การพัฒนายุทธวิธีการฝึกอบรมระบบแมคคาทรอนิกส์ยานยนต์เพื่อเสริมสร้างทักษะการแก้ปัญหาภายใต้สถานการณ์จริง

THE DEVELOPMENT OF AUTOMOTIVE MECHATRONIC SYSTEMS TRAINING STRATEGY FOR ENHANCING PROBLEM SOLVING SKILLS WITHIN CURRENT SITUATION

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อ 1) ศึกษาประสิทธิภาพของยุทธวิธีการฝึกอบรมระบบแมคคาทรอนิกส์ภายใต้สถานการณ์จริงเพื่อใช้ในการแก้ปัญหา และ 2) ประเมินความพึงพอใจของผู้เรียนที่มีต่อยุทธวิธีการฝึกอบรม กลุ่มตัวอย่างที่ใช้ในการศึกษาครั้งนี้ คือ นักศึกษาระดับปริญญาตรีชั้นปีที่ 2 ของภาควิชาครุศาสตร์เครื่องกลมหาวิทยาลัยเทคโนโลยีพระจอมเกล้าธนบุรีเลือกโดยใช้วิธีสุ่มตัวอย่างอย่างง่าย จำนวน 30 คน ระเบียบวิธีวิจัยที่ใช้ คือ แบบกลุ่มเดียวโดยทำการทดสอบก่อนเรียนและหลังเรียน เครื่องมือที่ใช้ในการวิจัย คือ แบบทดสอบก่อนเรียนและหลังเรียน แบบฝึกปฏิบัติการแก้ปัญหาระบบแมคคาทรอนิกส์ยานยนต์ และแบบสอบถามความพึงพอใจ การวิเคราะห์ข้อมูลประกอบด้วย ค่าเฉลี่ย ส่วนเบี่ยงเบนมาตรฐาน ค่าแจกแจงที ผลการวิจัยพบว่า คะแนนเฉลี่ยของผู้เรียนที่ทำแบบทดสอบหลังเรียนมีค่าเฉลี่ยสูงกว่าก่อนเรียนอย่างมีนัยสำคัญ คะแนนเฉลี่ยของผู้เรียนที่ฝึกปฏิบัติการแก้ปัญหาระบบแมคคาทรอนิกส์ยานยนต์มีค่าเฉลี่ยสูงกว่าก่อนเรียนอย่างมีนัยสำคัญ ได้แก่ งานวินิจฉัยข้อบกพร่องระบบควบคุมการฉีดเชื้อเพลิงเครื่องยนต์ดีเซลหัวฉีดอิเล็กทรอนิกส์ และ การวิเคราะห์วิธีการแก้ปัญหาระบบความพึงพอใจของผู้เรียนที่มีต่อยุทธวิธีการฝึกอบรมระบบแมคคาทรอนิกส์ภายใต้สถานการณ์จริงเพื่อใช้ในการแก้ปัญหาอยู่ในระดับมาก

คำสำคัญ: ระบบแมคคาทรอนิกส์ยานยนต์ ทักษะการแก้ปัญหา ยุทธวิธีการฝึกอบรม

Abstract

The objectives of this study were: 1) to investigate the effectiveness of automotive mechatronic Systems training strategy with current situation while students' solved ill-structured problems; and 2) to evaluate learners' satisfactions towards the training strategy. The sampling group was 30 samples on the second year students of Department of Mechanical Technology Education at King Mongkut's University of Technology Thonburi, selected by simple random sampling. The one group pretest and posttest design was employed in this study. The instruments consisted of the knowledge-based achievement tests, the practical tests, and a questionnaire on learners' satisfaction. Data were analyzed by mean, standard deviation, t-test dependent. The results indicated a significant difference in posttest scores. In practical, problem-solving skills was great significant difference in practical performances between the electronic control system and system solution. Students' satisfaction towards the ASM training strategy was at the high level.

Keyword: Automotive Mechatronic Systems, Problem Solving Skills, Training Strategy

Introduction

The technological transformation of the automobiles is associated with considerable changes in the applications of Automotive Mechatronics Systems (AMS) [1-2]. AMS are characterized by a tight coupling of different implementation technologies, (e.g. hydraulics, mechanics, pneumatics, electromechanics, electronics and computer software [3]. The computer software of these systems is performing in AMS specifically. Today, mechatronics plays over mostly important role for automotive electronic control systems. A modern automobile is becoming far more complex with the release of each new model. Complexity arises in the form of new mechanical devices, electronic devices and nowadays software components [4].

These demand of AMS are increasing; for example, high engine performance, low fuel consumption, low emissions, high accessibility, safe and reliable vehicles. As automotive technology becomes more sophisticated the ability to troubleshoot and identify a malfunction becomes a more difficult and complex task [5]. Continued advancement of vehicle features creates complexity that restricts service technicians' ability to understand how the vehicles are meant to behave and how to diagnose AMS problems [6]. The major branch of the evolution is focused on computer technology which is represented by embedded microcontroller systems [7]. Electronics use in automobiles has been increasing steadily to improve reliability and add more functionality. For example, car model in the 2001 year electronics increased for 19% of the cost of mid-sized cars and is expected to reach 25% by year 2005 for mid-sized cars and possibly 50% for luxury models [8].

