CHAPTER 3
Research Methodology

3.1 Chapter Overview

As mention in Chapter 1, this research proposed to use thealternative method, a knowledge game to solve the problem of the traditional training. This knowledge game is the efficiency tool for enhancing the engineering visual inspection performance of the personnel in the PEA of Thailand. This chapter presents the detail of research methodology. It is divided into 3 phases: 1) game conceptual framework development phase, 2) knowledge game development phase, and 3) validation and evaluation phase. The first section presents the conceptual framework development phase concerned with the concept of knowledge game framework development. The first section also presents the detail of the knowledge game framework, which is divided into three main parts: Knowledge Base and Scenario, Scenario Selection Machine, and Knowledge Game Interface. Next the second section explains the knowledge game development phase. This phase concerns the process, methods, related methodologies, tools and techniques to develop the prototype of the knowledge game. Then, the prototype is validated to check the validity and reliability of content. The last section explains the validation and evaluation framework. This section presents the testing objective, testing variable, validation method, and concerning data.

The research methodology adopted in the present study is as illustrated in Figure 3.1. The diagram in shows the process from the beginning to the end. As mentioned above, this research focuses on the knowledge game development to solve the problem PEA's HRD intervention.

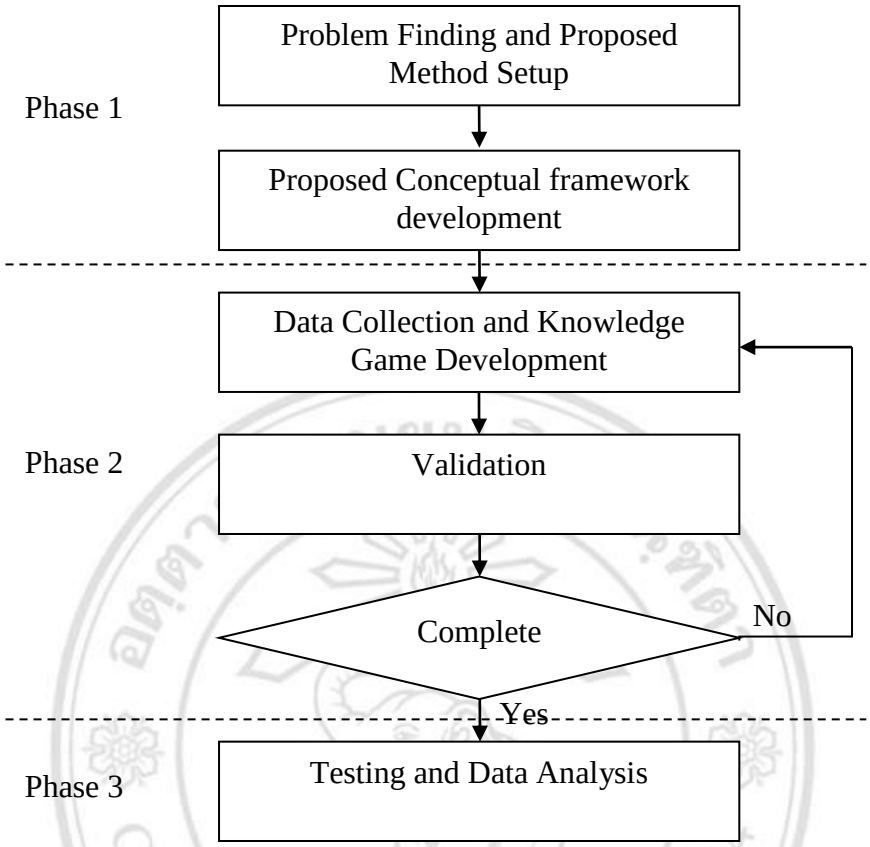


Figure 3.1 Research Methodology

3.2 Conceptual Framework of the Thesis

This research proposes the "Knowledge Game" to solve the problem of traditional development. The game based knowledge management is a computer game which can be used for transferring the knowledge and experience from experts to other employees in an organization. The knowledge game gives the staff a chance to make decisions and undergo experiences. The players will be able to exercise their decision making skills in a simulated environment without undergoing the pressure of making decisions in real life where the consequnces of their actions can be accountable. The knowledge game provides the content of maintenance tasks step by step while allowing the players to unlimited number of practice. This research proposes to train employee's visual inspection skills by combining work-instructions, expert knowledge, and case study examples into a maintenance database. The primary aims of the content are to

train the the staff on analysing risk and conditions of equipment, in other words, to support the staff to become. The conceptual framework which proposed to solve the problem of traditional development method can be performed as shown in Figure 3.2.

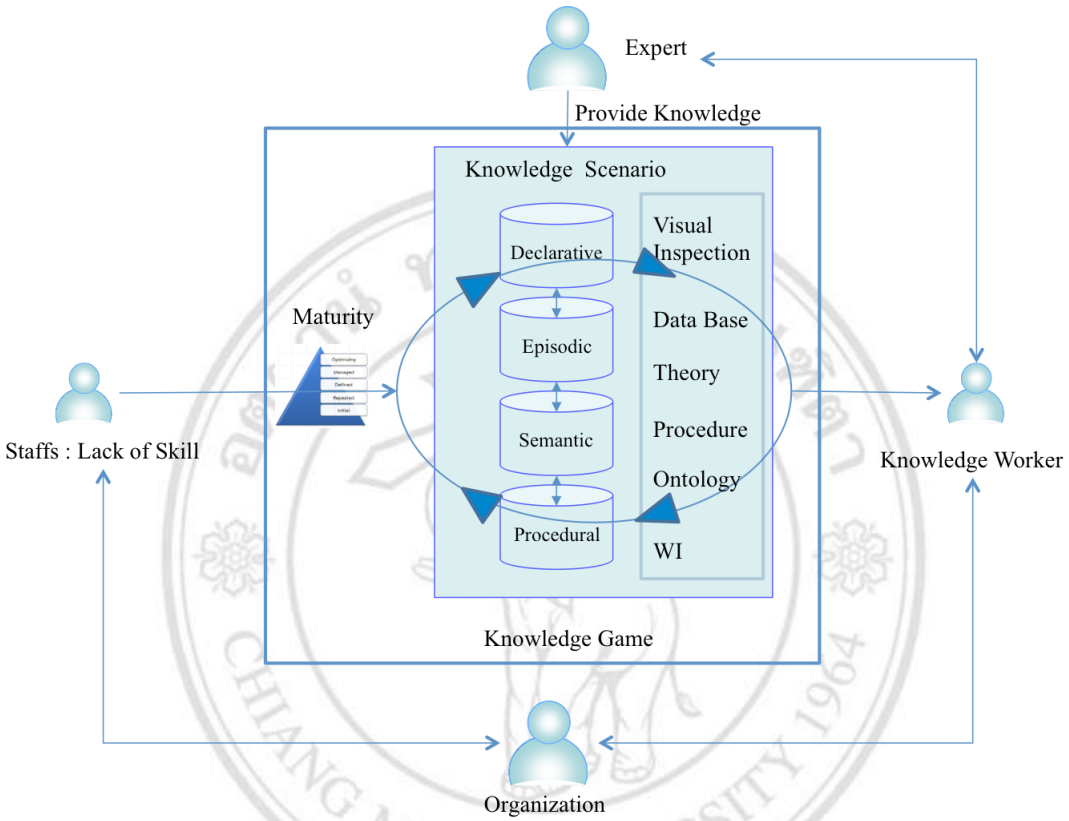


Figure 3.2 The Research Conceptual Framework

The conceptual framework presents that the staff who lacks the target knowledge and skill to play the game. The first step is for the staff to be evaluated on their knowledge and skill level. Then s/he can learn the entire content of game via game environment. They can repeat their learning in the game according to their needs. After they finish their training in the game, the knowledge and skill of player will be enhanced.

3.3 Proposed Competency Model Development based on CMM

As stated in the literature review in the previous chapter, it is found that the current competency models do not emphasize in technical skill, especially in the engineering aspects. The existing competency profile of substation maintenance

sections presents the technical competencies including knowledge in protective device in power system, inventory system, electrical equipment installation and maintenance. These competency skills are considered general maintenance knowledge, which is inefficient for enhancing the episodic knowledge, especially the inspection capability. Moreover, the proficiency levels in the current PEA competency model only provide the characteristics of each level with insufficient details for HRD personnel to set up the suitable method to develop the maturity of the personnel. For the competency model development of maintenance task, it has to focus on the functional competency because the maintenance personnel should have the specific skill, knowledge and ability in order to complete their job. Therefore, it is important to understand the learning process of the experts in the maintenance job. Chandarasupsang, Chakpitak, and Dahal (2008) proposed the organizational learning model on maintenance activities to categorize and develop the maintenance tasks by applying the Knowledge Engineering (KE). The development of the learning model is based on collective experience gained over a period of time. It is a time consuming process with many parties involved to develop the common best practices. This learning model proposes that there are five steps in the maintenance processes: breakdown maintenance, corrective maintenance, preventive maintenance, predictive maintenance, and proactive maintenance. The model presents a step-by-step learning development from breakdown to proactive maintenance. Therefore, the competency of maintenance task and maturity model can be developed based on this learning model.

In this research, Capability Maturity Model (CMM) is applied to develop the competency model of the maintenance task. CMM is a method for evaluating the ability of the organization. Although CMM is originally developed for software development, it can be used in various fields as a general model of the maturity of the process. These include, for example, software engineering CMM, and people CMM (Williams, 2008). This methodology describes essential attributes that would be expected to characterize an organization at a particular maturity level. A maturity level is a well-defined evolutionary period toward achieving a mature process. Each maturity level provides a layer in the foundation for continuous process improvement. Each level comprises of a set of process goals that when satisfied, stabilize an important component of the

software process. Achieving each level of the maturity framework establishes a different component in the software process, resulting in an increase in the process capability of the organization. The CMM organizes the capability of software process development into five levels and prioritizes improvement action for increasing software process maturity (Paulket al., 1993). Kim and Grant (2010) stated that CMM offers guidelines about essential requirement and component of each maturity level. Therefore, this research proposes to apply CMM in order to specify the proficiency level, and define the competency profile of each maturity level. By applying the CMM in the proposed framework, it gives the benefit for specifying the continuous development process of personnel capability, which cannot be found in the current PEA competency model.

