

e-Learning Application for Machine Maintenance Process using Iterative Method in XYZ Company

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Abstract. XYZ Company is a company based on manufacturing part for airplane, one of the machine that is categorized as key facility in the company is Millac 5H6P. As a key facility, the machines should be assured to work well and in peak condition, therefore, maintenance process is needed periodically. From the data gathering, it is known that there are lack of competency from the maintenance staff to maintain different type of machine which is not assigned by the supervisor, this indicate that knowledge which possessed by maintenance staff are uneven. The purpose of this research is to create knowledge-based e-learning application as a realization from externalization process in knowledge transfer process to maintain the machine. The application feature are adjusted for maintenance purpose using e-learning framework for maintenance process, the content of the application support multimedia for learning purpose. QFD is used in this research to understand the needs from user. The application is built using moodle with iterative method for software development cycle and UML Diagram. The result from this research is e-learning application as sharing knowledge media for maintenance staff in the company. From the test, it is known that the application make maintenance staff easy to understand the competencies.

1. Introduction

Knowledge externalization is a conversion process from tacit knowledge into explicit knowledge, the explicit knowledge can be realized into any other form such as recipe, book, procedure, e-learning, web-based application and any other form. This research focus on externalized the knowledge in maintenance process in Millac 5H6P machine that is being used in producing part of airplane and categorized as a key facility in the company. As a key facility, the machines should be assured to work well and in peak condition, therefore, maintenance process is needed periodically. Machine maintenance process is still dominated by the tacit knowledge from certain operator in maintenance department. From the interview and direct observation, it is known that not all maintenance operator understand and expert in maintaining all the machine. Some operator just know certain machine and still ask the expert operator about maintaining other machine, this can affect the effectivity of maintenance process, it is known that there are lack of competency from the maintenance staff to maintain different type of machine which is not assigned by the supervisor, this indicate that knowledge which possessed by maintenance staff are uneven.



The purpose of this research is to create knowledge-based e-learning application as a realization from externalization process in knowledge transfer process to maintain the machine. The application feature are adjusted for maintenance purpose using e-learning framework for maintenance process, the content of the application support multimedia for learning purpose. With the e-learning application, maintenance operator can learn the best practice in maintenance process of Millac 5H6P so the uneven skill of each maintenance operator can be minimize. The iterative method that is used in development in this research are sharpened with the help of Quality Function Deployment (QFD). QFD is used to determine the Voice of Customer (VOC), this VOC are needed as requirement from user perspective for designing and developing the e-learning application. By taking user requirement into consideration, the designed e-learning application will better suits the user specification and can help user to achieve the best practice in maintenance the Millac 5H6P machine.

2. Theoretical Background

2.1. SECI

Nonaka and Takeuchi in Tobing [6] describe the four phase of converting knowledge which are socialization, externalization, combination and internalization.

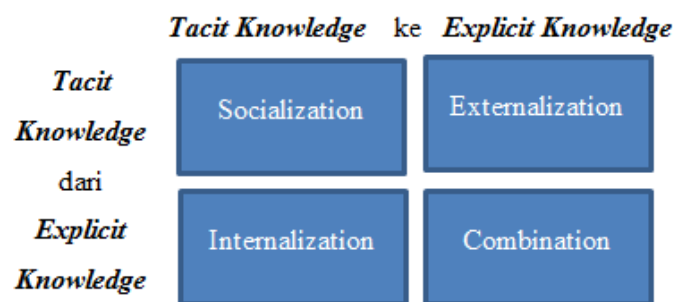


Figure 1. SECI Phase

- **Socialization** : sharing process and creation of tacit knowledge through interaction and direct observation.
- **Externalization** : articulation of tacit knowledge into explicit knowledge through dialogue and reflexion.
- **Combination** : conversion process of explicit knowledge into new explicit knowledge through systemization and information.
- **Internalization** : learning process and knowledge acquisition by organization member towards explicit knowledge that spread into organization through self experience so it can be tacit knowledge of organization member.