Therefore, maintaining a high level of AMS reliability by efficient repair and diagnosis is thus becoming important for several seasons. Firstly, the downtime of the automobile is expensive. Secondary, certain malfunctioning conditions can be a threat to safety of both human being and the environment [9]. With this increase in complexity, the students are becoming increasingly difficult, as the automotive electronic control systems now require problem solving skills in a range of disciplines. Duffy [10] explained that the electronic fuel injection control system increases have involved from simple mechanical repairs to high-level technology-related work. The increasing sophistication of automotive engine subject area requires students who can use computerized shop equipment and work with high-end electronic components while servicing their skills with specific tools.

According to Sudsomboon [11], suggested that the term of in order to gain a better understanding of the learning achievement in the automotive technology subject, the empirical methodology found the transferable knowledge of teaching an automotive scan tools can be simulated rapidly. Advances in AMS increase the need for highly skilled to explore the effective automotive technology is the training strategy [12]. Therefore, how to encourage students to be productive, innovative and enterprising is focused. This involves generating ideas and taking action, as well as developing techniques and problem solving skills that satisfy student needs [13]. Moreover, students must learn about materials, information and systems and the processes by which they are employed. Students examine the context of a task or activity to determine needs and opportunities and to relate what is known to what might be done.

State-Of-The-Art on Mechatronics Systems

Mechatronics, as an engineering discipline, is the synergistic combination of mechanical engineering, electronics, control engineering, and computers, all integrated through the design process. It involves the application of complex decision making to the operation of physical systems. Mechatronics systems depend on computer software for their unique functionally. ASM is a theoretical and practical level; balance between theory/analysis and hardware implementation is emphasized; emphasis is placed on physical understanding rather than on mathematical formalities.

ASM is embedded technologies in the automobile intelligent learning system. Researchers have had adapt the modeling and analysis of dynamic systems, electronics and instrument, and feedback control system in automotive mechatronics systems course at Department of Mechanical Technology Education, Faculty of Industrial Education and Technology, King Mongkut's University of Technology Thonburi. ASM can provide new paradigm for generating the body of knowledge. The analogical of ASM is existing pedagogical knowledge and learning environment through the development of higher order thinking skills such as, critical thinking, reasoning and systematic thinking.

The didactic of ASM is a case-study, problem-solving approach, with hardware demonstrations, and software analysis with Lab VIEW. The learning outcomes of ASM are modeling, analysis, measurement, control design, and control application.

Automotive Mechatronics Systems Diagnosis

Duffy [10] proposed that the On-Board Diagnosis (OBD) refers to a vehicle computer's ability to analyze the operation of its circuits and to output data showing any problems within current situation. All new cars and light trucks have this self-test feature. It is critical that you know how to use this vital troubleshooting aid. Recently, OBD can inspect the operation of almost every electrical-electronic part in AMS and every major vehicle system. A vehicle's Engine Control Module (ECM) refers to detect engine misfiring and air-fuel mixture problems. It monitors the operation of the fuel injectors, ignition coils, fuel pump, emission parts, and other major components that affect vehicle performance and emissions control.

According to Allen [14] can be identifying the effectiveness tools for solving the problems, is inspected by an Automotive Scan Tools (AST). AST is embedded the automotive mechatronics systems and access data processing via data bus line. Modern diagnosis called OBD II (On-Board Diagnostics, version II), which is standardized of the car world diagnosis. The fuel injection, ignition system and automatic transmission on most modern fuel-injected cars and trucks are run by one or more computers. These monitor sensors that collect data from the engine and other systems all over the car. The computers send commands to the fuel injectors and ignition coils to fire the cylinders.

They use the data to fine-tune the combustion process with the correct amount of gasoline and the correct ignition timing to provide efficient, clean combustion for good power, economy and low pollution. There are dozens of sensors and actuators, measuring such things as throttle opening, engine rpm, air and coolant temperature, crankshaft and camshaft position, and road speed as shown in Figure 1.

Figure 1 An automotive scan tools into the OBD II location

AMS can be noted by the complexity of operation, consisting of a large number of sensors and actuators under computer software control. Thus, AST get started the diagnosis; plug the OBD II connector under the dash to solve problems. For instance, students' will get an option to check for trouble codes, as well as a couple of other menu choices. Additionally, some AST a text explanation of the code onscreen, the diagnosis faulty symptoms are implemented on automotive mechatronics control system as shown in Figure 2. To understand and development the problem-solving skills is intensive accomplishment for communicate within man-machine interface.

