e-Learning Content Design for Corrective Maintenance of Toshiba BMC 80.5 based on Knowledge Conversion using SECI Method: A Case Study in Aerospace Company

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Abstract. Knowledge is a combination of experience, value, and information that is based on the intuition that allows an organization to evaluate and combine new information. In an organization, knowledge is not only attached to document but also in routine value creating activities, therefore knowledge is an important asset for the organization. X Corp is a company that focused on manufacturing aerospace components. In carrying out the production process, the company is supported by various machines, one of the machines is Toshiba BMC 80.5. The machine is used occasionally and therefore maintenance activity is needed, especially corrective maintenance. Corrective maintenance is done to make a breakdown machine back to work. Corrective maintenance is done by maintenance operator whose retirement year is close. The long term experience of the maintenance operator needs to be captured by the organization and shared across maintenance division. E-learning is one type of media that can support and assist knowledge sharing. This research purpose is to create the e-learning content for best practice of corrective maintenance activity for Toshiba BMC 80.5 by extracting the knowledge and experience from the operator based on knowledge conversion using SECI method. The knowledge source in this research is a maintenance supervisor and a senior maintenance engineer. From the evaluation of the e-learning content, it is known that the average test score of the respondents who use the e-learning increases from 77.5 to 87.5.

1. Introduction
Knowledge is a combination of experience, value, and information that is based on the intuition that allows an organization to evaluate and combine new information. In an organization, knowledge is not only attached to document but also in routine value creating activities, therefore knowledge is an important asset for the organization [1]. To gain benefit from the knowledge, organizations must explicitly manage their knowledge, the problem occurs when managing the knowledge because knowledge is difficult to imitate, intangible and also embedded in organization members and from past experience of the organization member [2]. An organization can obtain great profit if investing in knowledge asset, this can be done because knowledge is one of the un-depreciated assets, on the contrary knowledge, can be increased as long the knowledge is being used by another [3]. X company is a manufacturing company that focused on manufacturing part of aircraft. In order to maintain the productivity in optimum level, there is maintenance department which focused on maintain the machine in the company. Table 1 shows the machine that is used in Company X.
Table 1. Machine List in Company X

| Machine Group | Machine Name         | Quantity |
|---------------|----------------------|----------|
| Sheet Metal   | Cyril bath           | 1        |
|               | Sheridan             | 1        |
|               | ABB                  | 1        |
| Gantry        | Cincinnati           | 9        |
| 5 Axis        | HAAS 5 Axis          | 1        |
|               | Toshiba              | 3        |
|               | Droop Rein           | 2        |
|               | Deckel Maho          | 4        |
| 4 Axis        | 6H                   | 4        |
|               | HAAS EC 500          | 5        |
|               | YAASDA/JB            | 2        |
|               | Toshiba              | 4        |
| 3 Axis        | SHW                  | 4        |
|               | HAAS VF 6            | 8        |
|               | Quasser              | 5        |

Toshiba is one of the machine that is used in Company X. Toshiba BMC 80.5 is a machining center machine in the production process in Company X. The machine is used to make parts from roughing process until finishing process. The part that is manufactured in Toshiba BMC 80.5 is varied depending on the machine programs. Figure 1 shows the Toshiba BMC 80.5 Machine.

Figure 1. Toshiba BMC 80.5

All machine that is in the production process is considered important therefore maintenance process is needed. Maintenance department in company x is a division that specifically handles the maintenance operation of the machine for production. This division has 36 employees that consist of 25 permanent
employees, 3 outsourcing, and 8 laborers. The activity of maintenance department is divided into two big group which is preventive maintenance and corrective maintenance. In general, corrective maintenance is not scheduled activity, because the purpose of the activity is to repair the machine right after the machine is breakdown/failure [4]. Corrective maintenance needs to be done in order to fulfill the production schedule, the problem occurs when only specific maintenance operator that can handle the specific machine, therefore when the operator is retired there is no one in the department that can replace the operator. The knowledge from such operator is within the mind of a person, therefore it is hard to articulate and convert into tangible form. According to Davenport and Prusak [5], knowledge is a combination of experience, values and contextual information that provides a framework for the evaluation of information and new experiences. According to Frost [6], knowledge is divided into two type, which is tacit knowledge and explicit knowledge. Tacit knowledge is a knowledge that is hard to communicate in form of written or oral and hard to transfer into people minds where explicit knowledge is a knowledge that is written, archive, and can be used as a reference for others.