3.4 Proposed Game Conceptual Framework Development

This section presents the alternative game based knowledge management framework development. It focuses on how to develop the knowledge game which can be used to motivate and enhance the specific skill to the player. This game will solve the problems which occur in the tradition training. It is proposed to be the efficiency tools in order to enhance visual inspection skill and maintenance knowledge of substation maintenance staff. It differs from existing serious games in the learning aspects and environments. Instead of providing academic theory or engineering details, the proposed knowledge game focuses on the how-to-think concepts.

The research starts by literature review in concerning theories. These include professional development, human resource development, digital game based learning, learning theory, motivation theory, knowledge engineering, game theory and capability maturity model. Reviews on digital game based learning revealed that the game development process can be divided into 6 phases: (1) setting up game development, (2) determining project goals, (3) game design (creative aspect), (4) game design (technical aspect), (5) production and authoring, and (6) finish line (Iuppa and Borst, 2010). This research focuses on developing the instructional design and prototype of the game, from the 1st stage to the 3rd stage of the game development process.

The 1st phase – 3rd phase concern the instructional design development and game prototype development. During these phases, the instructional design is considered. The instructional design is very important for the game development project. The instructional design identifies principles of good instruction that can be added to the game to make it more effective. This analysis identifies exactly what the game have to teach. It also identifies the tasks that the player has to complete successfully to simulate the experience and learn correct behavior. The results of the instructional design define how to present the information in a way that will help the learner understand. Then, the prototype of game is developed based on instructional design to test the concept before graphic and animation development. However, the high level framework of knowledge game development is considered to cover the whole process of game development.

Then, the learning theory and motivation are considered to develop the method for teaching the player within the game environment. This consideration also investigates that how canoptimize motivate the learner or player to learn in game. The result of consideration found that the concept of adult learning and motivation theory can be applied to develop the game. These concepts are used as guidelines for the elements of scenario development.

After that the research considers the appropriate method to create the game story. CommonKADS is selected in this research for capturing the knowledge and experience of substation maintenance experts over MIKE and PROTÉGÉ. CommonKADS methodology is applied to elicit the knowledge and experience of experts in the organization. These knowledge and experience serve as resource materials to set up the capability classification model and develop the game scenario. CommonKADS inference templates are used as a guideline to interview the experts. As the present research focuses on inspection maintenance skill enhancement, this research proposes to combine CommonKADS with Maintenance Learning Model which was presented by Chandarasupsang in 2008. Through this combination, the questionnaires for the knowledge elicitation process can be developed. The knowledge and experience of experts are used to develop the knowledge based of the game.

Finally, the research considers the method to classify the ability level of the player. According to the Flow Theory of Csikszentmihalyi (1991), it defines the state of people engagement in learning. One of the factors which can be applied in the training design process is the suitable difficulty level of task compared to the personal skill. The original flow model presents the relation between personal skills and challenge of activity. From the trainee's perspective if skill level of the staff member is higher than the difficulty level of training session, it makes trainees uninterested in the training program. On the other hand, if the skill level of the staff member is lower than the difficulty level provided in the training session, the trainees feel anxious and sometimes they are observed to give up on the training program. Therefore, it is very important to consider and design the difficulty level of the training course. The trainers have to design the training course by taking into consideration the difficulty level of the content of the training session to match the skill, knowledge and abilities of the trainees. Therefore, this research proposes to develop the tool for player ability placement which will allow individual trainees to be practiced and tested on their abilities.

Based on the literature review as mentioned above, the knowledge game developing framework can be developed. It is divided into three main parts: Knowledge Base and Scenario, Scenario Selection and Knowledge Game Interface. This model is summarized in Figure 3.3.

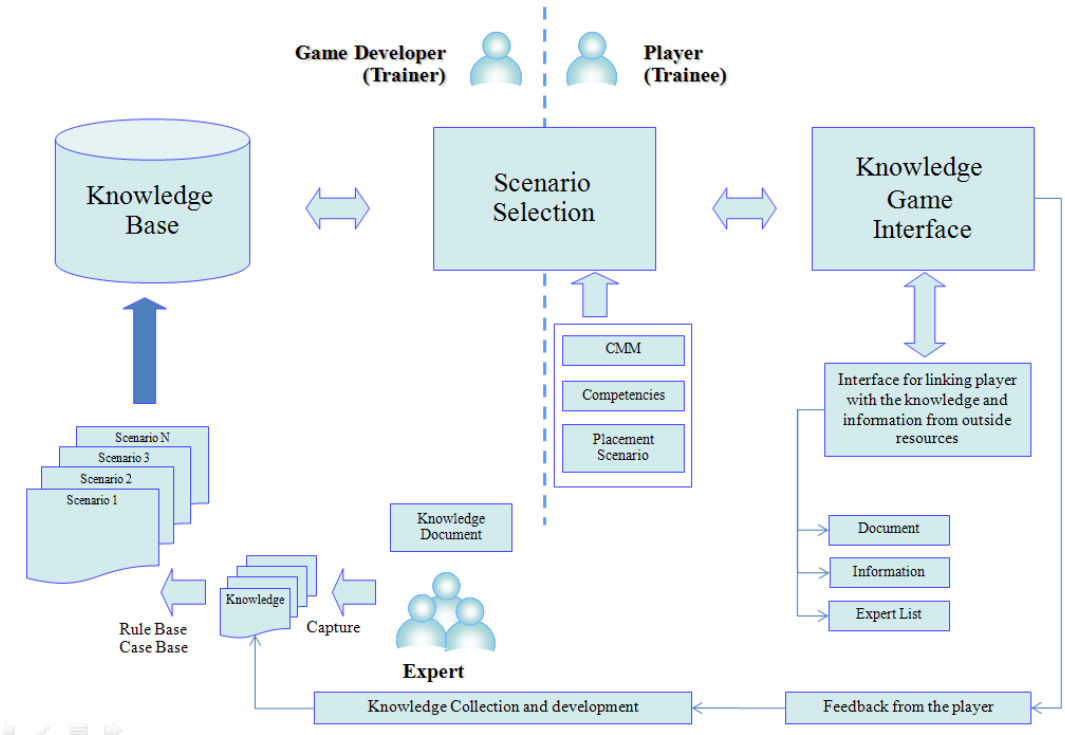


Figure 3.3 The Knowledge Game Development Model

1. Scenario Selection Machine

   The objective of the Scenario Selection Machine is to select a suitable scenario for each player. Although the player will be more motivated to learn when the difficulty of game is not too hard, it should not be too easy for them to play. Therefore, the game difficulty level has to appropriate to the ability and knowledge of the player. This research develops the capability classification model for identifying the ability of the player. It is used for identifying the skill and knowledge of the individual trainees compared with the expert in the organization. Game theory is applied to analyze the randomly appropriate selected scenario for player (staff). This theory will be used to find the equilibrium point of payoff between player and organization. At this point, both the player and instructor or organization will gain maximum payoff. Therefore, the selection engine is able to specify the proper scenario for enhancing knowledge of the employees in each level. It is based on the concept that the trainee will be more motivated when the difficulty of training course is matched up with the ability and knowledge of the trainees.

The HRD methods and Capability Maturity Model methodology and Game theory are applied to develop this model. Knowledge engineering is used to gather the informationand knowledge of experts to set up the competency model.

2. Knowledge Base and Scenario

The Knowledge Base and Scenario step is used for containing the scenarios of the knowledge game. Scenario development goal is to make the players acquire the complex knowledge and skill by letting the players perform their jobs in short realistic story lines. The scenarios address well-formulated learning objectives and contain the proper learning environments. Scenarios are designed and developed by professional instructor within the training domain to fit the learning objectives for each part of training (Peeters, 2013). For this research, in order to develop this part, the CommonKADS and Knowledge Engineering methodologies are applied. Both methodologies are applied to elicit the knowledge/experience from experts. The specific knowledge from exerpt is used to develop the mini game, while the general concept is taught by storytelling method. The analyzed knowledge is transformed to be the rule of the game for creating the scenarios and stored into the knowledge based and scenario. The rule, knowledge, and information are used to develop the game scenarios. The game scenarios are based on 6 key structural elements of games which was proposed by Prensky (2001) applied together with adult learning theory and motivation theory.

3. Knowledge Game Interface

The knowledge game interface is computer interface between the player and the game content. It is used to provide feedback and information to the player. The presented game technology, such as Torque Demo, will be used to develop the game animation. Moreover, the interface also has been designed for linking the player to the knowledge and information from outside resources. It will be used for collecting all of players' erroneous decisions for analyzing and building up the best practice. It can be used for collecting new knowledge that can be gained from players during the game.

The present research focuses on how to develop the knowledge base, scenario and scenario selection phases. It does not pay attention in order to develop the Knowledge Game Interface part because of the knowledge game interface can be developed by existing game technology such as Torque Demo. Therefore, it does not require new methodology development for the interface part.

3.5 Knowledge Game Development

This section presents the second phase of the research methodology. It presents the process to develop prototype of knowledge game following the conceptual framework. The detail of data collection, target group selection, technique, and tool of game development are also presented. This prototype game is developed focused on a specific task. Therefore the focus group is the experts of 22kV switchgear maintenance. The collected data is the knowledge and experience of the experts. Various data collection methods such as structured interviews, protocol analysis, surveying, and literature review are applied. The process of prototype development is divided into 3 parts including scenario selection engine part, knowledge based and scenario development part, and validation part. The detail of all steps will be described in this section. Table 3.1 presents the methods and related theories which are used.

