chicago Press, Chicago, USA. 1967.

[6] Hori, M., et al., Cloud Computing Applied for Agriculture and Other Fields. *Magazine of Fujitsu.* 2010, vol61, no3, pp. 314-320.

[7] Kawakami, A., et al., PotPet: Pet-like Flowerpot Robot. *73th Information Processing Society of Japan.* Tokyo, Japan. 2011, 1W-6.

[8] Isoe, Y and Nakatani, Y., Knowledge Transfer in Agriculture based on Failure Experiences. *73th Information Processing Society of Japan.* Tokyo, Japan. 2011, 6R-7, vol. 4, pp. 881-882.

[9] Reeves, B and Nass, C., *The Media Equation, How People Treat Computers, Television, and New Media Like Real People and Places*, University of Chicago Press. 1996.

[10] Fukuda, M and Nakatani, Y., Clothes Which Propose Fashion Coordinate Based on the Previous Experience. *73th Information Processing Society of Japan.* Tokyo, Japan. 2011, 2ZA-8, vol. 4, pp. 881-882

[11] Taguchi, G and Kanetaka, T., *MT system ni okeru gijutsu kaihatsu (Developing technologies in the MT system).* Japan Standards Association, Japan. 2002