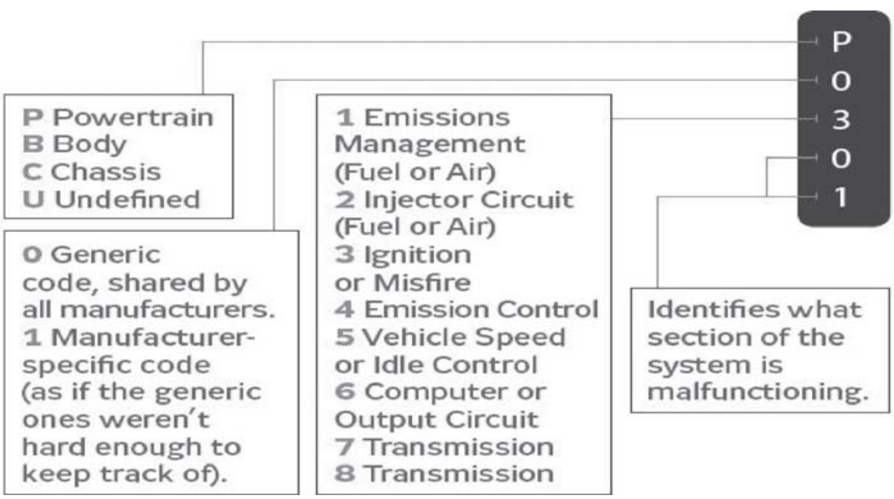


Figure 2 The multi-functional flow chart of an AST

Furthermore, the new modern car is communicated ASM with the optical fiber can be called "CAN-bus". They are sending and receiving also high speed, and accuracy to respond networking all of the systems on the car. Students' must be a knowledge domain and practical to perform on high technology with competencies. Students' must learn to know – how to solve the complex problems (ill-structured problems) that show in Figure 2. Researchers get a new idea to develop an automotive scan tools training material package on problem solving skills, which it will be an innovative training method. Its can increase problem-solving skills and rapidly to inspection. It was more benefit than traditional teaching method.

Learning Enhancement

A study on the effectiveness is the most important for other educators have increasingly been urged to adopt a variety of constructivist approaches in order to facilitate student-centered learning environments [15-16]. A particular emphasis of this movement has shifted the focus from teacher to learner, inviting learners to take active roles in their learning [17-18]. Among various constructivist approaches, problem-based learning (PBL) has been advocated and promotes students' understanding, integration, and retention of concepts, facts, and skills [19-20]. A PBL learning approach is based on the use of ill-structured problem situations that are complex, requiring students to develop expertise in information seeking and making decision to solve the problem. Because the problem situations are messy, confusing, and complex, students need to gather information in order to understand, define, and solve the problems. During an authentic problem solving process, students are able to develop their own approaches and set their own goals. Under the guidance and coaching of a skillful teacher, students work collaboratively to inquire, investigate, and plan their activities [21].

According to Margaret [22], the development of practitioner skills in real-world settings is a major issue. In-course projects, however, offer limited exposure to the complex evaluator role and also present logistical problems. After reviewing selected alternative ways to offer real-world experiences, this paper describes the directed evaluation experience, in which students and a professor are involved in short-term contracted evaluations separate from academic course-work. Lewis [23] listed a number of barriers to effective professional development including opportunities to practice, access to outside resources and expertise, and support from the community, and emphasized the importance of having on-site assistance and support while teachers attempt to develop and implement new instructional practices.

The epistemological foundation for most education is absolute knowing [24]. Students believe that knowledge and truth are certain and should be obtained from authorities. Solving problems requires transitional knowing (Knowledge is partially certain and requires understanding using logic, debate and research), independent knowing (Knowledge is uncertain and requires independent thinking and open-mindedness), and contextual knowing (knowledge is based on evidence in context). If student never face ill-structured problems, they probably will never develop independent or contextual thinking skills. In order to, Sage [21] contended that a problem-based learning (PBL) approach was an effective way to integrate technology into the classroom.

Also, Hill [25] suggested that teacher technology development can be based on the same problem-centered methods that are suggested for students in problem-based learning. Because technology is a critical tool for information searching, modeling task or content decision making, and presenting solutions during PBL activities, technology integration with PBL can be a meaningful learning experience for both teachers and students [26]. Furthermore, all of literature is available regarding the guidelines of researchers development focused on an automotive scan tools on problem solving skills training course.

Conceptual Framework

In design, a problem is current situation where students' have an assignment to solve problems. Most actively involved in problem solving are denoted that the term "design" is used most often in art (for graphic design) and engineering, the process of design occurs in the Common-Rail Diesel Direct Injection Control System (CRD). Researchers' creative/critical process is summarized in a brief 5-step with Jonassen model [27]. This concept was conducted into 5 categories show in Figure 3.