Table 3.1 Knowledge Game Prototype Development Process

Framework Part	Process	Method	Related Theory
Scenario Selection Engine Development	1. Literature and Document Review	• Review the Job Description, Work Manual , Training Document	• HRD
	2. Job Analysis	• Structured Interview	• HRD • Knowledge Engineering
	3. Task Analysis and Knowledge Capture	• Structured Interview	• HRD • Knowledge Engineering (CommonKADs) • SIPOC Model

Table 3.1 Knowledge Game Prototype Development Process (Continue)

Framework Part	Process	Method	Related Theory
	4. Staff Analysis	• Structured Interview	• HRD • Motivation Theory
	5. Knowledge and Skill Analysis	• Competency Analysis Table	• HRD • Competency Base • SEPA Model
	6. Competency Model Development	• Competency Catalogue Form	• CommonKADS • Competency Base • CMM
	7. Classification Model Development	• CMM Analysis • Radar Diagram • Surveying	• CommonKADS • Competency Base • CMM
	8. Placement Scenario Development	• Interview • Knowledge Analysis and Modeling	• CommonKADS • Competency Base • CMM
Knowledge Base and Scenario Development	9. Knowledge Capture	• Structured Interview • Video recording on real operation	• CommonKADS • CMM • Protocol Analysis
	10. Knowledge Analysis	• Knowledge Analysis and modeling	• CommonKADs
	11. Scenario Development	• Scenario Framework	• HRD • Learning Theory • Flow Theory • Motivation Theory • CommonKADS Serious Game Development
Validation	12. Validation	• Pencil and Paper Testing • Prototype Testing • Validation Meeting	• HRD • Learning Theory • Knowledge Engineering

The concerning participants of the research comprised of human resource (HR) staff, substation maintenance executive, substation maintenance expert, and substation

maintenance staff. The details of the participants and the processes which they took part in are as shown in Table 3.2.

Table 3.2 The Detail of Process Participation

Process	Participant	No.
1. Literature and Document Review	-	
2. Job Analysis	- Substation Maintenance Executives - HR Managers	2 1
3. Task Analysis and Knowledge Capture	- Substation Maintenance Experts	4
4. Staff Analysis	- Substation Maintenance Staff	4
5. Knowledge and Skill Analysis	-	
6. Competency Model Development	-	
7. Classification Model Development	- Substation Maintenance Executives	2
8. Placement Scenario Development	- Substation Maintenance Experts	4
9. Knowledge Capture	- Substation Maintenance Experts	4
10. Knowledge Analysis	-	
11. Scenario Development	-	
12. Validation	- Substation Maintenance Experts	12
13. Case Study 1	- Substation Maintenance Staff	4
14. Case Study 2	- Substation Maintenance Experts - Substation Maintenance Staff	1 1
15 Case Study 3	- Substation Maintenance Staff	6

3.5.1 Scenario Selection Engine Development Part

This part focuses on how to identify the performance of maintenance personnel and how to specify the capability maturity development. The CMM methodology is applied in this framework in order to develop competency model and competency profile of the capability classification model proposed in Chapter 2. CommonKADS is

used to elicit the knowledge and experience of the subject matter experts as discussed in Chapter 2. With this proposed framework, the organization can make the right decision to provide the suitable method for enhancing the employee performance. The proposed framework is shown in Figure 3.4.

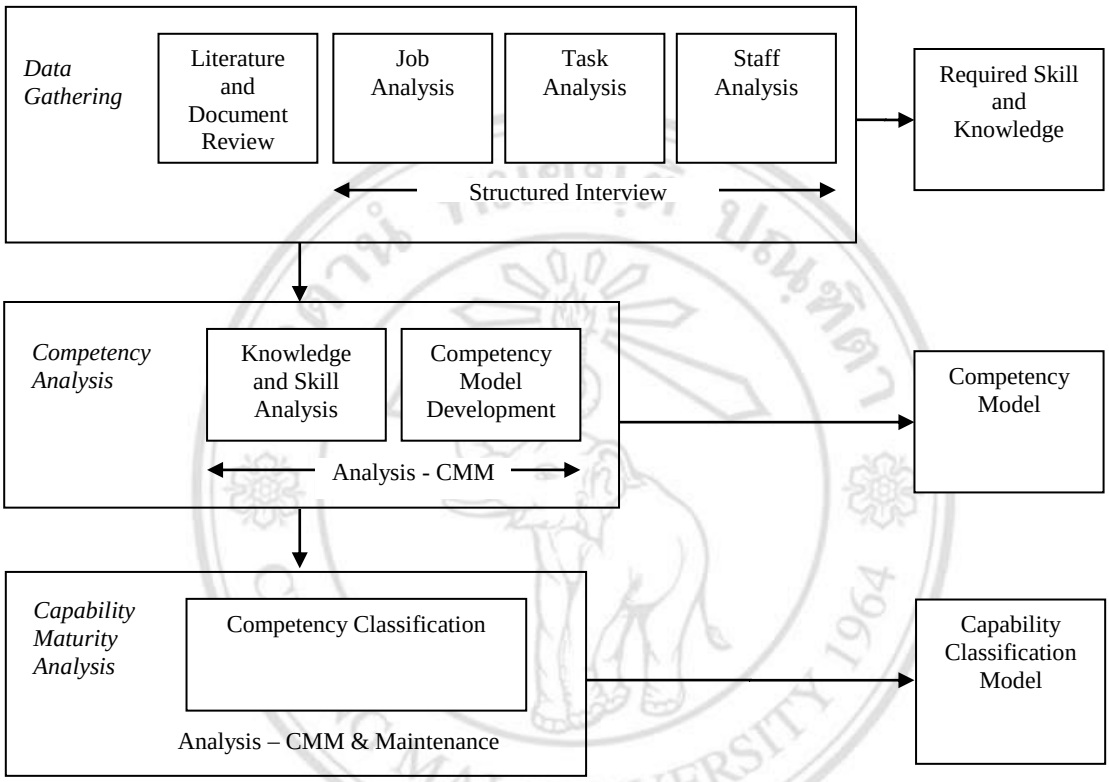


Figure 3.4 Personal Capability Classification Development Framework

Step 1: Literature and Document Review

The objective of this process is to define the problems of training and development efforts in an organization. The process starts with a reveiew of the concerned documents and manuals. This covers relevant working manuals, worksheets, and training documents. By reviewing the materials mentioned, the interviewing questions for job analysis and task analysis step can then be prepared constructively. This step provides the interviewer a better understanding of the basic concepts and ontology of the specific task.

Step 2: Job Analysis

This step starts by reviewing the existing job description. Then, the line manager is interviewed to define the needs of HRD effort in organization and job description, and to identify tasks or sub-tasks of the job. Required knowledge and skill of the job as well as the subject matter experts are also identified during this step. After that, the questionnaires are developed by applying the CommonKADS templates.

The design method used in this step is semi-structured interview. The first interview of this research is called "Scoping Meeting". In order to interview the line manager, the agenda of this interview is developed. During the interview process, the voice recorder is used. The developed interview agenda for asking the line managers are presented in table 3.3.

Table 3.3 Agenda of Scoping Meeting

Agenda of Scoping Meeting	
Agenda 1:	Present the project objectives
Agenda 2:	Present the meeting objective
Agenda 3:	Identify Critical Tasks and Subtasks
Q:	Please identify the critical tasks and subtasks of substation maintenance work.
Q:	Please roughly describe the details of each task.
Agenda 4:	Identify the subject matter expert
Q:	Who are concerned in the 22 kV switchgear maintenance job?
Q:	Who are the experts of the 22 kV switchgear maintenance job? Do you have the name list of them?
Agenda 5:	Identify the recent training and development method
Q:	What are the training and development methods for enhancing the staffs' employees?
Q:	What is the method to motivate the staff to learn?
Agenda 6:	Knowledge Base
Q:	Are there the knowledge bases of this task?
Q:	Are there related documents such as training documents, working manuals, wiring diagrams, working reports?

Step 3: Task Analysis and Knowledge Capture

A task analysis is a step to collect the data about a specific job or group of jobs. The aim of this process is to determine what an employee should acquire to achieve optimal performance (Werner and DeSimone, 2006). The data collection of this process is conducted by applying the methods including structured interviews, job observations, and reviewing literature of the jobs. The results include the performance standards, the details of the action which should be performed to meet task standards, and the knowledge, skills, abilities, and other characteristics that employees need to possess in order to meet the standards.

This research proposes the semi-structured interview as a means to elicit experiences of the selected experts. This interview is called "Knowledge Capture Meeting". The meeting is done one-on-one interview. As mentioned previously, CommonKADS concept is applied in this step. CommonKADS provides the common knowledge model templates to elicit knowledge and experience from experts. These templates can be used as a guideline to set up the questionnaires for knowledge elicitation process. After that, the experts of the task are selected for interview.

This research focuses on the substation maintenance staffs' performance development. Therefore, it proposes to develop the technical competencies of the maintenance staff. The maintenance staff should have the specific skill, knowledge and ability to complete their task. In order to develop the competency model of maintenance job, it has to understand the maintenance process and learning progress of the staff. This research proposes to apply the Organizational Learning Model on Maintenance Activities which developed by Chandarasupsang and his colleagues (2008). This model categorizes and develops the knowledge of the maintenance tasks by applying the knowledge engineering. This model divides the maintenance task into 5 steps presented in Figure 3.5.

