CHAPTER 1 INTRODUCTION

Today's working faulty symptoms of automotive service technicians have required strategy-based diagnosis in the profiles of competence, which is compulsory attribute of the performance base on the validly, accurately and objectively. Modern automotive technology, especially car, grows fast, but many technicians do not know how to solve effective their car. These causes the technicians will get difficulty if their cars are complicated. Car fault identification is not easy for inexperienced technicians because it is needed a lot of knowledge for finding the fault. Therefore, they extremely depend on expert technicians.

Dependence of the expert can be minimized if its expertise can be documented into a computer system. The proposed system for dealing with the problem is an Expert System (ES). An expert system is a system that employs human knowledge captured in a computer to solve problem that ordinarily require human expertise (Boyle & Weishaar, 1997; De Boer & Klingenberg, 2008). With the expert system, the user can interact with a computer to solve a certain problem. This can occur because the ES can store heuristic knowledge. This ES is provided to recommend those who are in need of guides to deal with their car's problems (De Kleer & Kurien, 2003).

Although it might not suggest a complete guides and help as a human expert namely technicians solve, but at least the ES can employ a temporary assistance to those who are in need of an instance guide, maybe because the limitation of situation and problem occur. A good approach to improving fault diagnosis efficiency is to capture and reuse know-how that exists in the heads of the key technicians who really understand how a complex works. This know-how can be made accessible, and usable by: machine operators, less skilled technicians, and experienced technicians. Such an approach has been taken before in the form of the ES (Gelgele & Wang, 1998; Frank, Ding, & Marcu, 2000; Jonassen & Hung, 2006; Sudsomboon & Anmanatarkul, 2009).

This ES will guide a human technician through the entire service process, from the initial customer complain at the service desk to the diagnosis and repair of the car in the workplace (Angeli & Chatzinikolaou, 2002; Biswas et.al, 2004). ES provide powerful

and flexible means for obtaining solutions to a variety of problems that often cannot be dealt with by other, more traditional and orthodox methods (Diederich, Ruhmann, & May, 1987; Fisher, Gleitman, & Gleitman, 1991; Gegele & Wang, 1998). The terms Expert System and Knowledge-Based System (KBS) are often used synonymously. The four main components of KBS are: a knowledge base, an inference engine, a knowledge engineering tool, and a specific user interface.

Iserman (2005) described some of model-based fault detection and diagnosis which KBS important applications include the following: medical treatment, engineering failure analysis, decision support, knowledge representation, climate forecasting, decision making and learning, and chemical process controlling. Previous work has shown that systems concerned with car fault detection were very limited. For example, an expert system for car fault diagnosis called the Service Bay Diagnostic System (SBDS). The SBDS knowledge base model is being developed by a joint project team at Ford Motor Company, the Carnegie Group, and Hewlett Packard.

The SBDS's knowledge base model will contain the expertise of Ford's top diagnosticians, and it will make their diagnostic skills available to mechanics in every Ford dealership in North America (National Automotive Technicians Education Foundation, 2010). Additionally, almost automobile company requires considerable the KBS. The functional KBS is botany for car faulty diagnosis. The individual professional competency must be capable of rapidly diagnosing problems and making adjustments or repairs (Jonassen & Hung, 2006; Pass, Renkl, & Sweller, 2003). A Knowledge-Based Expert System for Car Faulty Diagnosis (KBESCFD) is presented in this paper.

1.1 Background

Automotive service technicians' responsibility has evolved from simple mechanical parts to high-level technology-related work. The increasing sophistication of automobiles requires workers who can use innovative shop equipment and work with electronic components while maintaining their skills with traditional hand tools (U.S. Department of Labor, 2008). As a result, automotive service technicians are integrated electronic systems and complex computer regulate vehicles and their performance while on the road. Technicians must have an increasingly broad knowledge of how vehicles' complex component work and strategy-based diagnosis.

They also must be able to work with electronic diagnostic equipment and digital manuals and reference materials for solving the problems. When the mechanical system or the electrical/electronic system trouble occurs, technicians first get a description of the problem from the owner or, in a large shop, from the repair service estimator or service advisor who wrote the repair order. To locate the problem, technicians use a diagnostic approach. Therefore, the goal is always for the technicians to transfer what they have solved the problems. In order to accomplishment concentrate only on the problem solving procedures, and fail to identify and teach the moderately-and identify faulty symptom diagnosis.