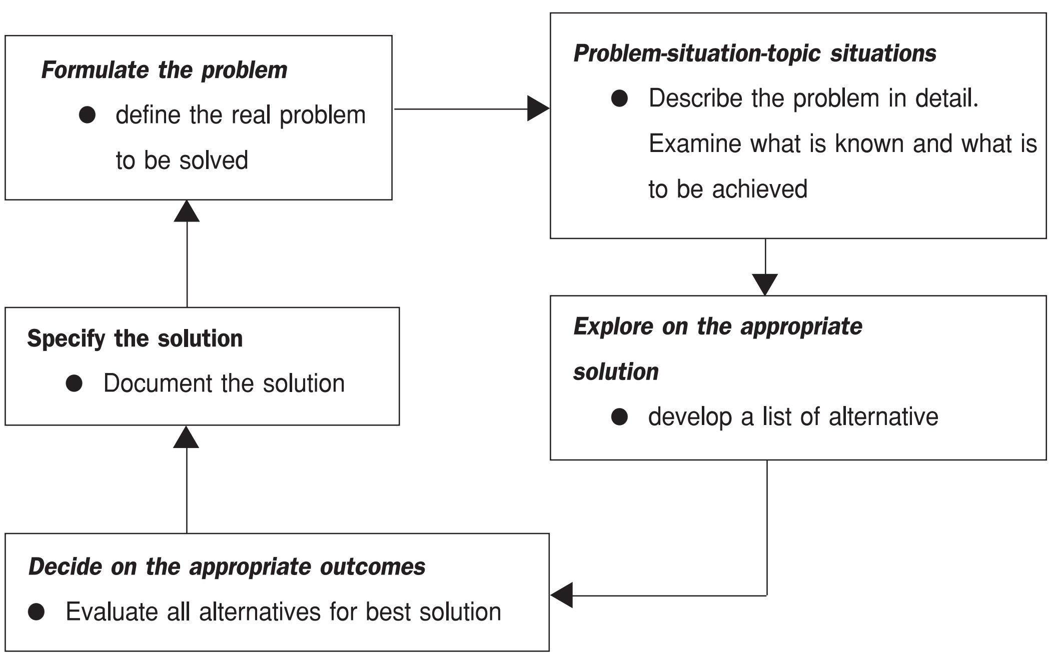


Figure 3 Conceptual framework of this study

Objectives

The objectives of this study were: 1) to investigate the effectiveness of automotive mechatronic systems training strategy with current situation while students' solved ill-structured problems; and 2) to evaluate learners' satisfactions towards the training strategy. The hypotheses were: 1) the students' learning achievement scores of the post-test were higher than the pre-test significantly different at .01 level; and 2) the students' satisfaction towards the ASM training strategy was the high level.

Methods

Research design

The one group pre-test and post-test design was employed in this experiment show in Figure 4.

Group	Pre-test score	Treatment	Post-test score
Experiment group	O_1	X	O_2

Figure 4 Research Design in this study

The treatment effect also was $(O_2 - O_1)$. This means subject are randomly assigned to a group, which is then given a pretest, then there is a treatment, then there is a posttest.

Subjects

The sampling group was 30 samples on the third year student of Mechanical Technology Education Program at King Mongkut's University of Technology Thonburi in the 1/2010 academic year, selected by simple random sampling. The sampling must be who have not been studied in the field of Common-Rail Diesel Direct Injection Control System (CRD).

Instrumentation

The training materials can be provided into 5 categories:

1. Training packages: researchers have included the theoretical framework of CRD which had emphasized in 3 modules: 1) the fuel delivery system, 2) the air induction system, 3) the electronic control systems, and 4) system solution.

2. Workshop manual: researcher have contained practical session that separated in 3 modules were: 1) diagnosis the general status on current situation of the CRD; 2) analyze and synthesis on problem-solving performance (solving on real-time); and 3) discuss and suggest the solution.

3. AST was employed by CAMAN SCAN VG Version 5.121 with connected to RS 232 port interfaced via laptop.

4. The electrical instruments were analog multi-meters, digital multi-meters, analog oscilloscope.

5. The pre-test and post-test have included in each modules.

6. The practical test have included in each modules.

7. A questionnaire was measured by students.

In knowledge domain, the item test was developed by the researchers. The test items were composed of 30 multiple-choice. The learning strategy focused on symptoms diagnosis of CRD. It can be separated to solve the problems; students' have selected analyze a situation by identifying, testing, inspecting the problem towards well-structured problems or ill-structured problem. The pretest and posttest examination consists of multiple choice and practical test questions. Both tests consist of case current situation requiring interpretation and application of problem solving processes. The multiple-choice questions assed the following skills [28]:

- Reminding (identify example/outcomes)
- Identify/explain failure
- Identify/recognize problem
- Select/recognize solution, adaptation
- Identify/predict outcome
- Identify/explain success
- Identify/judge alternate strategies/actions
- Identify information needed (on obstacle)

In practical, researchers can be designed by training strategies as identify the relevant problem-solving environment that would allow situations to be recall in the experiment. Choose from among the following indexes, most of which are suggested by Kolodner [29]:

Problem-situation-topic situations

1) What are the goals-intensions to be achieved in solving the problem or explaining the situation?

2) What constraints affect this goal?

3) Which features of the problem situation are the most important and what is the relationship between its parts?

4) What plans are develop for accomplishing the goal?

Explore on the appropriate solutions

1) What solution is used?

2) What activities are involved in accomplishing the solution?

3) What is the reasoning steps used to derive the solution?

4) How do you justify the solution?

5) What expectations do you have about results?

6) What acceptable, alternative solutions, are suggested but not choose?

7) What unacceptable, alternative solutions, are not chose?

Decide on the appropriate outcomes

1) Is the outcome fulfilling?

2) Are expectations violating?

3) Is the solution a success or a failure?

4) Can you explain why any failures occur?

5) What can you do to avoid the problem?

Procedure

The procedure has been conducting on the conditions that:

Phase I: Validity the efficiency of the ASM training strategy on problem solving skills for undergraduate students. The research was conducted as follows:

1. Students were matched by giving a pre-test.
2. Academic content in the CRD was identified and sequenced.
3. A pre-test for each module was constructed and administered before instruction.
4. Each unit was taught with an ASM training strategy.
5. A post-test for each module was administered after instruction.
6. A criterion test for the whole content was administered after instruction.
7. Suitable statistical techniques were employed to analyze the data collected.

Phase II:

1. Students were matched by giving a pre-test.
2. A pre-test for each module was structured and administered before implementation.
3. Evaluate (scan) data on solving the problems after teacher's' diagnosis.
4. Determine the simulation of problem for choosing alternatives and solution.
5. Select and use information and AST to select the right tools to solving the problems.
6. Determine the current data and situation and collect and analyze the problems.
7. Perform utilize tools and true under the current data in each situation of the CRD.
8. Interpret the problems and resolve under standardization of the CRD.
9. Definite the types of problems and collect data to perform in the appropriate alternative assess teachers' perception.
10. Make and justify job launch recommendations and positioning recommendations.
11. Students' can propose the solving problems in groups and exchange the new information.
12. Students' can be participating to conduct and collect the case on practical tests.
13. A post-test for each module was structured and administered after instruction.
14. A criterion test for the whole content was administered after instruction.
15. Suitable statistical techniques were employed to analyze the data collected.