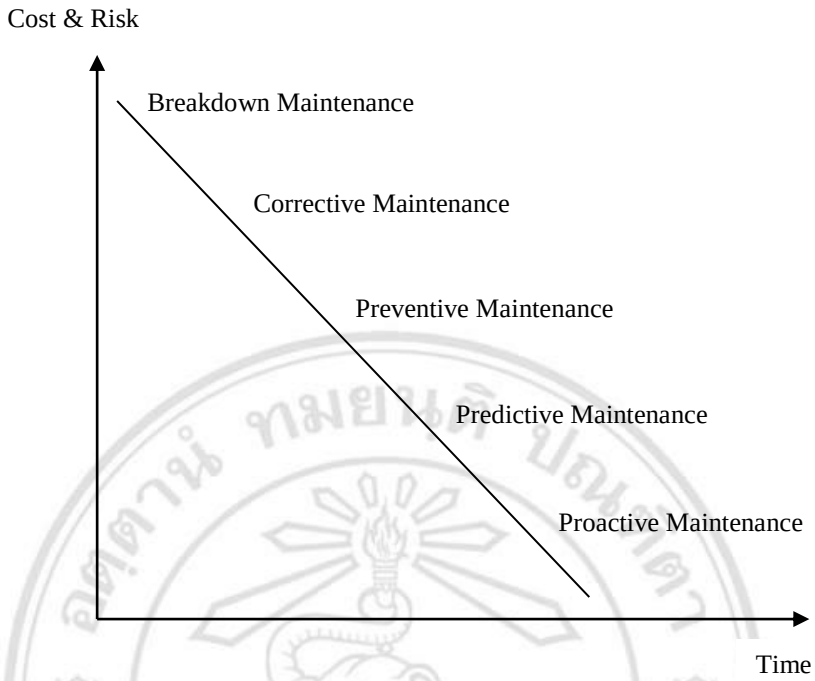


Figure 3.5 Maintenance Learning Model

Source: Chandarasupsang, Chakpitak, Dahal (2008)

Chandarasupsang and his colleagues (2008) explained in their research that the maintenance learning process is based on experience collectively gained over a period of time. It is a time consuming process with many parties involved to develop the common best practices. This learning model presents that there are 5 steps in the maintenance process. The model presents a step-by-step maintenance job development from breakdown to proactive maintenance. Therefore, the competency of maintenance task can be developed based on this learning model.

Therefore, the questionnaire for developing the knowledge capture meeting agenda can be done by following the maintenance learning model. This model provides the benefit to the researcher in order to select the four CommonKADs inference planning inference, diagnosis inference, scheduling inference, monitoring inference, and assessment inference templates to develop the agenda questionnaires of breakdown maintenance, corrective maintenance, preventive maintenance, predictive maintenance, and proactive maintenance respectively.

For breakdown maintenance, knowledge on ‘how-to operate’ and ‘how-to maintain’ 22 kV switchgear has to be developed. Therefore, the planning template as shown in Figure 3.6 is selected to capture knowledge for breakdown maintenance processof 22 kV switchgear.

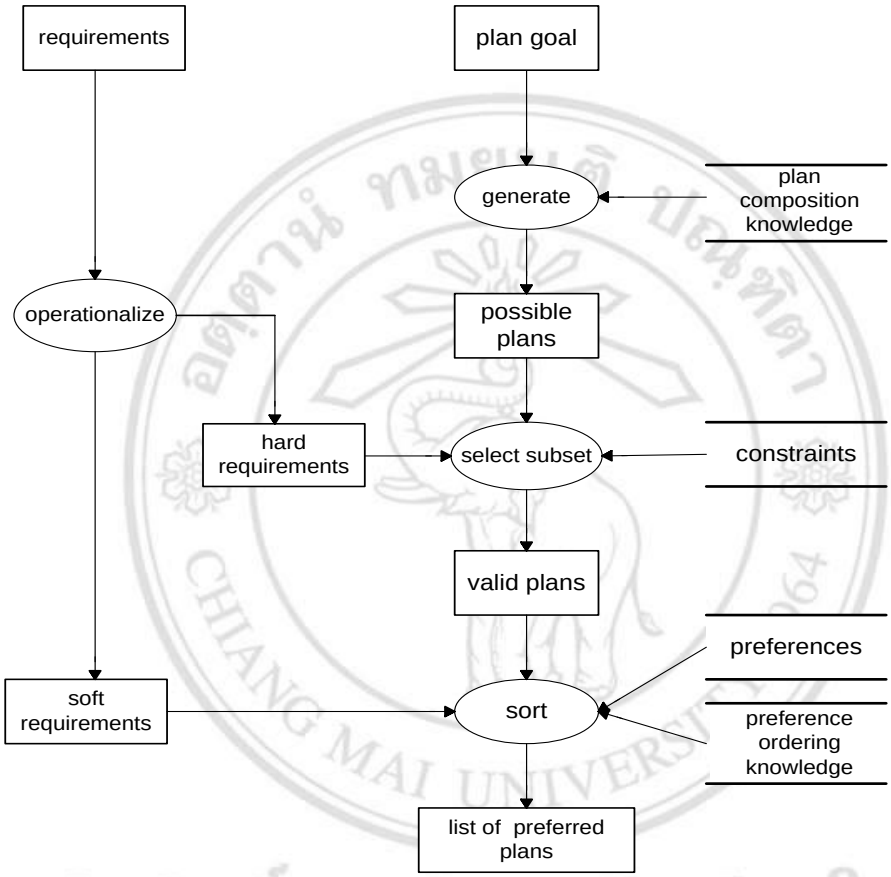


Figure 3.6 Planning Inference Template

Source: Schreiber et al., 1999

In order to do the corrective maintenance process, the workers have to understand ‘how-to identify’ the faults in each particular failure. Therefore, the diagnosis inference template is selected to apply to capture this knowledge. The diagnosis inference template is as shown in Figure 3.7.

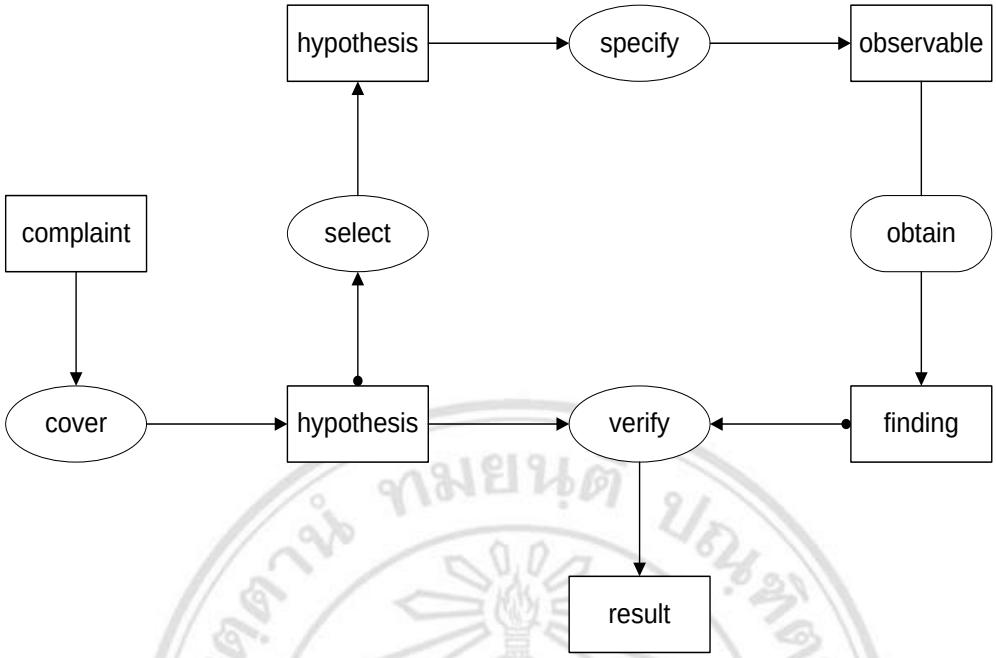


Figure 3.7 Diagnosis Inference Template

Source: Schreiber et al., 1999

In the preventive maintenance process, the maintenance staff attempt to schedule the activities and their existing resources as well as minimize costs in order to prevent unplanned outage from faults and unexpected events. This involves the development of their resource's scheduling and optimization techniques. The scheduling inference template is selected to capture this type of knowledge. It is shown in Figure 3.8.

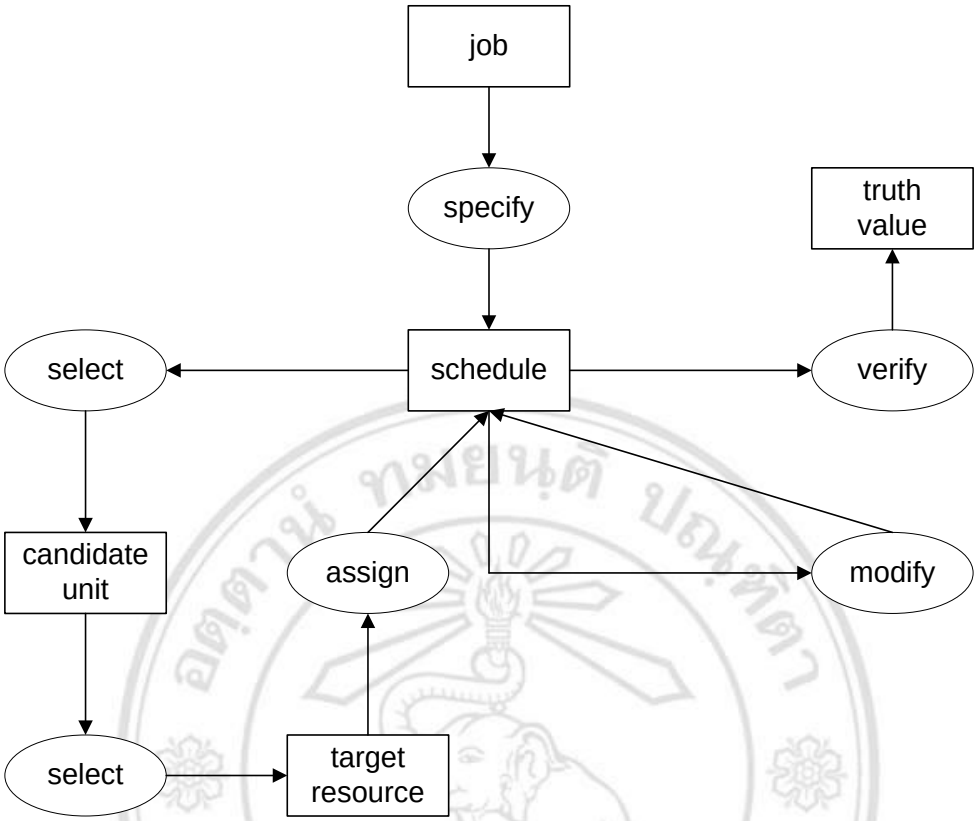


Figure 3.8 Scheduling Inference Template

Source: Schreiber et al., 1999

In the predictive maintenance, the maintenance workers should able to detect some incidents or some conditions as well as predict the likelihood of faults. Predictive maintenance scheme indicates the abilities of the knowledge workers to foresee the future faults and events based on present condition of the equipments. Therefore the monitoring inference template is selected to set up the questions to elicit the knowledge and experience of this task. This template is shown as shown in Figure 3.9.