2.2. Knowledge Management

Knowledge management describe how to create, acquire, capture, sharing and used knowledge [5]. Horwitch and Armacost in Sangkala [5] state that knowledge management as implementation of creation, capturing, transfer and access of knowledge and information when needed to make a better decision. Amrit Tiwana in Tobing [6] stated that knowledge management is a process of managing knowledge in a company for creating business value and produce sustainable competitive advantage with optimize creation process, communication and application all knowledge that needed in order for achieve the business objective.

2.3. *Quality Function Deployment*

Quality Function Deployment (QFD) is developed by Yoji Akao. Akao [1] define QFD as a method to translate customer demand in quality characteristic and develop design quality for finished product with expose systematically relationship between demand and characteristic. QFD is a way to improve quality of goods and service with understanding the needs of customer and link it with technical aspect for producing goods and service in every step.

2.4. *E-Learning*

e-Learning is type of learning and teaching which allows the material can be delivered with using a media such as internet, intranet and any other computer network [4]. E-learning activity is more democratic than conventional way of learning and teaching because the student can have a freedom to ask a question and give opinion without interference from other student.

3. **Research Method**

This research use framework of e-learning content developed by Kurniawati et al [3] which is for machine maintenance in general, the framework used as base to determine the overall design for the application. The input in this research is a best practice for maintenance activity, before the e-learning is designed, the first step of this research is to do a literature study and benchmarking with other application. After the benchmarking process, the next step is to create the application based on moodle framework. Output of this research is an application of e-learning maintenance process. Literature study is conduct by understanding the theory that support the research. The theory are obtained from any other reference that linked with the research such as journal, books, internet and previous study. Field study is conduct by interview the maintenance department operator. In inception phase, system design is made, problem domain analysis state the problem and the scope of the research. System analysis analyzed the existing system. In elaboration phase, the analysis of needs is sharpened by using QFD. Output from QFD is the characteristic and feature that suitable with the requirements from the maintenance operator. In construction phase, the e-learning are designed with the use of use case, activity and sequence diagram. After the diagram is finished, the next step is to design the storyboard with mockup pencil software, the next step is to create the e-learning to the moodle. The final step from the construction phase is to test the application to the maintenance operator.

4. **System Analysis and Design**

4.1. *Inception Phase*

In this phase, the information for requirement and the feature of the e-learning is needed, to get the appropriate result, requirement analysis is conducted. The analysis for requirement consist of the machine description, existing system identification, problem identification, system needs identification, functional needs identification and device needs identification while designing the system.

4.1.1. *Machine Description*

Millac 5H6P is a CNC (Computerized Numerical Control) horizontal machine for making work tool with the basic shape of block. This machine have 4 axis which are x, y, z and b. This machine also have 6 pallet that automatically changing and bring the work tool to be produced. The maintenance operator already have the machine on maintenance scheduled, whether it's corrective or preventive maintenance to keep the best performance. Millac 5H6P is one of the key facilities in the company, if the machine is down, it will affect the entire process in the company.



Figure 2. Millac 5H6P

4.1.2. Existing System Identification

Learning method that is done by maintenance operator are only based on documents and direct observation. This is not effective for sharing knowledge process from one operator to other operator and it's considered not valid and unstandardized.

4.1.3. Problem Identification

The problem in maintenance department are:

1. There is no e-learning application that can accommodate knowledge of maintenance operator that are skilled about the detail step to do the maintenance process.
2. There is no e-learning application that can be used by new maintenance operator to understand maintenance process faster.
3. There is no web based e-learning application that can facilitate maintenance operator to access the system when needed.
4. There is no e-learning that is interactive that combine video, text, animation and image so that the maintenance operator can learn the maintenance process faster for Millac 5H6P.
5. There is no system that can accommodate discussion and sharing knowledge and can be used as a facilities to give feedback about maintenance of Millac 5H6P.

4.1.4. System Needs Identification

Maintenance operator needs learning system that is distinct from previous system, which are :

1. There needs to be e-learning application that contain the detail step for maintenance process.
2. Maintenance operator needs learning system which are more interesting so the operator can be easily learn the maintenance process.
3. Maintenance operator needs web-based e-learning that can be accessed everywhere and anywhere.
4. Maintenance operator needs e-learning application that can be a place to discussion and knowledge exchange and also give feedback about maintenance of Millac 5H6P.