Validity and Reliability

The pretest and posttest items consisted of 30 multiple choices by in relate fields consist of content expert, instructional design expert, and language expert among 5 persons. Then finding Index of Conjugate (IOC) is effective in terms of the content validity: in the overall IOC was .83 and overall reliability coefficients was .91, the level of difficulty (p) = 0.2 – 0.8. And then try out with 30 undergraduate students' on the third year persons to find reliability of test that tested by alpha coefficient = 0.6 -1.00. Discrimination of test was 0.2 – 1.0 [30].

A Likert's rating scale with 12 items (4 aspects) was developed by the researchers. The items was rated on a five point rating scale from (5) strongly agree to (1) strongly disagree. The pilot form of the attitude scale with 20 items was applied to 30 students, reliability coefficients of overall 0.92 respectively using Cronbach's Alpha Coefficient.

Data Collection

In this study, we conducted the experiment of the training package as follows: 1) Conduct the experiment was existing problem-solving training program; 2) examine the efficiency of training package by implementing pretest and posttest; and 3) collect the students' opinions through a questionnaire. The pretest, posttest and questionnaire were designed to assess the impact of the ASM training strategy. In practical, we were collected by practice scores, which employed the training evaluation based on service manual. The scores can measure in 100 points per aspects.

Data Analysis

The data analysis was scores, percentages, mean standard deviation. The t-test used for calculate the significance of differences between the groups [31]. The effectiveness of ASM training packages on problem solving skills presented a p-value of less than .01 which was considered statistical significance difference. All the analysis was done by using the Statistical Package for Social Sciences (SPSS) computer program [31].

Effects of ASM on Problem-Solving Skills

Students' engaged that the malfunction to identify faulty symptom within current situation. AST was employed by CAMAN SCAN VG Version 5.121 with connected to RS 232 port interfaced via laptop [32]. The problem-solving skills were evaluated by diagnosis as follow as:

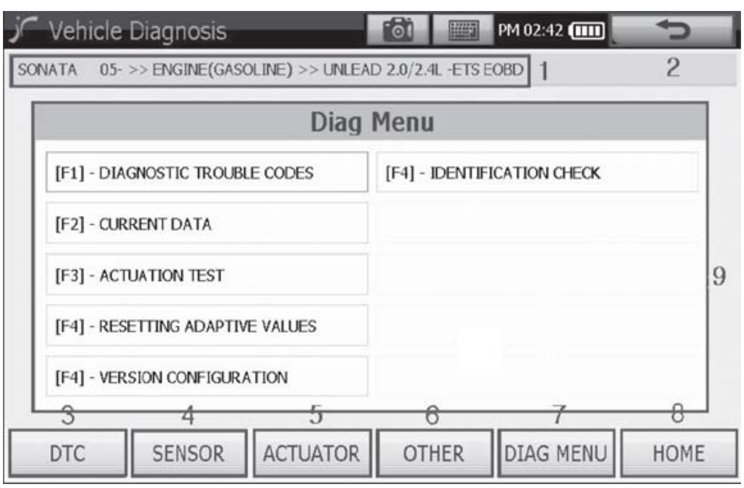


Figure 5 How to access the diagnosis menu

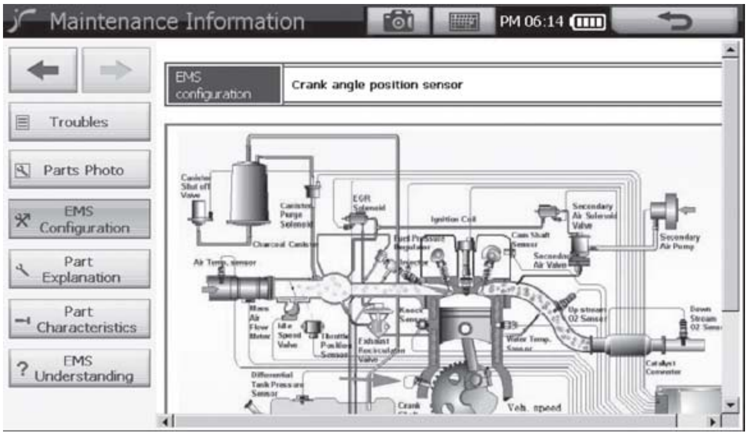


Figure 6 Describe and identify the functionally aspects; sensors, processing and actuators