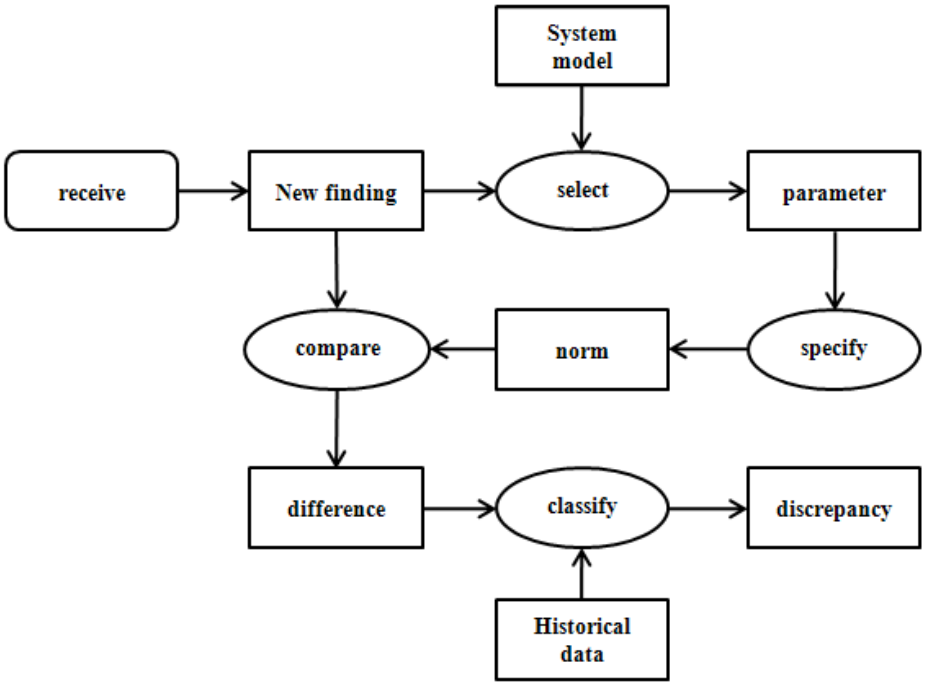


Figure 3.9 Monitoring Inference Ttemplate

Source: Schreiber et al., 1999

The proactive maintenance indicates abilities of the knowledge workers to assess the asset life time as well as its' parts, which consequently assists the utilities in the decision making on the replacement or the refurbishment. The assessment inference template of CommonKADs model can be used to capture the knowledge in proactive maintenance task. This template is shown in Figure 3.10.

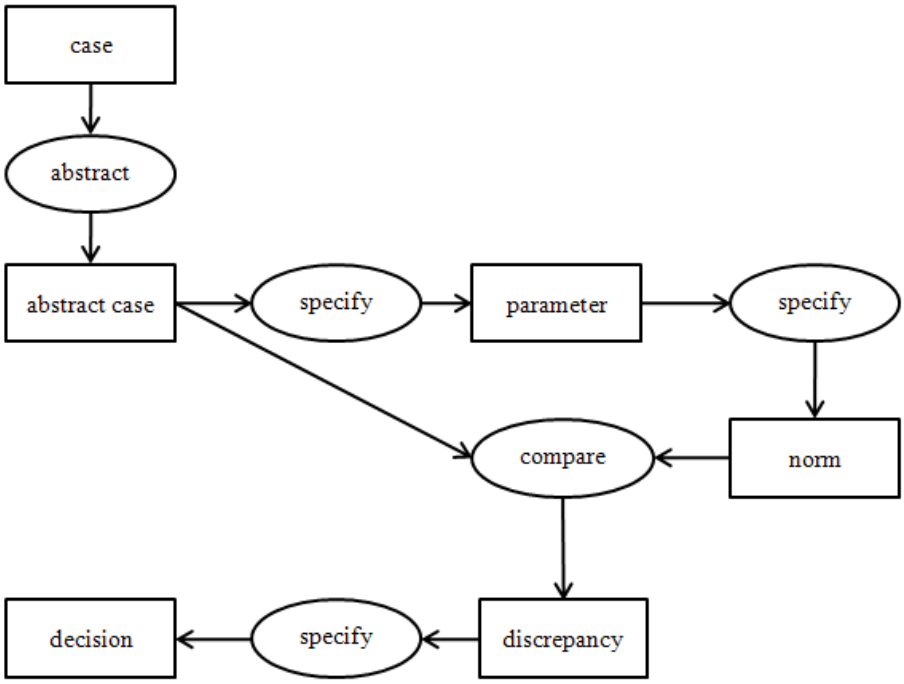


Figure 3.10 Assessment Inference Template

Source: Schreiber et al., 1999

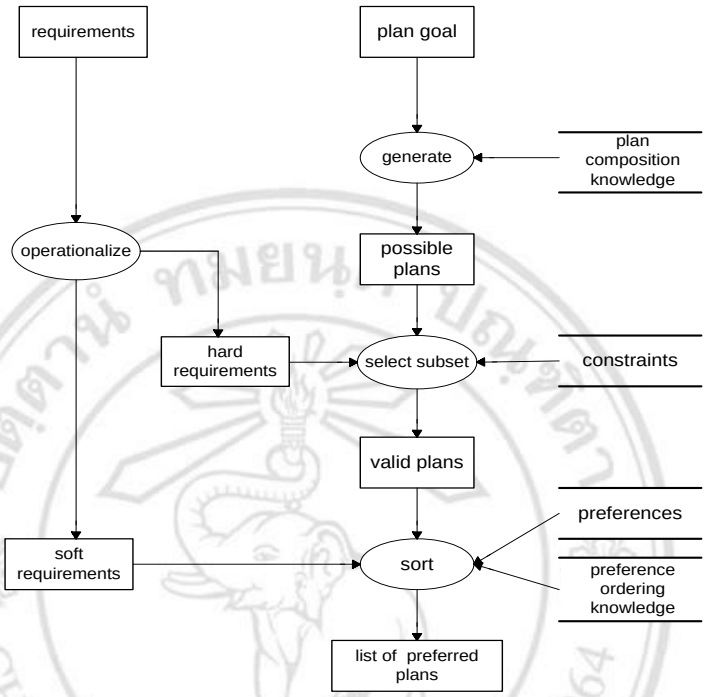
By the five CommonKADs inference templates, the question and meeting agenda can be developed as shown in Table 3.4.

Table 3.4 Agenda of Knowledge Capture Meeting

Agenda of Knowledge Capture Meeting
Agenda 1: Present the project objectives Agenda 2: Present the meeting objective Agenda 3: Task Overview Q: Please roughly describe the detail of each task. - Breakdown Maintenance - Corrective Maintenance - Preventive Maintenance - Predictive Maintenance - Proactive Maintenance

Table 3.4 Agenda of Knowledge Capture Meeting (Continue)

Agenda of Knowledge Capture Meeting
Agenda 4: Capture knowledge and experience of breakdown maintenance



Q: What is the goal of the task?

Q: How do you do this task?

Q: What you should know to do this task?

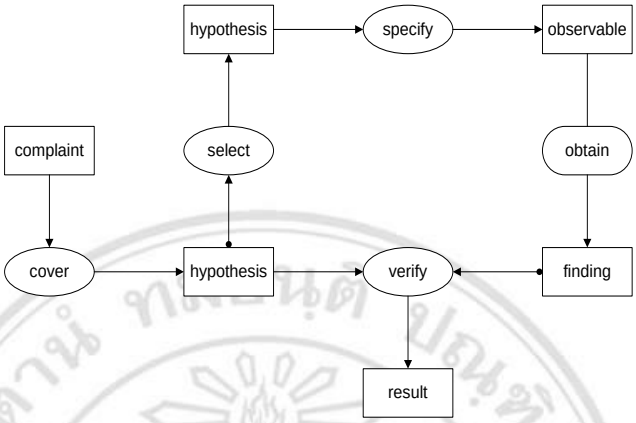
Q: How many approaches to operate the switchgear? What is the step?

Q: Which is the approach that you prefer?

Q: Are there any constraints of the approach? What are they?

Table 3.4 Agenda of Knowledge Capture Meeting (Continue)

Agenda of Knowledge Capture Meeting	
Agenda 5:	Capture knowledge and experience of corrective maintenance

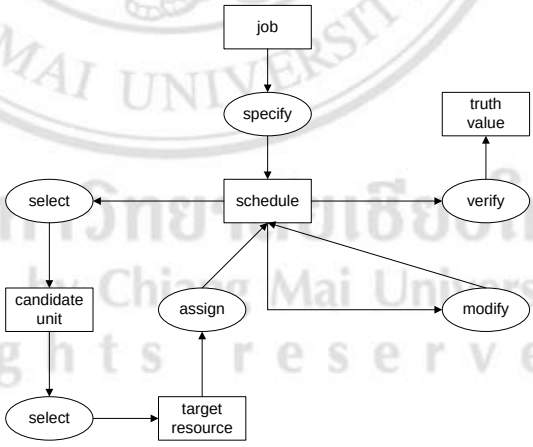


Q: Which kind of the problem shave you encounter before?