4.1.5. System Functional Needs Identification

After the learning system is designed, the function needs to be identified, the identification of the function is conducted by using QFD method to understand the needs what the maintenance operator wants as end user.

4.2. Elaboration Phase

4.2.1. System Needs Identification

Identification of system needs is conducted by interviewing the maintenance operator.

Table 1. Needs identification

No.	Customer Statement
1	Menu and button are easy to use
2	There is a feature to help operate the e-learning
3	Information in the application are fit and comprehensive
4	Information is easy to understand
5	Information is served in interactive way
6	Information always up to date
7	There is a feature to evaluate the operator skills
8	Security of private data
9	There is a mechanism to discussion and sharing knowledge
10	Application color is appropriate
11	Application is appealing

4.2.2. Determine the Voice of Customers

VOC (Voice of Customers) is a customer statement and organized by WEBQUAL quality dimension.

Table 2. VOC from WEBQUAL

No.	WEBQUAL	Code	Voice of Customer
1	Usability	V1	Menu and button are easy to use
2		V2	There is a feature to help operate the e-learning
3		V3	Information in the application are fit and comprehensive
4		V4	Information is easy to understand
5		V5	Information is served in interactive way
6		V6	Information always up to date
7	Service	V7	There is a feature to evaluate the operator skills
8		V8	Security of private data
9		V9	There is a mechanism to discussion and sharing knowledge
10		V10	Application color is appropriate
11		V11	Application is appealing

4.2.3. Determine the Technical Characteristic

Technical characteristic are derived from the voice of customer.

Table 3. TechnicalCharacteristic Derived from Voice of Customers

No.	Voice of Customer	Technical Characteristic
1	Menu and button are easy to use	Size of menu and button Layout design of e-learning
2	There is a feature to help operate the e-learning	Appropriateness of feature
3	Information in the application are fit and comprehensive	Multilanguage support Information accuracy Appropriateness of information
4	Information is easy to understand	Appropriateness of information design Multilanguage support
5	Information is served in interactive way	Appropriateness of feature Layout design of e-learning Use of animation
6	Information always up to date	Choice of words System ability to update
7	There is a feature to evaluate the operator skills	Appropriateness of information
8	Security of private data	Appropriateness of information
9	There is a mechanism to discussion and sharing knowledge	User access control
10	Application color is appropriate	Use of color
11	Application is appealing	Layout design of e-learning Use of color Use of text

4.2.4. Determine the Critical Part

Critical part are derived from the Technical characteristic.

Table 4. Critical parts derived from Technical Characteristic

No.	Technical Characteristic	Critical Part
1	Size of menu and button	Menu size in e-learning Button size in e-learning
2	Layout design of e-learning	Layout design of button Layout design of menu Layout design of content
3	Appropriateness of feature	Quiz feature Forum feature Help menu
4	Choice of words	Detail of language usage Clarity of language Language fitness
5	Information accuracy	Availability of preventive maintenance information Availability of accurate corrective maintenance information
6	Appropriateness of information	Availability of accurate proper preventive maintenance information Availability of proper corrective maintenance information

4.2.5. Hardware and Software Needs Identification

The needs of hardware and software to design the e-learning are :

Software :

1. *Operating system* : Windows 7, 8, Vista, XP atau Linux
2. *Framework* : Moodle
3. *DBMS* : MySQL minimal versi 5
4. *Web server* : Apache
5. *Web browser* : Google Chrome atau Mozilla Firefox
6. *Editor* : Adobe Dreamweaver
7. *Design* : Corel Draw, Adobe Flash CS4

Hardware :

1. *Processor* : AMD Athlon(tm) Neo Processor MV-40 1.60 GHz
2. *Memory* : 2 GB

4.2.6. User Identification

Table 5. User Identification

Role	User	User Privileges
Super Admin	IT Staff	Manage application and learning (blog, front page, course, quiz, forum, etc)
Admin	Maintenance Department Manager	Manage quiz, course and forum
	IT Staff	
	Maintenance Department Manager	
User	Experienced Maintenance Department Staff	
	Maintenance Department Staff	Access course, quiz and forum
	General	Restricted to front page

4.3. Construction Phase

In this phase, the e-learning is designed and later will be present to the user. To help the e-learning design process, UML is used, the type of UML that is used in this research are use case diagram, activity diagram, sequence diagram and entity relationship diagram. The use case, activity diagram, sequence and entity relationship diagram are not completely shown in this paper.