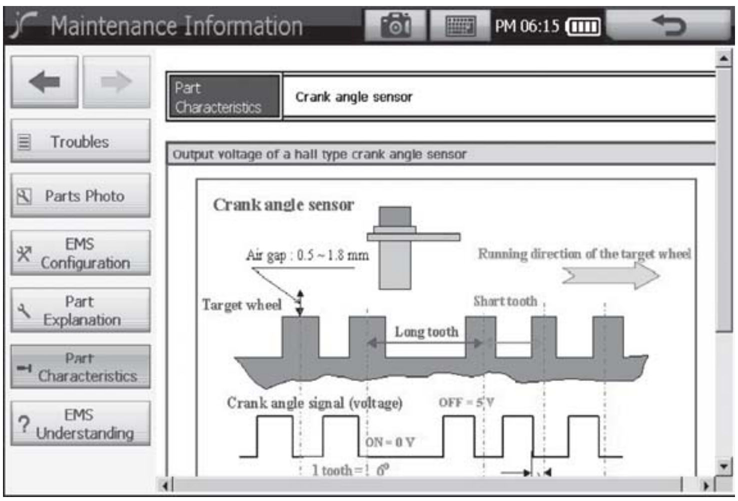


Figure 7 Diagnosis and suggestion of the digital signal

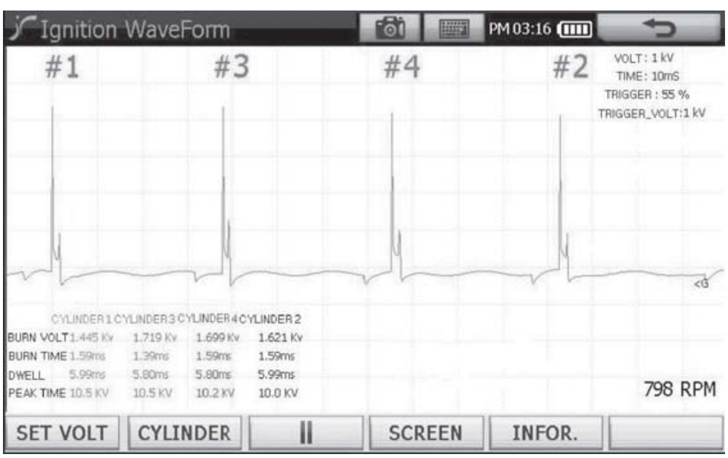


Figure 8 Analyze and synthesize of the CRD injection pulse generator

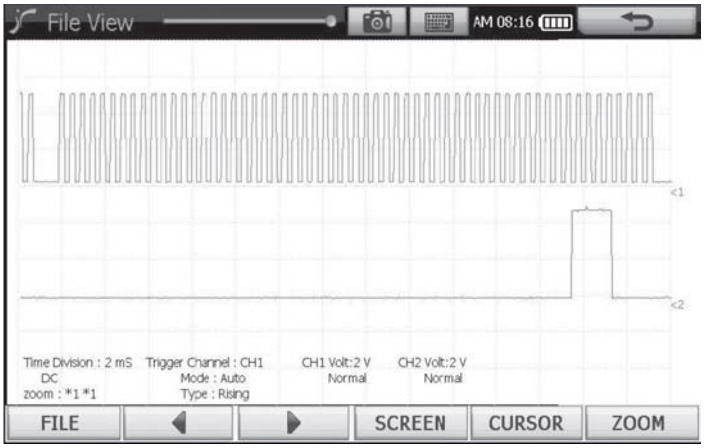
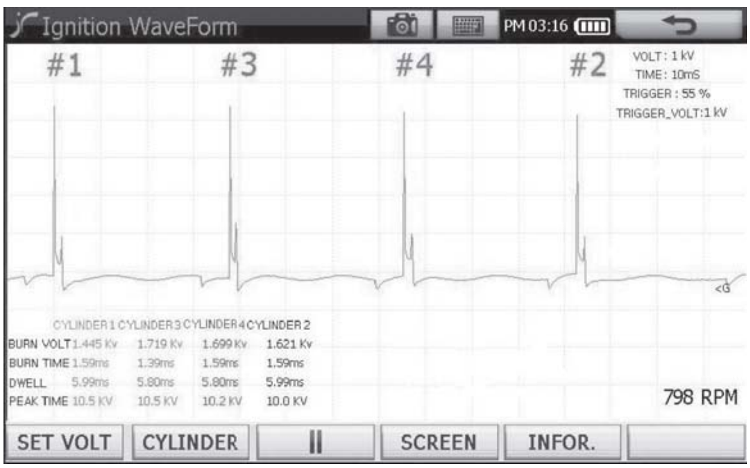


Figure 9 Comparison the pattern wave form base on electronically service manual



	CYLINDER 1	CYLINDER 3	CYLINDER 4	CYLINDER 2
BURN VOLT	1.445 Kv	1.719 Kv	1.699 Kv	1.621 Kv
BURN TIME	1.59ms	1.39ms	1.59ms	1.59ms
DWELL	5.99ms	5.80ms	5.80ms	5.99ms
PEAK TIME	10.5 KV	10.5 KV	10.2 KV	10.0 KV

Figure 10 Adjustable the correction of emission control base on vehicle regulation

Results and Discussion

As instruments, the training measurement and evaluation achievement test, attitude scale and questionnaire were used in the study. The instruments have involved from 3 experts in the field of automotive technology education, 2 experts in the field of instructional technology, and 1 expert in measurement and evaluation were consulted during designing instruments as shown in Table 1 and 2.

Table 1 Summary of quality assessment from experts on the ASM training material package

Item	Description	$\bar{X}$	S.D.	Quality Level
1	Appropriateness (Content, Work instruction, Operation Sheets, and etc.)	4.35	0.51	high
2	Correctly (Instruction manual, Learners manual, Learning modules)	4.56	0.34	highest
3	Completely (Course curricular, Training procedure, Teaching methods, and evaluation and assessment methods)	4.27	0.73	high
4	Evidence to reference	4.66	0.39	highest
5	Outsource to fulfillment (Internet, Library, Other sources)	4.74	0.21	highest
	Average	**4.52**	**0.44**	**highest**

In Table 1, the result of 5 experts' can be found that the mean at 4.52 which were at the high level.