Q: How can you set up the hypothesis to analyze the problem that you have experienced?

Q: How can you prove that hypothesizes?

Agenda 6: Capture knowledge and experience of preventive maintenance



Q: What are the jobs that you have to do in this task?

Q: How do you schedule the maintenance plan?

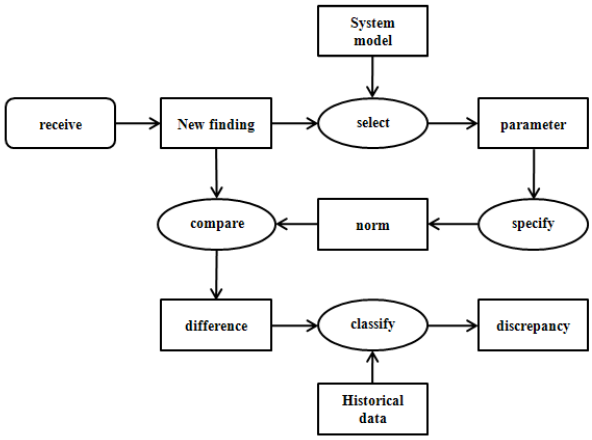
Q: What are the resources needed for this task?

Q: How can you adjust the maintenance plan?

Q: How do you check your plan?

Table 3.4 Agenda of Knowledge Capture Meeting (Continue)

Agenda of Knowledge Capture Meeting	
Agenda 7:	Capture knowledge and experience of predictive maintenance



Q: What are the reports obtained from the preventive maintenance?

Q: What are the parameters that can be used to evaluate the condition of equipment?

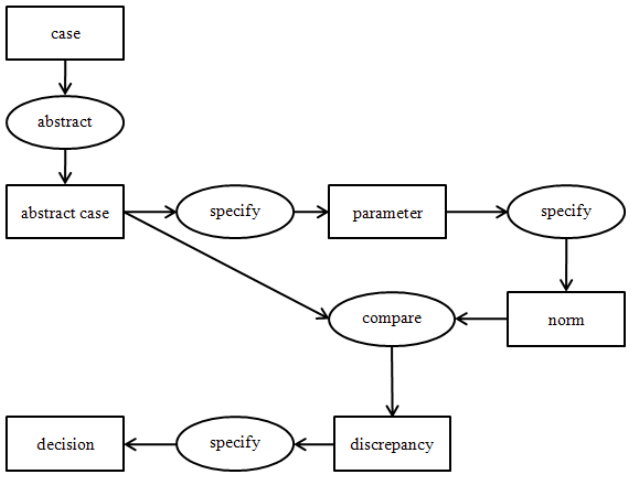
Q: What is the norm of parameter?

Q: How can compare normal values and abnormal values?

Q: How can analyze the data to evaluate equipment condition?

Q: How can you decide that the equipment is damage?

Agenda 8: Capture knowledge and experience of proactive maintenance



Q: When you decide to evaluate?

Q: What are the factors or parameters which you consider?

Step 4: Staff Analysis

The aim of this process is to explore the method for motivating the staff to learn. The method to collect the data in this step is interviewing method. The motivation and learning theories are applied to develop the interview agenda. These include adult learning theory, need hierarchy theory, and flow theory. The result of this process will be compared with the existing incentive model of target organization. The target group of this interview is the operators of 22 kV switchgear maintenance job. The proposed agenda of this meeting is shown in Table 3.5.The objectives of this process are to understand the detail as follows:

- the preference training method of maintenance staff
- the staff needs for motivating them to learn
- the reward and incentive need of staff

Table 3.5 Agenda of Staff Analysis

Agenda of Staff Analysis	
Agenda 1:	Present the project objectives
Agenda 2:	Present the meeting objective
Agenda 3:	Explore Motivation
Q:	Have you ever joined the training or development program?
Q:	What are the most interest training programs that you have joined before?
Q:	What are the factors that motivate you to join the training program?
Q:	What are the factors that motivate you to learn in your job?
Q:	What kind of incentives would you like to receive?

Step 5: Knowledge and Skill Analysis

To perform task successfully, it is required that personnel possess the knowledge and skill to perform the task. This step is conducted to analyze the data, information, knowledge and experience which capture from experts. The analyzed data is used to ultimately model the competency framework of specific job.

This research proposes the competency analysis table form (Table 3.6) for considering the knowledge, and skill. This competency analysis table is developed based on SEPA (State Enterprise Performance Appraisal) which is developed based on the Malcolm Baldrige National Quality Award (MBNQA). SEPA provides the framework to improve performance and competitiveness of the organization by considering in 6 separate parts in leadership, strategic planning, customer focus, measurement analysis and knowledge management, workforce focus, and process management. Traditionally, the human resource development part of SEPA application is considered separately from other aspects. However, for effective organization development, this research proposes to consider the HRD by integrating the data and information from other parts of SEPA as the holistic model. In other words, the HRD has to integrate data and information from many aspects including organization system, job process, job task, knowledge, skill and risk. This step identifies the necessary knowledge and skill of the task by using the competency analysis table form as shown in Table 3.6.

Table 3.6 Competency Analysis Table

Function	System	Process	Task	Knowledge	Skill	Risk

The list of the task is clarified and filled in the Table 3.6. The data collected from the concerning parties were analyzed and listed in the proposed competency analysis table. The first column of competency table “function” presents the job of 22kV switchgear maintenance work. The second column “system” shows the set of processes. The third column “process” defines the process of 22 kV switchgear maintenance job. The fourth shows the task of each process. The next two columns

show the essential knowledge and crucial skill which supports to perform and complete the task. The last column identifies the risk which impact directly to the task if the staff are lack of the knowledge and skill.

Step 6:Competency Model Development

This objective of this step is to develop competency model. It is the list of knowledge and skill which is stated as what the personnel must be equipped to perform each task. The clear knowledge and skill statements are written in this model. In this research, after knowledge and skill are clarified in the competency analysis table, they are evaluated to select the importance knowledge/skill and grouped into the competency cluster. Then, CMM methodology is applied to classify the level of the knowledge and skill. Normally, many organizations including PEA identify the proficiency level by simple rating system such as four patterns or five patterns. Currently, the proficiency of competency is divided into five levels. These are beginner, apply, supervise, master, and strategic levels respectively. Although this classification method is convenient for the development of the competency model, this rating system is insufficient for enhancing the personnel' performance in some special skill, especially the inspection skill. Therefore, to overcome this issue, this framework proposes to apply CMM when ranking the competency level for each skill and knowledge.

The process of this step is to combine the competency analysis table (Table 3.6) with CMM methodology. By this process, the competency model has been revised. The competencies have been selected and grouped by applying the CMM classification methodology. The proposed level of competency in this framework can be divided into 5 levels: initial, repeat, define, manage, and optimize. The criteria are developed for classifying the proficiency level can be shown as Table 3.7.

Table 3.7 Criteria of Proficiency Level Classification

Level	Proposed Criteria
Level 1 - Initial	know the basic knowledge of the task.
Level 2 - Repeat	know the process and able to repeat the process
Level 3 - Define	understand the standard of the task
Level 4 - Manage	able to use the knowledge and skill to analyze the task.
Level 5 - Optimize	able to use the knowledge to develop task or solve the problem

By the above criteria, each competency can be rated. The competency catalogue of target task is then set up in this process. This research also proposes the competency catalogue form as the tool for describing the detail of each competency. The competency catalogue form is shown in Table 3.8.

Table 3.8 Competency Catalogue Form

Competency Name:		
Definition:		
Level	**CMM**	**Knowledge and Skill Expected**
1	Initial	
2	Repeat	
3	Define	
4	Manage	
5	Optimize	

Step 7: Classification Model Development

After competency models are developed, the CMM methodology is also applied for classifying the staff capability maturity level. Kim and Grant (2010) stated that CMM offers guidelines about essential requirement and component of each maturity level. Therefore, this research proposes to apply CMM in order to specify the proficiency level, and define the competency profile of each maturity level. Each maturity level contains the set of competencies. By this classification model, the proper training program can be set up and provided for the individual staffs.

As the present study's focus is on the maintenance competency development, themaintenance learning model is then applied to establish the maintenance maturity model. It divides the maturity development step of maintenance personnel into six levels. These include newcomer level, breakdown level, corrective level, preventive level, predictive level, and proactive level as shown in Table 3.9.

Table 3.9 Detail and Criteria of Competency Classification

Level	CMM	Maintenance	Criteria	Knowledge	Skill
0	Newcomer	Basic	Understand an overview of switchgear and relevance equipment	Equipment and instrument	Understand the detail of equipment
1	Initial	Breakdown	How-to operate and how-to maintain assets	Breakdown maintenance	Able to operation the equipment
2	Repeat	Corrective	How to repair the faults	Corrective maintenance	Understand the malfunction of equipment
3	Define	Preventive	Resource scheduling to avoid unplanned outages	Preventive maintenance	Define difference between normal and malfunction.
4	Manage	Predictive	Foresee the future faults and events based on present condition of the equipments	Condition-based maintenance	Compare condition of equipment with past situation
5	Optimizing	Proactive	Assess the equipment life time and its parts' life-cycle, and do the decision-making process to refurbish or replace some equipment	Proactive maintenance	Risk assessment

Table 3.9 specifies and explains the details of each maturity level. It also defines the knowledge and skill, which should be developed in each level. After that, each maturity level is identified and classified by different competency set based on CMM and maintenance learning model. Then, the tentative capability classification model of 22 kV switchgear maintenance task is developed.

After that, the tentative capability classification model is verified and validated. In order to validate the capability classification model, the focus group interview was conducted. The focus group comprises of twelve experts and executives of substation maintenance units. In the validation process, the focus group was asked to individually rate each competency according to their level of importance. The interviewing process began with the competency detail explanation. Then, each member of the focus group was asked to rate the importance of each competency. The survey can be shown in Table 3.10.