4.3.1. E-Learning Design

The e-learning is designed with help of UML diagram which are use case, activity and sequence diagram. Besides the UML diagram, in this research entity relationship diagram is used to design the database structure for the e-learning application. The next step is to create the storyboard to obtain detail design using pencil mockup software.

4.3.2. Use Case Diagram

Use case diagram is a modelling tools for designing the e-learning application, the diagram describe all interaction within one and another actor with the developed application. Use case diagram is used in this research to know all the function that is needed by the user.

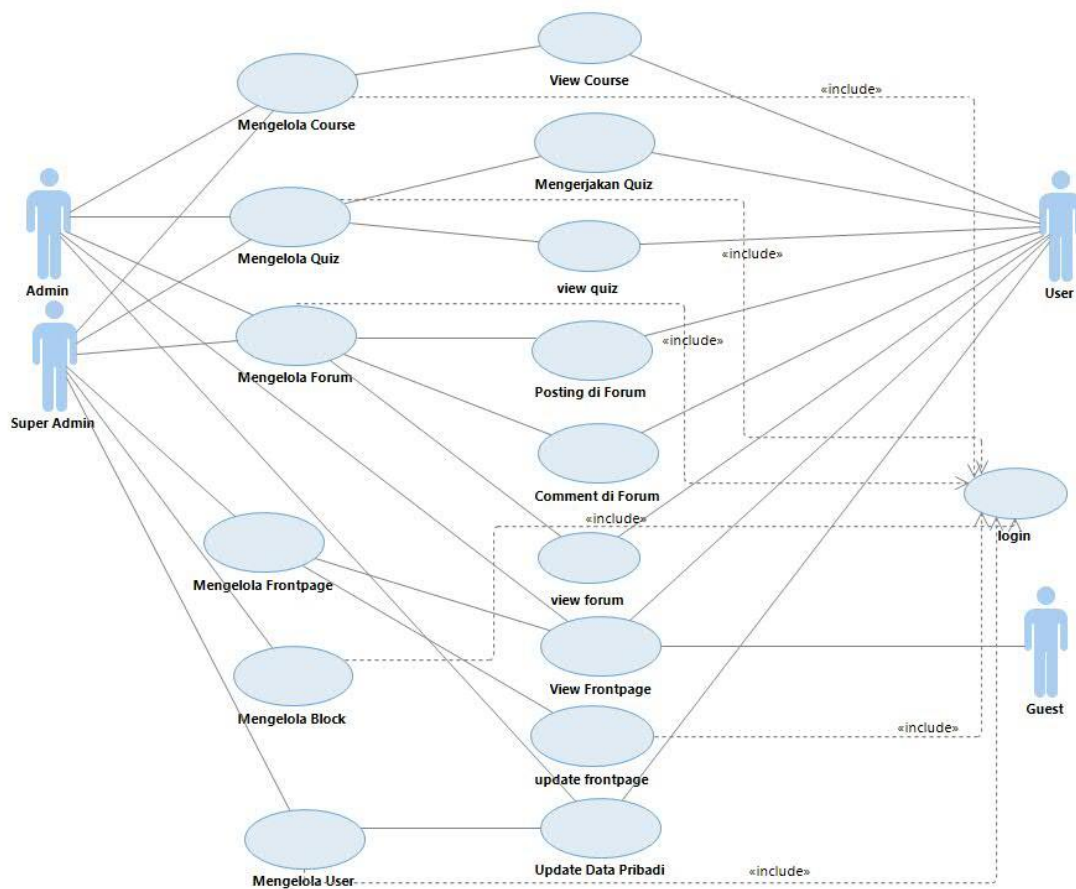


Figure 3. Use Case Diagram

4.3.3. Activity Diagram

Activity diagram is an UML tools for showing the workflows of activities and actions in the application. The activity diagram show the overall flow of the application and can be used to model the processes that occur in the real system and the computer-aided process.