Table 2 Summary of quality assessment from experts on the achievement test

Item	Description	$\bar{X}$	S.D.	Quality Level
1	level of difficulty	4.83	0.20	highest
2	Clearness	4.46	0.57	high
3	Correctly	4.81	0.21	highest
4	Solution	4.52	0.60	highest
	Average	**4.65**	**0.40**	**highest**

The quality assessment from 5 experts' on the achievement had the results were at the highest level.

Table 3 Effects of knowledge domain test scores in the ASM training strategy

Knowledge Domain	*N*	*Mean*	*S.D.*	*t*	*p*
Pretest	30	13.92	12.34	9.25	.000**
Posttest	30	21.47	7.88		

Note. *$p < .05$ **$p < .01$

Descriptive statistics for the multiple choice and short answer tests are presented in Tables 4. Analysis of *t*-test showed that significant difference between the group performance on the multiple-choice pretest, indicating that all groups possessed not equivalent levels of problem-solving skills at the outset of the study.

Table 4 Effects of practical test in the ASM training strategy

Practical	Educational study CB-CM (N = 30)		*t*	*p*
	Mean	*S.D.*		
Fuel delivery system	73.14	8.36	0.02	.104
Air induction system	80.95	10.47	2.67	.076
Electronic control system	64.72	13.63	2.94	.005**
System solution	58.36	14.59	4.16	.008**

Note. *$p < .05$ **$p < .01$

Scores on the practical test were also statistically compared. The *t*-test also showed that there was great significant difference in practical performances between the electronic control system and system solution. Following problem analysis, the performance of the groups on the practical test was considered. Unlike the practical assessment, there was no significant difference between the group performances on the fuel delivery system and the air induction system. All of which indicate that the difficulty of the short answer test resulted in test fatigue. Students were not inured to completing this type of examination requiring higher-order thinking skills.

Table 5 Students 'satisfaction towards the ASM training strategy

Item	Mean	Standard deviation	Rank
1. Applications	4.32	0.74	high
2. Knowledge Acquisition	4.58	0.62	highest
3. Simulation	4.46	0.57	high
4. Problem-solving skills	4.21	0.85	high
Average	**4.40**	**0.69**	**high**

Students' satisfaction towards the ASM training strategy was at the high level.

Conclusions

This study focuses on the students' problem-solving skills after the learning of automotive mechatronics systems training strategy. We first investigated the overall scores of this strategy on practical test in the ASM training strategy they invested in that performance regardless of their problem-solving skills. The superior transfer performance of students who practiced problem solving supported our theoretical framework. The finding provided evidence that, regarding the electronic control system and the system solution problem solving skill enhancing multidisciplinary techniques [5-8].

As a result, Sudsomboon [33] found that students must have an increasingly broad knowledge of how engine operates' complex components work and interact. They also must be able to work with electronic diagnostic equipment (scan tools) and digital manual and reference materials. When the gasoline engine troubles occur, students first get a description of the problem from the owner or training instructors who considered the repair order. To locate the problem, students use a problem-solving skills approach. First, they test to see whether components and systems are secure and working properly [21]. Then, they isolate the components or systems that might be the cause of problem.

For example, if the fuel supply system malfunctions, the student might be check for a simple problem, such as low fuel pressure in delivery pipe, fuel pressure sensor damage, fuel pipe leak, or a more complex issue, such as a bad fuel pump that has shorted out the fuel supply system. As a part of their investigation, students may test start engine or use a variety of testing equipment, including on-board diagnostic, and scan tools diagnostic computers [11]. These tests may indicate whether a component is salvageable or whether a new one is required.

The results also showed that, with this study's students, the ASM training strategy was significantly different from another one in regard to the students' problem-solving skills. We found that mechatronics systems are great challenge for automotive technology education. However, the training strategy limitations of our cognitive architecture represent a significant factor influencing the effectiveness of learning flexible knowledge and skills. In order to enhance problem-solving skills of higher-order thinking skills suitable for solving ASM problems, instruction needs to be focused on articulate troubleshooting learning tasks rather than on separate fragmented components of complex tasks. ASM solution need to construct schemas for controlled effortful performance to identify faulty symptom [34].

Because of many ASM that need to be analyzed simultaneously rather than sequentially, complex solving problems may implement the effectiveness. Therefore, training strategy scaffolding of control system with task performance that is dynamically adjusted to learning situations and cognitive characteristics of students is essentially. Hence, integrating intelligent cognitive tutors with ASM could be an effective training strategy approach. However, learning insight knowledge and metacognitive skills is usually associated with investigating germane problem-solving conditions. The system-controlled learning environment could be generated for the future research. The development of task-specific knowledge and skills have optimize for the development of essential attributes of adaptive expertise.

References

[1] Iserman, R. (2003). *Mechatronic Systems: Fundamentals.* Springer-Verlag.

[2] Janchek, K. (2011). *Mechatronic Systems Design: Methods, Models, Concepts.* Springer.

[3] Craig, K. (2011). http://mechatronics.rpi.edu, homepage of Mechanical Engineering. Ransselaer Polytechnic College.