The main idea that foundations of an expert system increase the workforce competition is employed in this study. There is an extensive and promoting research on the use of faulty diagnosis in car systems has received a lot of theoretical and practical attention over the last years. Diagnosis is a complex reasoning activity, which is currently one of the domains where Artificial Intelligence (AI) techniques have been successfully applied as these techniques use association rules, reasoning and decision making processes as would the human brain in solving diagnostic problems. A variety of fault detection and diagnosis techniques have been developed for the diagnostic problem solving process (De Kleer & Kurien, 2003; Diederich, Ruhmann, & May, 1987; Frank, Ding, & Marcu, 2000).

KBESCFD is a variety of fault detection and diagnosis techniques have been developed for the problem solving process. These techniques include model based approaches, knowledge based approaches, qualitative simulation based approaches, and neural network based approaches and classical multivariate statistical techniques. ES found broad application in fault diagnosis from their early stages because an expert system simulates human reasoning about a problem domain, and performs reasoning over representations of human knowledge and solves problems using heuristic knowledge rather than precisely formulated relationships, in forms that reflect more accurately the nature of most human knowledge.

This study is concerned with development of an expert system that uses human heuristic reasoning mechanism for car faulty diagnosis. The ES provides instant expert guidance

in dealing with problem occurs when time is limited and when decisions have to be made in a situation where a technician specialized in a sub system of a car faulty diagnosis is not available. Thus, researchers present a development of knowledge-based expert system for car faulty diagnosis (KBESCFD) in this study.

1.2 Problem Statement

In addition, according to the recent report by the Office of the National Education Commission (2009) stresses the workforce competencies of the technical and vocational education and training areas. In order to facilitate of this report, students must continually adapt to changing technology and cognitive skills as knowledge procedures and systems become increasingly sophisticated. Researchers have been investigating the numerous research paper, and found that 'Problem-solving' are exactly professional competency that able to increase basic knowledge, reflective practice and metacognitive reasoning.

There are many applications on which car faulty diagnosis are used including. Many dealers have been established that deal mostly with car maintenance and repair. The ES on car faulty diagnosis constitute complex parts requiring highly skilled technicians to diagnose faults. There is a scarcity of highly skilled mechanics that diagnoses. There are ES for performing car faulty diagnosis; however, most of these are not available on the local market (Angeli & Atherson, 2001; Korbicz et.al, 2004). Some companies have computerized diagnostic tools but these tools are only suited to particular manufacturer's products.

Most car companies' applications that are mostly used do not have computerized diagnostic tools and maintenance is usually carried out in a repair shop where automotive service technicians are the experts who do the diagnosis to find out faults and solve them. In this study, researchers focus on validly, accurately and objectively diagnosis of car faults is vital to the availability for the services for which they are required. The availability of an expert system is beneficial in providing expert guidance because of the limitation of time; and in situations where specialized technicians are not available.

1.3 The Purposes of this Study

The major goal of the project was to develop a knowledge-based expert system for car faulty diagnosis that provides expert guidance while alternate solutions are needed absolutely in diagnosing car faults. The specific objectives of the study were: 1) to develop a knowledge-based expert system for car faulty diagnosis that provides expert guidance; 2) to implement a knowledge-based expert system for car faulty diagnosis that supports the functionality required in extended for modifications and additions; and 3) to determine the effectiveness of the knowledge-based expert system for car faulty diagnosis in automotive troubleshooting tasks.

1.4 Significance of this Study

Developmental research methodology was used for conducting this research study. Development-focused domains like knowledge-based system, knowledge engineering and learning innovation in technology invite developmental research where lessons can be studied from the development of the KBESCFD, human expertise's on concept mapping as a method and applications for troubleshooting and performance support. As a type of applied research produces have findings that can be immediately applied to resolving domain issues (Chularut & Debacker, 2004; Jonassen, 2000; Jonassen 2002; Hao, Kwok, Lau, & Yu, 2010; Hernandez-Serrano & Jonassen, 2003; Hilbert & Renkl, 2009; Jonassen & Hung, 2006; Novak & Gowin, 1995; Tzeng, 2009).

This research study adds to the relatively automotive problem solving skills is essential to effectively resolving troubleshooting tasks diagnose faulty systems and repair such as electronic fuel injection control system, diesel common-rail fuel direct injection system, and transaxle system. Research design is employed in troubleshooting problems. Jonassen and Hung (2006) explain that troubleshooting is a common form of problem solving. Technician (e.g., automotive mechanics, electricians) and professional (physician) diagnose faulty systems to their normal states. The troubleshooting tasks integrates experiential, domain, and device knowledge in a learning system that enables learners to generate and test hypotheses for every action they take, relate every action to a conceptual model of the system, and query experienced troubleshooters about what they would do.