To prevent the loss of knowledge in the department, it is needed knowledge management. Knowledge conversion with SECI (Socialization, Externalization, Combination, Internalization) method by Nonaka and Takeuchi [7] can be used as a solution to externalized the knowledge from the experienced operator. The long term experience of the maintenance operator needs to be captured by the organization and shared across maintenance division. E-learning is one type of media that can support and assist knowledge sharing. This research purpose is to create the e-learning content for best practice of corrective maintenance activity for Toshiba BMC 80.5 by extracting the knowledge and experience from the operator based on knowledge conversion using SECI method.

2. Theoretical Background

2.1. Knowledge
Knowledge is a main essential for any companies because, in the knowledge based era, the knowledge itself became the source of competitive advantage [8]. According to Drucker [9] knowledge is an information that changes something or someone.

2.2. SECI Model
SECI model first mentioned in the research conducted by Nonaka and Takeuchi [7]. The model describes four phase of converting knowledge which is socialization, externalization, combination, and internalization. Socialization is defined as sharing process and creation of tacit knowledge through interaction and direct observation. Externalization is defined as an articulation of tacit knowledge into explicit knowledge through dialogue and reflexion. The combination is defined as conversion process of explicit knowledge into new explicit knowledge through systemization and information. Internalization is defined as a learning process and knowledge acquisition by organization member towards explicit knowledge that spread into the organization through self-experience so it can be tacit knowledge of organization member. Figure 2 shows the SECI method by Nonaka and Takeuchi [7].

![Figure 2. SECI Method](image)
3. Research Methodologies
The purpose of this research is to create the e-learning content for best practice of corrective maintenance activity for Toshiba BMC 80.5 by extracting the knowledge and experience from the operator based on knowledge conversion using SECI method. The focus of this research is the corrective maintenance activity. SECI method is used in this research for managing knowledge that is held by senior employees regarding the experience of handling Toshiba BMC 80.5 machine. The SECI method converts the knowledge of a person's tacit knowledge into an explicit knowledge so that the knowledge can be used by others. The knowledge that is gathered from SECI method is converted into best practice for e-learning content. In socialization phase, tacit knowledge is transformed into another tacit knowledge, in this case, tacit knowledge will be converted into knowledge about corrective maintenance activity of Toshiba BMC 80.5. The data is gathered by interviewing to the maintenance operator. The corrective maintenance activity is repairing the bearing in the machine spindle. In externalization phase, the previous knowledge about the corrective maintenance activity is articulated into explicit knowledge. In combination phase, explicit knowledge is converted into new explicit knowledge through a combination of knowledge. The combination process is done by conducting a brainstorming session with two senior operators. The discussion focused on what is the best action about how to maintain the machine. In internalization phase, the best practice is shared into all maintenance department employee. The process is done by giving insight about new best practice through informal communication.

4. Result and Discussion
4.1. Socialization
In this phase, socialization process is done by interviewing the respondent. The result of this phase is a tacit knowledge about how to maintain the bearing in the machine spindle of Toshiba BMC 80.5. From the interview result, it is known that there is two alternative way to repair the bearing.

4.2. Externalization
In this phase, tacit knowledge from the previous phase is articulated into explicit knowledge. The explicit knowledge is the detailed diagram about how to repair the bearing. Figure 3 shows the externalized corrective maintenance procedure.