[4] Foran, J. T. (2005, April). An Intelligent Diagnostic System for Distributed, Multi-Ecu Automotive Control Systems. *SAE International, 2005-01-1444.* Retrieved September 1, 2008, from SAE 2005 World Congress & Exhibition database.

[5] Butler, A.R. (2005, April). Wireless Gateway for Intelligent Diagnostics. *SAE International, 2005-01-1433.* Retrieved September 1, 2008, from SAE 2005 World Congress & Exhibition database.

[6] Mills, W. N. (2005, April). Automated Analysis of Automotive Data. *SAE International, 2005-01-1437.* Retrieved September 1, 2008, from SAE 2005 World Congress & Exhibition database.

[7] Peatman, J.B. (1988). *Design with PIC Microcontrollers*, New Jersey: Prentice Hall.

[8] Jones, W. D. (2002). *"Can You Trust Your Car?.* [Online] Available: http://www. actapress. com/PDFViewer.aspx?paperId=14929.html

[9] Gegele, H. L., & Wang, K. (1998). An expert system for engine fault diagnosis: development and application. *Intelligent Manufacturing.* 9: 539-545.

[10] Duffy, J.E. (2000). Modern automotive technology (5th ed.). Illinois: The Goodheart-Willcox company, INC.

[11] Sudsomboon, W. (2008). Construction of an Automotive Technology Competency Analysis Profile for Training Undergraduate Students: A Case Study of Automotive Body Electrical Technology Systems. [Online] Available: http://educom2008.scis.ecu.edu.au/papers.php

[12] James, P. (2006). Mechatronics and automotive systems design. *International Journal of Electrical Engineering Education.* 41(4).

[13] Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: recent developments. *Educational Psychologist.* 38: 1-4.

[14] Allen, M. (2008). *New Tech Community.* [Online] Available: http://www. popularmechanics.com/automotive.

[15] Becker, H. J. (2000) .*Findings from the teaching, learning, and computing survey: Is Larry Cuban right?* Center for Research on Information Technology and Organizations. [Online] Available: http://www.crito.uci.edu/tlc

[16] Howard, B. C., McGee, S., Schwartz, N., & Purcell, S. (2000). The experience of constructivism: Transforming teacher epistemology. *Journal of Research on Computing in Education.* 32: 455- 465.

[17] Means, B. (1994). Introduction: Using technology to advance educational goals. In B. Means (Ed.), *Technology and education reform: The reality behind the promise* (pp. 1-21). San Francisco: Jossey-Bass.

[18] Reigeluth, C. M. (1999). *Instructional-design theories and models Volume II – A new paradigm of instructional theory*. Mahwah, NJ: Lawrence Erlbaum.

[19] Gallagher,S. A. (1997). Problem-based learning: Where did it come from, what does it do, and where is it going? *Journal for the Education of the Gifted.* 20: 332-362.

[20] Savery, J. R., & Duffy, T. M. (1995). Problem based learning: An instructional model and its constructivist framework. *Educational Technology.* 35(5): 31-38. p. 706.

[21] Sage, S. M. (2000). A natural fit: Problem-based learning and technology standards. *Learning & Leading with Technology.* 28(1): 6-12.

[22] Margaret, E.G. (2001). Lessons Learned from the Directed Evaluation Experience. *American Journal of Evaluation.* 22(1): 97-104.

[23] Lewis, A.C. (1998). A new consensus emerges on the characteristics of good professional development. In R. Tovey (Ed.), *Professional development* (pp.12-15). Cambridge, MA: The Harvard Educational Letter Focus Series No.4.

[24] Koul, R., Clariana, R., & Salehi, R. (2005). Comparing several human and computer-based methods for scoring concept maps and text summaries. *Journal of Educational Computing and Research.* 32(3): 239-245.

[25] Hill, J. R. (1999). Teaching technology: Implementing a problem-centered, activity based approach. *Journal of Research on Computing in Education.* 31: 261-279.

[26] Jonassen, D., Howland J., Moore, J., & Marra, R. (2003). *Learning to solve problems with technology: A constructivist perspective* (2nd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

[27] Jonassen, D.H. (2004). *Learning to solve problems: an instructional design guide*. San Fransico: Pfeiffer.

[28] Jonassen, D.H. (2000). Toward a design theory of problem solving. *Educational Technology Research & Development.* 48(4): 63-65.

[29] Kolodner, J.L. (1997). Educational implications of analogy. A review from case based reasoning. *The American Psychologist.* 52(1): 57-66.

[30] Kothari, C. R. (2003). *Research Methodology*, New Delhi: Wishwa Par kasha.

[31] Creswell, J.W. (2008). *Educational research: planning, conducting, and evaluating quantitative and qualitative research (3rd ed.)*. Pearson Merill Prenctice Hall.

[32] Nextech. (2006). CARMAN SCAN VG: Vehicle Diagnosis Integrated System. *Operation Manual*.

[33] Sudsomboon, W. (2007). The Unit of Competence Development on Automotive Electricity and Electronics Systems Technology Subject for Learner Capability Improvement of Faculty of Industrial Education and Technology at King Mongkut's University of Technology Thonburi. *Khon Kaen University, Journal of Education.* 30(4): 56-64.

[34] Dieterle, W. (2005). Mechatronic Systems: Automotive applications and modern design methodologies. *Annual Reviews in Control.* 29: 273-277.