In order to construct the theoretical framework, researchers have synergized the KBESCFD and concept mapping in architecture for automotive troubleshooting tasks that able to propose. In the rule-based systems, knowledge is represented in the form of production rules. A rule describes the action that should be taken if a symptom is observed. The empirical association between premises and conclusions in the knowledge base is their main characteristic. These associations describe cause-effect relationships to determine logical event chains that were used to represent the propagation of complex phenomena. The general architecture of these systems includes domain independent components such as the rule representation, the inference engine and the explanation system (De Kleer & Kurein, 2003; Mills, 2005; Schreiber et. Al, 1994). Basic structure of a classical rule-based expert system is presented in Figure 1.1.

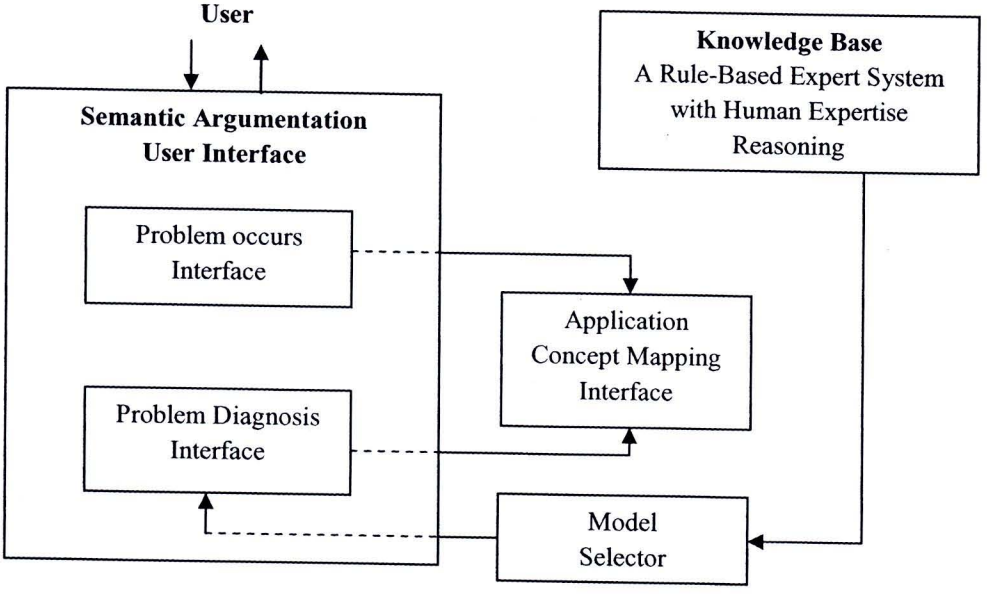

Figure 1.1 KBESCFD architecture

The diagnosis of a particular KBESCFD problem is modeled using a rule-based expert system with human expertise reasoning. The knowledge base thus comprises a variety of KBESCFD modeling the Figure 1.1. These models are used during the diagnosis process. A rule-based expert system with human expertise reasoning models is made available through a model selector. An application concept mapping is used to connect the problem occurs interface to the problem diagnosis interface. These characteristics are consistent with the basis for generating expert's concept maps specifications. This

developmental research study suggests significant implications for further exploring the creation of KBESCFD supports.

1.5 Research Questions

This study addresses the following three research questions:

1.5.1 To what extends that experts' establish a model of knowledge-based expert system for car faulty diagnosis that provides guidance?

1.5.2 Do experts' perceptions and transferable a model of knowledge-based expert system for car faulty diagnosis in the diverse of concept maps with human expertise reasoning?

1.5.3 Is there a significant difference between the pre-test and the post-test of knowledge acquisition scores of technicians?

1.5.4 Is there a significant difference between the computer-assisted concept mapping and the service manual concept mapping scores of technicians on knowledge-based expert system for car faulty diagnosis?

1.5.5 How do technicians satisfaction about the usability of a knowledge-based expert system for car faulty diagnosis?

1.6 Research Hypotheses

This study addresses the following three research hypotheses:

1.6.1 The quality of a knowledge-based expert system for car faulty diagnosis is appropriate level.

1.6.2 There is no difference between the pre-test and the post-test of knowledge acquisition scores of technicians.

1.6.3 There is a significant difference between the computer-assisted concept mapping and the service manual concept mapping scores of technicians on knowledge-based expert system for car faulty diagnosis?

1.6.4 Technicians will have satisfaction towards a knowledge-based expert system for car faulty diagnosis Training course at high level.

1.7 Outcomes

This study will produce the following outcomes:

1.7.1 Technicians have beneficial the innovative training strategy on car faulty diagnosis and development reasoning is increasingly.