Table 3.10 Competency Validation Survey Form

Competency	Frequency How often that you use this knowledge or skill in your job? 1 = Never 2 = Seldom 3 =Regular 4 = Frequently 5 = Often					Importance How much is this knowledge importance to your job? 1 =Not important 2 = Less important 3 = Important 4 = More Important 5 = Most Important				
Planning	1	2	3	4	5	1	2	3	4	5
Coordination	1	2	3	4	5	1	2	3	4	5
Maintenance Operation	1	2	3	4	5	1	2	3	4	5
Measuring	1	2	3	4	5	1	2	3	4	5
Corrective	1	2	3	4	5	1	2	3	4	5
Monitoring	1	2	3	4	5	1	2	3	4	5

Then, the competencies with average ratings less than 4 are eliminated from the competency model. After eliminating unnecessary competencies, the experts and executives of target task were asked to review and proof the proficiency level and competency profile. Then, the final version of capability classification model was developed.

This capability classification model gives the benefit to organization in order to identify the capability level of staff. Comparing to traditional competency model, the framework proposed in this paper not only identifies the capability level of specific competency, but it also provides maturity development for enhancing the employee performance. The aim of this model is to develop scenario selection engine of the knowledge game. It is used as the mechanism to identify the players' ability level when individual start to play the game.

Step 8: Placement Scenario Development

This step designs the method to select suitable game level for individual game player or learner. This research proposes to develop the placement scenario for testing the player's ability. This testing is done when player starts to play the game. The experts of the target task are interviewed in order to develop theplacement scenario. For the interview process, the research proposed to set up the questionnaire by applying the capability classification model which is the result of step 7 to capture knowledge and experience. Then, the captured data is used for the placement scenario development. This research proposes the basic elements of the placement scenario. These elements include tests of each competency, quiz information, and time limit for each quiz. The limited time of each quiz is set up based on the time it took the expert to do the quiz. The time taken by the expert is used as the reference time it should take the trainees to finish the game.

As previsously methioned, the present research focus is on the instructional design of the development of the knowledge game. Therefore, the graphic animation and interface are not fully developed in this research. This research proposed to apply the pen-and-pencil testing concept to test the game development framework. The game

prototype is developed by using Microsoft Powerpoint porgram. After the design was finished, it was piloted by substation maintenance personnel. The placement scenario is designed to start the activity with the introduction and word of command. This screen introduces the activities each player has to do. The game is also designed to proceed the story by avatar or non-player character. Figure 3.11 shows the introduction screen.

Figure 3.11 Introduction Screen of Placement Scenario

For the following interface designs, the research proposes to develop the activity screens of prototype game with real photos. The basic elements in the quiz screen is comprised of timer tab, activity area, and skip button. The timer tab is used to show the remaining time of the activity. The activity area is the area where each player handles the assigned task. The skip button is used when the player does not need to play this activity. The activity screen of placement scenario is shown in Figure 3.12.

Figure 3.12 Activity Screen of Placement Scenario

The last screen of the placement scenario is the conclusion of the testing. The screen presents the score of each quiz. This conclusion gives the benefit to players in order to know their ability before they play the game. The interface is shown in Figure 3.13.

Figure 3.13 Conclusion Screen of Placement Scenario

The placement scenario prototype of 22kV switchgear maintenance is developed according to the design concept and knowledge captured from the expert. This placement scenario will be used to evaluate the knowledge of the player or trainee. After the player has been evaluated, game theory is used to define the proper strategic choice which provides the optimal payoff for both employee and the organization. The prisoners' dilemma of game theory is applied in this thesis.

In order to motivate the player to learn by playing the game, the knowledge game should provide a proper difficulty game scenario to the player. The game has to balance between the player's skill and the difficulty level of the tasks. The adequate level of the challenge refers to the challenge provided by the game while it is within the ability of the players. In the trainee's viewpoint, they want to play games that give them a challenge. On the other hand, the game should not be too difficult to play. However, in the trainer viewpoint, the knowledge game should provide more difficult items as it will help them learn new skills. The concept of game theory can be used to select the appropriate scenarios. All players in the game have to make the decision at the same time. Each player has 5 strategies. These strategies include (1) initial level, (2) repeated level, (3) define level, (4) manage level, and (5) optimizing level.

After the placement test, game theory is applied to check the appropriate set of scenario for individual player. These criteria were set up based on knowledge and information captured from the staff. The criteria used to set the payoff of each player are as follows:

- The trainee will be satisfied if the scenario is the appropriate level. (payoff =1)
- The trainee will be satisfied if the scenario is the trainee's selection. (payoff =1)
- The organization will be satisfied if the player can play the game. (payoff =1)
- The organization will be satisfied if player can play the game in expected level. (payoff =1)
- The trainee will be upset if he cannot play the game. (payoff =0)

- The organization will be upset if player cannot play the game. (payoff =0)

According to the criteria, the payoff matrix can be performed for analyzing the appropriate scenario of each skill. Table 3.11 presents the payoff of planning skill scenario selection for PEA N3 technician.

Table 3.11 Payoff Matrix of Planning Skill Scenario Selection for PEA N3 Technician

	1	2	3	4
1	(2,1)	(0,1)	(0,0)	(0,0)
2	(1,1)	(1,1)	(0,0)	(0,0)
3	(1,1)	(0,1)	(1,0)	(0,0)
4	(1,1)	(0,1)	(0,0)	(1,0)

The placement test shows that the trainee's skill level is initial level. The competency require for this position is Repeat level. The payoff matrix can be analyzed and explained by dividing into 5 cases as follow;

Case 1: The payoff is (2,1). The trainee selects the scenario. The organization provides the scenario which each player selects. Therefore, the trainee is satisfied. Therefore, payoff of trainee is 2. However, the organization is not satisfied because the scenario is not at the expected level. So the organization's payoff in this case is 1.

Case 2: The payoff is (0,1). The trainee selects the scenario. The organization provides scenario which is more difficult than the trainee's ability. It means that trainee should be upset because he cannot play the game. The payoff of trainee in this case is 0. On the other hand, the organization is satisfied because organization can provide expected level to the trainee.

Case 3: The payoff is (1,1). The trainee selects scenario but the organization selects another scenario for the trainee. It means that the trainee can play the game but it is not a requirement scenario so that the payoff of trainee is 1. The organization's payoff is 1 as well.

Case 4: The payoff is (1,0). The trainee selects scenario and the organization provides the scenario which player selects. However, this scenario is more difficult than his or her ability. Therefore, s/he can not play this scenario. In this case, the payoff of player is 1. The organization is not satisfied because of the player cannot play the scenario. The payoff of the organization is 0.

Case 5: The payoff is (0,0). The organization provides the scenario which is not what the player needs and it is more difficult than his ability. Therefore, the payoff of the player is 0. The organization is not satisfied in this case as well because the player cannot play this scenario. The payoff of the organization is 0.

According to the payoff matrix analysis, it was found that both the organization and the player will obtain maximum payoff when the organization provides the scenario which the player selects and it is not more difficult than the player's ability. Therefore, according to the payoff matrix, the appropriate scenario of this case is the initial level. Then, the game theory concept is applied to analyze the appropriate scenario level for player in every competency.

The placement scenario prototype and game theory will be validated and evaluated the research framework in the evaluation phase. This prototype is the instructional design of the knowledge game. It will be the guideline for the game designer and programmer to develop the game engine, avatars, game environment, the rules of the game, animation, and interface in the game design process.

3.5.2 Scenario Development Part

This part focuses on the scenario development of visual inspection of 22 kV switchgear maintenance. The knowledge engineering and capability classification model which are the results of previous section are applied to capture the knowledge from the maintenance experts. The adult learning theory, motivation theory, and flow theory are considered to set up the elements of the game scenario. This part begins at the 9th step of the knowledge game development phase.

Step 9: Knowledge and Experience Elicitation

The aim of this part is to elicit the knowledge and experience of the target task experts for developing the scenario of game. The aim of this step is to capture the additional knowledge and experience. This knowledge and experience are completed for developing game scenarios. This process is done by using the knowledge engineering method such as CommonKADS extended with scenario development framework which is proposed in this research and capability classification model which is the results of step7.

The knowledge and experience of the experts are captured by structured interview process. The knowledge and experience elicitation process of this research is based on knowledge engineering technique which can be divided into 3 steps: knowledge capture, knowledge analysis, and knowledge modeling. This process is the first step to elicit knowledge from experts. The interview questionnaires are set up by using CommonKADs templates. As this research aims to capture the knowledge for developing the scenario of the knowledge game, using a questionnaire to collect data was considered in the scenario development phase. Moreover, the knowledge and experience were considered to be classified into maturity level by using the maintenance capability classification model. This knowledge and experience elicitation process also requires the expert to perform the protocol analysis by real-life operations of the target tasks. During the real operation, the video recording is done. The agenda which is used in this step meeting is shown in Table 3.12.

Table 3.12 Agenda of Knowledge and Experience Elicitation Meeting

Agenda of Knowledge and Experience Elicitation Meeting	
Agenda 1:	Present the project objectives
Agenda 2:	Present the meeting objective
Agenda 3:	Present the Maintenance Capability Classification Model of 22kV Switchgear task
Agenda 4:	Capture knowledge and experience
Q:	If this task is divided into 5 levels following the classification model, how can you explain the activities of each level?
Q:	What are the objective and goal of each level?

Table 3.12 Agenda of Knowledge and Experience Elicitation Meeting (Continued)

Agenda of Knowledge and Experience Elicitation Meeting	
Q:	How do you do this task in each level?
Q:	What prior knowledge do you need to do this task at each level?
Q:	What is the step in order to operate switchgear of each level?
Q:	Are there any constraints of the approach of each level? What are they?
Q:	What is the human error of the personnel at this level?
Q:	What are the jobs that you have to do in this task?

Moreover, this step also captures the knowledge from the case study. This step is done by structured interview called "Case Study Meeting". The purpose of this meeting is to ask the experts about the detail of case studies that experts met in their jobs. The case studies that captured from the experts can be used to check if the game has sufficient input of expert knowledge and it can also be used to simulate the situation in game scenarios. This research proposes the case study agenda as Table 3.13.