4.3.4. Sequence Diagram

Sequence diagram is an UML tools for showing the interaction between object that is managed in sequence of time. Sequence diagram captured the object and class that is involved in a scenario.

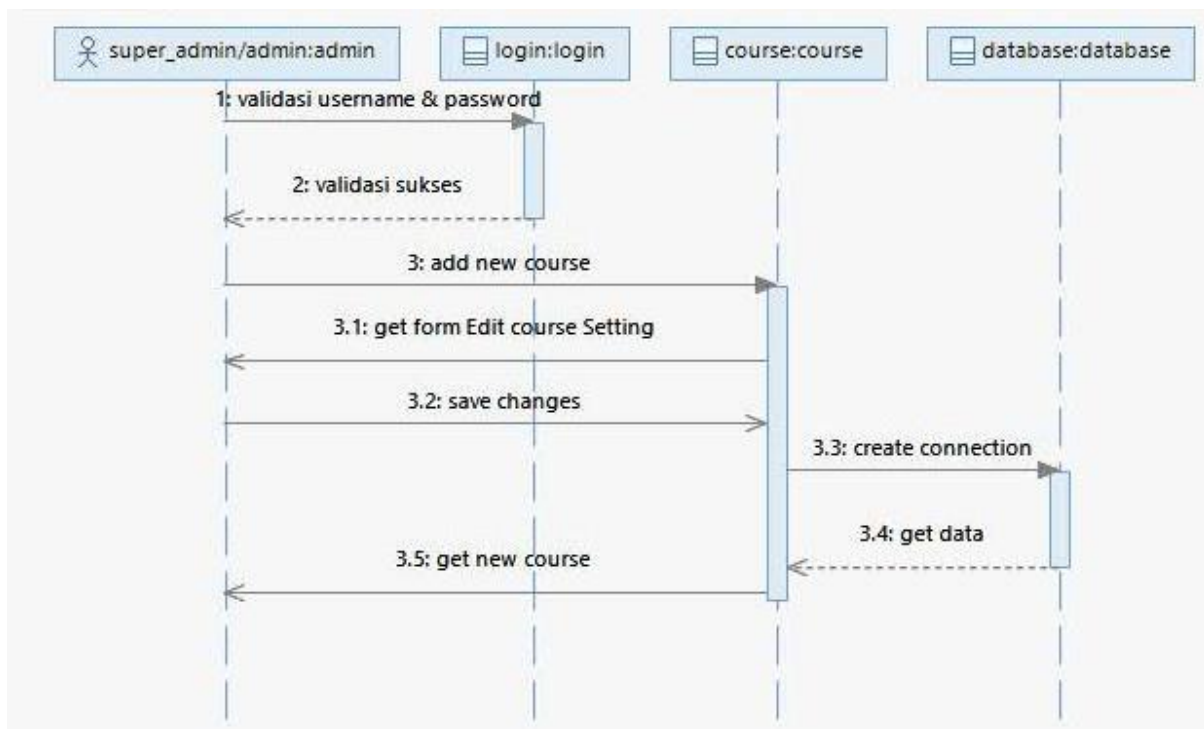


Figure 4. Sequence Diagram

4.3.5. Entity Relationship Diagram

Entity relationship diagram is used in this research to design the database structure of the e-learning application. The entity relationship diagram can show the relationship of all entity within the application scope that is stored in the database by modelling the logical structure of the database.