1.7.2 The automotive companies have new innovative training strategy for competition improvement professional competency of automotive service technicians.

1.7.3 Training achievement that diffusion of learning innovation in technology as an offers potential tool for increasing the compatibility of Thai automotive service technicians.

1.7.4 Thai industrial sectors can be applied this study for solving the problems of manpower development competency, and attention extend to prospect donors into definable Thai related industrial sectors.

1.8 The Research Scopes

This study addresses the following of the research scopes have the following:

1.8.1 Population and Sampling

1.8.1.1 The experts' who was established a model of knowledge-based expert system for car faulty diagnosis that involved 11 training managers from 8 well-known the car automobile companies in Thailand.

1.8.1.2 The expert's who was designed and developed by consensus among the concept mapping with human expertise reasoning team of six participants.

1.8.1.3 Population is automotive service technician that operate in the master technician level, who employees under authorized by dealer of Mitsubishi Motors (Thailand) in 2010 year amount 124 persons.

1.8.1.4 The sampling size is automotive service technician that operate in the master technician position that selected by purposive method among 64 persons. Then, separate into two groups: experiment group (computer-assisted concept mapping) and control group (paper-pencil concept mapping) is 32 persons equally.

1.8.2 Research Strategy Scopes

1.8.2.1 A model of knowledge-based expert system for car faulty diagnosis is established by expertise's consensus within the realistic workplace.

1.8.2.2 The concept mapping with human expertise reasoning is exploring the problem statement underlying the contextual conditions of the experts' map judgement from Mitsubishi Motors (Thailand).

1.8.2.3 All six tasks are based on the frequency problem occurs of Mitsubishi Motors (Thailand) that has the following: 1) Diesel engine faulty diagnosis; 2) Multi-point injection (MPI) engine faulty diagnosis; 3) Common-rail diesel direct injection system (CRD) faulty diagnosis; 4) Steering system faulty diagnosis; 5) Manual transmission system faulty diagnosis; and 6) Automatic transmission system faulty diagnosis.

1.8.3 The Instrument Scopes

1.8.3.1 The computer-assisted concept mapping software delicates IHMC CmapTool have recently been made available.

1.8.3.2 Concept mapping was reliability and validity with the intension of analyzing based on Novak Scoring Protocol (1984) relationships, hierarchical structure, cross-links, and examples.

1.8.4 Variables of this Study

1.8.4.1 Independent variable is a knowledge-based expert system for car faulty diagnosis.

1.8.4.2 Dependent variables are the quality of transferable a model of knowledge-based expert system for car faulty diagnosis in the diverse of concept maps as an innovative training strategy, Training achievement and Training satisfaction of technicians.

1.9 Conceptual Framework

This study will produce the following conceptual framework:

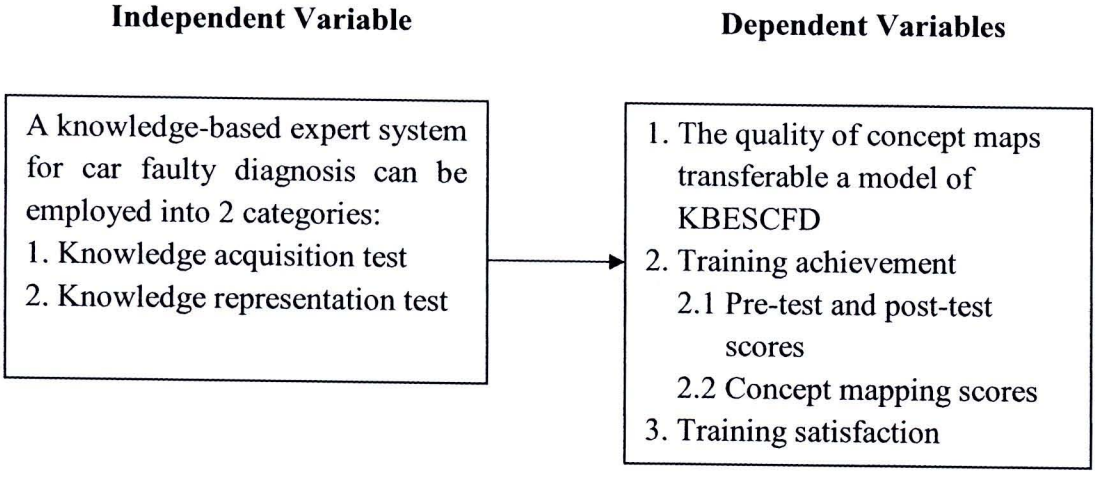

Figure 1.2 Conceptual Framework of this study

1.10 Limitations

This study addresses the following ten limitations:

1.10.1 This study is limited to test only technicians of Mitsubishi Motors (Thailand).

1.10.2 This study is limited by using concept mapping as an innovative training strategy.

1.10.3 The computer-assisted concept mapping used software delicates IHMC CmapTool version 4.8 have recently been made available.