![Corrective Maintenance Procedure Diagram](image-url)

**Figure 3.** Externalized Corrective Maintenance Procedure
After the procedure is defined, the next step is to externalized the tools that are used to repair the machine. Table 2 shows the externalized result from corrective maintenance tools requirement.

Table 2. Externalized Corrective Maintenance Tools Requirement

| Items               | Quantity | Notes                                          |
|---------------------|----------|------------------------------------------------|
| Ring Key no. 8-24   | 1 Set    | To open the cover and spindle mechanic         |
| L Key               | 1 Set    | To open the cover and spindle mechanic         |
| Dial Indicator      | 1        | To measure the run out of the spindle          |
| Mandrel BT60        | 1        | To help calibrate the machine                  |
| Screw               | 1        | -                                              |
| Majun Cloth         | 1        | To clean parts of the machine                  |
| Solar fluid         | 1        | To clean up the spindle                        |
| Grease              |          | To lubricate the bearing in the spindle        |
| Sand Stone          | 1        | To clean rust in the spindle                   |
| Sand Paper CC 1000  | 1        | To finishing the rust cleaning process in the  |
| CW                  |          | spindle                                        |
| Crane               | 1        | To lift the spindle from the machine           |
| Paintbrush          | 1        | To lubricate the solar                         |
| Pallet Jack         | 1        | To handle the spindle                          |

4.3. Combination
In combination phase, the externalized knowledge from the previous step is combined into one best practice, the externalized activity from the two operators will be merged into one best practice, this step is done by conducting a brainstorming session. Figure 4 shows the combined result of the corrective maintenance process.

**Figure 4. Combined Result of Corrective Maintenance Process**

From figure 4, it is known that the best practice that is used after brainstorming session is from the operator 1. The differences between the two operators are that in the third activity. Operator 1 heats the collar, cones, and bearing first using the heater to put the parts into the spindle. Operator 2 cool down...
the spindle using dry ice first before taking the bearing. From brainstorming session, it is known that the effective way to put back the parts is by heating the parts first. Using dry ice is not recommended because after the part is assembly, there is a chance that the residue of the dry ice creates rust in the machine.

After the information of the best practice is gathered, the next step is designing the content of e-learning about the corrective maintenance activity. The proposed e-learning focused on the topic of corrective maintenance activity, in this case, the corrective maintenance process of replacing the bearing in Toshiba BMC 80.5 machine. The content is designed for the initial phase of replacing the bearing until doing run test for the machine. Figure 5 shows the example of the e-learning content for replacing the bearing.

![Figure 5. Example of Corrective Maintenance Content in e-learning](image)

In the end of the section, there is a quiz to evaluate the result of the learning. The evaluation is done by answering the multiple choice question in the e-learning system. Figure 6 shows the example of the evaluation in e-learning.

![Figure 6. Example of Corrective Maintenance Evaluation in e-learning](image)

4.4. Internalization
The best practice is shared into all maintenance department employee. The process is done by giving insight about new best practice through informal communication. The internalization phase is done to verbally communicate the detailed step about replacing the bearing from the spindle in Toshiba BMC 80.5 machine. In internalization process, the e-learning is tested, from the result, it is known that the maintenance operator understands the topics and the e-learning are considered as the effective way to understand the maintenance process because the operator just only sees the e-learning. The preliminary test is conducted for the operator to know the initial score before using the e-learning.
taking the e-learning, it is known that the average test score of the respondents who use the e-learning increases from 77.5 to 87.5.

5. Conclusions
The purpose of this research is to create the e-learning content for best practice of corrective maintenance activity for Toshiba BMC 80.5 by extracting the knowledge and experience from the operator based on knowledge conversion using SECI method. The focus of this research is the corrective maintenance activity. SECI method is used in this research for managing knowledge that is held by senior employees regarding the experience of handling Toshiba BMC 80.5 machine. From the result, it is known that the average test score of the respondents who use the e-learning increases from 77.5 to 87.5. From the interview, the maintenance operator understand the topics and the e-learning is considered as the effective way to understand the maintenance process.

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