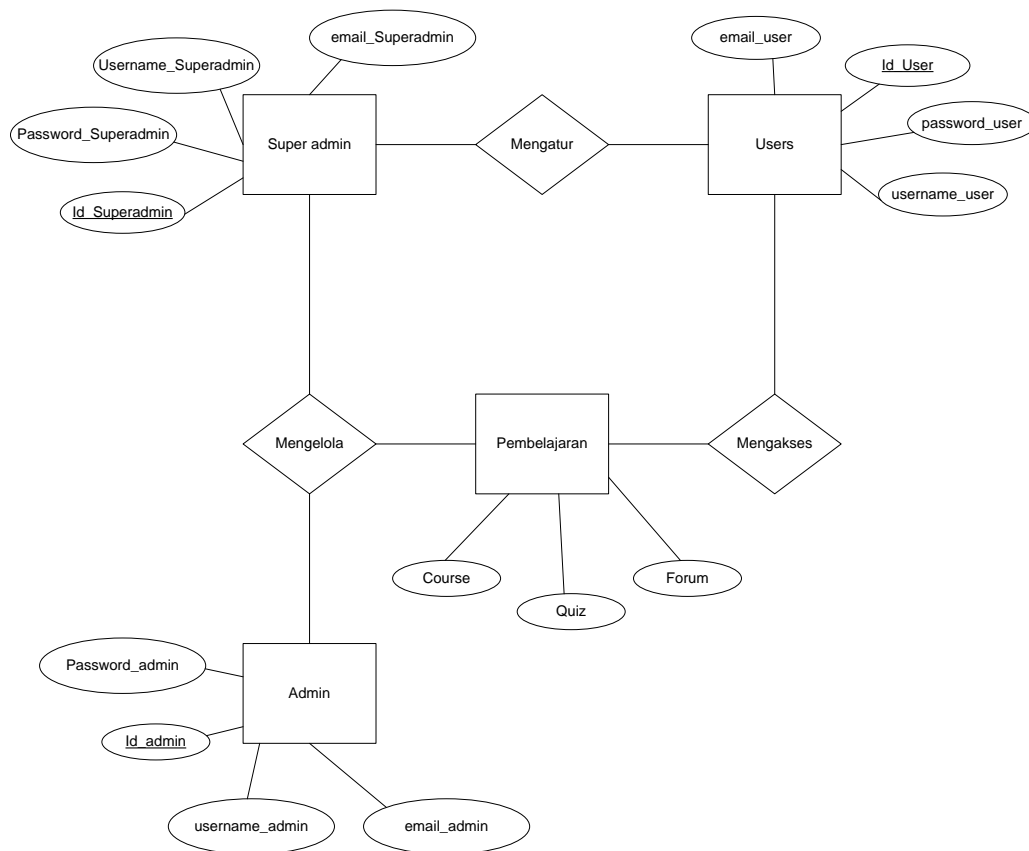


Figure 5. Entity Relationship Diagram

4.3.6. *E-Learning Development*

e-Learning development is done by coding in Moodle. Moodle is suitable for this research because it have features that is fit to the user requirement. Feature and characteristic that is made with moodle is fitted with the characteristic from the QFD.

4.3.7. *System Testing*

From the testing phase, it's clear that the operator give "good" and "enough" for all variable whether it's about application and interactive learning with flash. It is concluded that e-learning application is good enough and accepted by user.

4.3.8. *Application Screenshot*

This section represent the e-learning application of this research.