1.10.4 The validity and reliability of the responses to the instruments used in this study was limited to the experienced and judgment of the experts of Mitsubishi Motors (Thailand).

1.10.5 The personal characteristics of the study might have affected training outcomes and the satisfaction scale.

1.11 Delimitations

This study addresses the following three delimitations:

1.11.1 This study is delimited by researcher in several ways.

1.11.2 The item on knowledge acquisition test will designed, validated, and reliabilities by only experts of Mitsubishi Motors (Thailand).

1.11.3 This sample was selected by training committees of Mitsubishi Motors (Thailand).

1.12 Assumptions

This study addresses the following four assumptions:

1.12.1 Technicians understand of the KBESCFD is valid and valuable measures of how well a training strategy and development system is functioning.

1.12.2 Technicians have a good skill on computer.

1.12.3 Technicians do the answer question with no bias.

1.12.4 Technicians have the norms of ability and problem-solving skills that equivalent in Mitsubishi automotive experience.

1.13 Definition of Terms

1.13.1 A Knowledge-Based Expert System for Car Faulty Diagnosis: A knowledge-based expert system for car faulty diagnosis is a variety of fault detection and diagnosis techniques that have been developed for problem solving process.

1.13.2 Automotive Troubleshooting Task: Automotive troubleshooting task is a common form of problem solving and professionals diagnose faulty systems and take direct, corrective action to eliminate any faults in order to return the systems to their normal states (Jonassen & Hung, 2006).

1.13.3 Computer-Assisted Concept Mapping: Computer-assisted concept mapping is computerized concept mapping in a learning strategy leads learners to construct concept maps actively to achieve positive effects quickly (Liu, Chen, & Chang, 2010).

1.13.4 Concept Mapping: Concept mapping is one of the tools that technicians can use to help organize new and existing knowledge about a topic by relating concepts in a way that promotes successive and progressive changes in learning along the rote learning/meaningful and learning continuum (Novak, Mintzes, & Wandersee, 2000).

1.13.5 Human Expertise Reasoning: Human expertise reasoning is an iterative process of generating and testing that consists of four sub-processes: problem space reduction, hypotheses, generation/testing (fault isolation/diagnosis process), and solutions generation/verification (Johnson et al., 1993).

1.13.6 Knowledge Acquisition Test: Knowledge acquisition test is personal beliefs concerning one's capacity to learn or perform skills at designated level that affect

several aspects of their behaviour, including their choice of activities, their effort and persistence, and ultimately, their learning and achievement.

1.13.7 Knowledge base: Knowledge base is a knowledge inventory of factual and heuristic knowledge. An ES tool provides one or more knowledge representation schemes for expressing knowledge about the application domain.

1.13.8 Knowledge Representation Test: Knowledge representation test is used as summative instruments with their value for the purpose supported by the relatively high correlations that have been observed between concept map scores and classroom and other achievement test (Anderson & Thiede, 2008).

1.13.9 Novak Scoring Protocol: Novak scoring protocol is a method for scoring maps that relies solely on manually counting the number of *valid* components in a map (Novak & Gowin, 1984).

1.13.10 Problem-Solving Skills: Problem-solving skills are possesses a complete schema for any problem type, then constructing the problem representation involves mapping an existing problem schema and using the procedure that is part of the problem schema to solve it (Jonassen, 2000).

1.10.11 Reasoning engine: Reasoning engine is the inference mechanisms for manipulating the symbolic information and knowledge in the knowledge base to form a line of reasoning in solving a problem.

1.13.12 Service Manual Concept Mapping: Service manual concept mapping is the traditional paper-pencil method (Novak & Gowin, 1984).

1.13.13 Technicians: Technicians is automotive service technician that operate in the master technician level makes a living diagnosing, servicing, and repairing cars in dealer authorizing of Mitsubishi Motors (Thailand).

1.13.14 Training Strategy: Training strategy is a knowledge-based expert system for car faulty diagnosis by combining the concept mapping and the troubleshooting learning environment.

1.13.15 Training Achievement: Training achievement is the evaluation results of knowledge acquisition and knowledge representation of technicians under the criteria underlying.

1.13.16 Training Satisfaction: Training satisfaction is the evaluation results of technicians towards a questionnaire.

1.13.17 User interface: User interface is the communication with the user. The user interface is generally not a part of the ES technology, and was not given much attention in the past.