Table 3.13 Agenda of Case Study Meeting

Agenda of Case Study Meeting	
Agenda 1:	Present meeting objective
Agenda 2:	Explain Maintenance Capability Classification Model
Agenda 3:	Present Case Study Overview by Expert
Agenda 4:	Task Review/Reflect
Q:	What is the knowledge which used to complete this case study?
Q:	Are there any methods to complete this case study?

The case studies, with experts present in the meeting, were analyzed to develop the game scenario in the next step.

Step 10: Knowledge Analysis

After the knowledge and experience was captured, it is analyzed according to the CommonKADS methodology. In the first step, the knowledge and experience is translated into transcripts. Then, these scripts were analyzed and refined by spotting for key words. After that the analyzed knowledge is structured and modeled to become the knowledge map which is divided into 3 levels: Task Level, Inference Level, and Concept Level (Schreiber.,Akkermans, 2000). The detail of each level is as follows:

- Task level: This level shows the task activities that must be done to reach the job's goal.
- Inference level: The inference knowledge used by the maintenance experts to complete the tasks are shown at this level.
- Domain level: This level describes the detail concept of the knowledge in each inference. These knowledge show how experts do their jobs.

Moreover, the knowledge is divided into generic knowledge and specific knowledge. The generic knowledge is the basic concept of the task. The specific knowledge is the necessary knowledge which players have to know in order to do their task. Then, the knowledge is classified into 5 levels based on capability classification model.

Step 11: Scenario Development

This step designs and creates the game scenario. Generic knowledge is used to create the game story. The specific knowledge is used to create the mini game. This mini game provides the player to make the decision in order to solve the problem. This research framework proposes to develop the knowledge game by separating the scenarios for each level of competency. The proposed scenario development framework in this research consists of 7 parts which is based on the 6 key structural elements of games by Prensky, combined with adult learning theory and motivation theory. These parts include (1) learning objective, (2) player target, (3) knowledge and skill, (4) game story, (5) information, feedback, (6) information, (7) feedback, and (8) reward. The proposed scenario framework can be described in Table 3.14.

Table 3.14 The Knowledge Game Scenario Development Framework

Part	Detail
1. Objective	Show why the player has to learn in this scenario
2. Player Target	Show the player level fit for this game level
3. Knowledge and Skill	Show the knowledge and skill that the learner will learn in this scenario.
4. Game Story	Use the generic knowledge to create the narrative of the game.
5. Mini Game	Use the specific knowledge to create mini game.
6. Information	Select the data, information and knowledge for helping the player to finish the task.
7. Feedback	Show message or graphic when the player finishes the scenario: If the player can complete the task, the game should give positive feedback and reward. If the player cannot complete the task, the game should have a negative feedback and penalty system.
8. Reward	Set up the reward system by considering the real benefits in the workplace.

The concept of scenario development can be divided into 5 parts which is shown as follows:

1) Scenario introduction part
2) Activity introduction part
3) Knowledge and information part
4) Mini game part
5) Feedback part
6) Conclusion part

In the beginning of every scenario, the framework proposes to start with scenario introduction part. Referring to Adult Learning theory, adults need to know why they should learn something. This introduction screen is designed to present the overall learning

objectives of that scenario. These objectives make players understand and know what they must learn from the game scenario. Moreover, the game is designed to proceed the story by avatar or non-player character. The Figure 3.14 shows the introduction screen.

Figure 3.14 Scenario Introduction Screen

Then, the objective of each activity in each game is presented before starting the mini game. These objectives make the players understand what they should learn and know in the mini game.

Figure 3.15 Activity Introduction Screen

After that the scenario is designed to provide information to the player. This information gives the benefit to the player in order to do the activity. It is the knowledge which is captured from the experts. For prototype development in this research, the game environment is developed by real pictures which is recorded from the protocol analysis process. The reason for using real pictures is because the PEA personnel prefer to learn by doing and seeing as presented in Figure 1.6. The example of information screen as shown in Figure 3.16.

Figure 3.16 Information Screen

After the player receives the information, he is asked to play the mini game. The basic elements of the mini game screen include the timer tab, score, word of command, and activity area. The first two elements are used to challenge the player to learn in the game. The challenge is the advantage factor of the game compared to the traditional HRD intervention such as in-class training, simulation, and etc. The player is asked to review the information again before start the activity. However, the player can either select to review or not review. This is developed from adult learning methodology. The mini game screen is presented as Figure 3.17.

Figure 3.17 Mini Game Screen

When the players finish the mini game, they should receive the feedback about their decisions. The feedback in the game is information that is presented for a specific pedagogical purpose, usually informing the player about the correctness of player's responses. Feedback has many variables. It can be as simple as a single word such as "Incorrect", or a statement of the expected response such as "The answer is correct", or it can be more complex in explaining why the response is correct or not (Tennyson and Jorczak, 2008). Hsieh and O'Neil (2002) stated in their research that learners receiving feedback that indicates what is incorrect about response outperformed than receiving only a correct/incorrect judgment.

In this research,the knowledge game is designed to provide the feedback to the players. With this feedback, the players will know their learning progress. The feedback shows that player makes the right or wrong decision. If the player makes the wrong decision, the screen will show negative feedback and the mistake details. The feedback shows the wrong choices made by the player. Then the game will ask the player to retry the mission again. On the other hand, if a player makes the right decision, the feedback screen will present the positive feedback. The feedback screen is designed based on adult learning theory and motivation theory. The negative feedback screen and positive feedback screen are shown as Figure 3.18 and Figure 3.19 respectively.

Figure 3.18 Negative Feedback Screen

Figure 3.19 Positive Feedback Screen

The last part of the scenario is the conclusion part. In this part, the conclusion screen is presented. It is used to summarize the knowledge that the player learned from the scenario. This conclusion allows the players to rethink about the knowledge that they learned through the game. It makes the player remember the knowledge and information provided in the game.

Figure 3.20 Conclusion Screen of Scenario

After this step, the game scenario and prototype are created. This prototype will be validated in order to check the validity of the content and set up the mini game time in the next step.

3.5.3 Validation and Criteria Set up Phase

Step 12: Validated

The objectives of this step areto validate the game content and set the activities time of knowledge game prototype. This step is done by structured interviewing called "validation meeting". The interviewees are the experts of the switchgear maintenance task. This interview applies the knowledge engineering technique to set up the validation meeting agenda which is shown as Table 3.15.

Table 3.15 Agenda of Validation Meeting

Agenda of Validation Meeting	
Agenda 1:	Present the meeting objective
Agenda 2:	Present the game content
Agenda 3:	Task teach back via game playing
Agenda 4:	Content validation and time setting
Q:	Are there any mistake content in game and activity?
Q:	How long is appropriate time for conducting in each activity?

The task teaches back process is done by paper and pencil testing method. The prototype of game in this research is created by Microsoft Powerpoint software. Then, it is printed out as hard copy and used for experts to carry out the activity in the game. By this step, the prototype of knowledge game is improved and verified the contents of the game. The results of the meeting provide the information to improve the game content. The activity time is set by reference from the time the expert took to complete the task. The contents are improved to fit the jargon of PEA switchgear maintenance work. This step also checks and corrects the technical terms of the game contents.

3.6 Testing and Data Analysis

The last phase of research methodology is the testing and data analysis. The aim of this phase is to test the proposed framework and game prototype. In order to test this framework, the paper and pencil testing method is applied. The prototype of knowledge game is developed as paper and pencil games. The meaning of the concept of paper and pencil game is game that it can be played solely with paper and pencil. Iuppa and Borst (2010) presented that 51% of surveyed commercial developers still prefer paper and pencil prototyping tools. They defined this testing method is cheap and flexible becauseit allows the experts and clients to be involved since the early state of game development. Therefore, they can contribute before the code is written and changes become costly.

After the prototype is developed in pen and pencil game pattern, the process of testing and analysis is started. The steps of testing includethe player knowledge checking, behavior observation and interviews to gather information on the players' interview. The first step is to check the knowledge of the player. The knowledge checking step is done by asking the player to do the pre-test before playing the game and then do the post-test after playing the game. This step is done to check the learning progress in game. Then, during the game, the players' behavior is observed and recorded by the video recorder. This step is to inspect the behavior changes of the player via game play. Finally, after finishing the game play, the player also asks to make the opinion survey to analyze the game effectiveness regarding to Prensky's theory and flow theory. The research proposes to apply the EGameFlow which was developed by Fu, Su, and Yu (2008). The EGameFlow is the survey questionnaire to measure the game enjoyment and knowledge improvement. This survey questionnaire assesses 8 factors: concentration, goal clarity, feedback, challenge, autonomy, immersion, social interaction, and knowledge improvement. However, this research game prototype develops the game based on the paper and pencil game. Therefore, the social interaction factor is removed from the survey questionnaire because this factor is not applicable to the game.

Testing is done with a focus groups which include engineering, technician, and operator of PEA switchgear maintenance. These focus groups are selected from 3 different units. The detail of the focus group is described as a case study in Chapter 4.

3.7 Chapter Summary

This chapter was divided into 4 main parts. The first part presented the research methodology divided into 3 phases: proposed game conceptual framework development, knowledge game development, and testing and data analysis. Then the second part describes the originality of the research framework. It also describes the concept, methodologies, and theories which are applied to develop the game framework. HRD theory, adult learning theory, motivation theory, knowledge engineering methodology, competencybased development and capability maturity

model are applied for this matter. The third part of the chapter presented the proposed knowledge game development process and the switchgear maintenance game prototype development process. The final part presented testing and data analysis phase of research methodology. In order to test the knowledge game development, the 22 kV switchgear maintenance task of Provincial Electricity Authority, Thailand is selected as a case study. The detail of case studies will be presented in Chapter 4 and the result of testing will be analyzed and shown in Chapter 5.