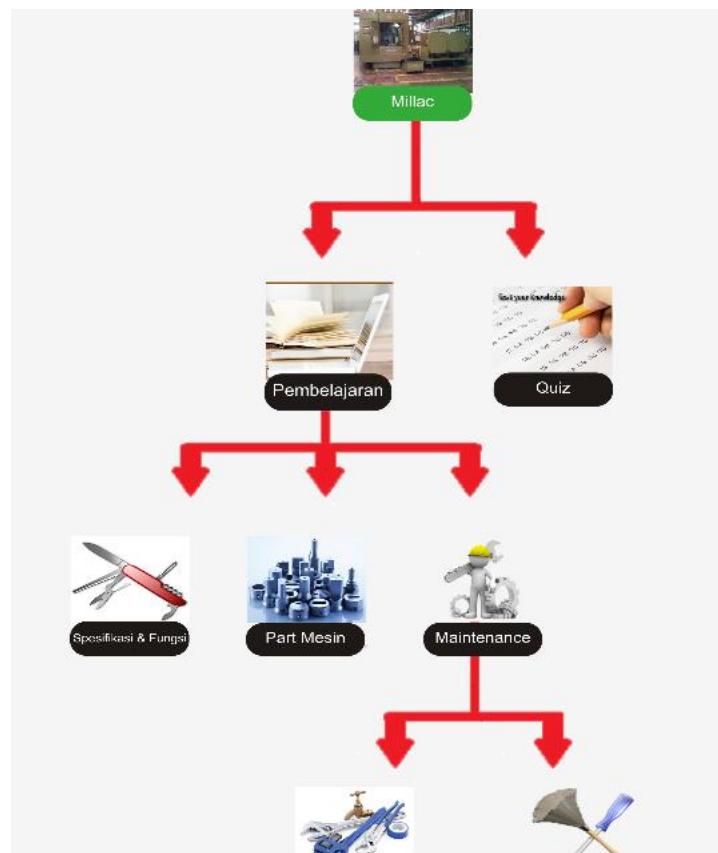


Figure 6. e-Learning Menu

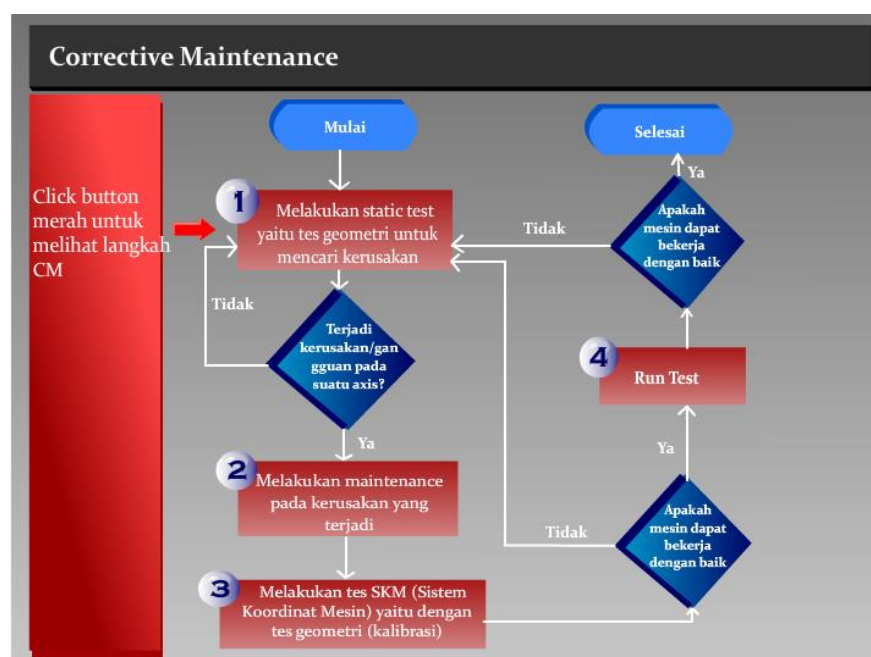


Figure 7. Corrective Maintenance Step

Question 6
Answer saved
Marked out of 1.00
Flag question
Edit question

Perangkat yang berfungsi untuk mengambil *cutter* yang terdapat di *magazine tool* dan meletakkannya di *spindle* sesuai dengan perintah yang diberikan . . .

Select one:

- ☒ a. *Arm ATC*
- ☐ b. *Piston ATC*
- ☐ c. *Pallet*
- ☐ d. *Axis*

Question 7
Answer saved
Marked out of 1.00
Flag question
Edit question

Berikut ini yang termasuk bagian *Automatic Tool Change (ATC)* adalah . . .

Select one:

- ☒ a. *Magazine tool*
- ☐ b. *Filter*
- ☐ c. *Pallet*
- ☐ d. *Spindle*

Figure 8. Quiz for Maintenance Process

5. Conclusion

This research intend to provide a system that can be used as a knowledge sharing between maintenance operator. Features in the application is fitted with the requirement by using analysis from QFD so the users are involved within the development process. The main feature of this application are :

- Course
The subject in e –learning is about maintenance process for Millac 5H6P that is present to the user more interactive by using flash animation.
- Quiz
Quiz in this application is about the maintenance process to test the understanding form the operator about the process.
- Forum
Forum that is provide in this application can be set for a place to post and comment so that the knowledge sharing and creation process can be achieved.

This application are designed with the use of UML and iterative method for development.

6. References

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