

## ผลของยุทธวิธีการเรียนรู้เพื่อเพิ่มพูนทักษะการแก้ปัญหาในระบบแมคคาทรอนิกส์ ยานยนต์สำหรับนักศึกษาระดับปริญญาตรีสาขาเทคโนโลยีเครื่องกล

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### บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของยุทธวิธีการเรียนรู้เพื่อเพิ่มพูนทักษะการแก้ปัญหาในระบบแมคคาทรอนิกส์ยานยนต์ กลุ่มตัวอย่างที่ใช้ในการวิจัยครั้งนี้ คือ นักศึกษาระดับปริญญาตรีสาขาวิชาเทคโนโลยีเครื่องกล คณะเทคโนโลยีอุตสาหกรรม มหาวิทยาลัยราชภัฏนครศรีธรรมราช ในการจัดการเรียนการสอนรายวิชา 5592103 การออกแบบเครื่องจักรกล 1 ภาคการศึกษาที่ 1/2556 จำนวน 35 คน จำแนกออกเป็นนักศึกษากลุ่มทดลอง จำนวน 18 คน และนักศึกษากลุ่มควบคุม จำนวน 17 คน โดยให้กลุ่มทดลองทำการเรียนรู้ด้วยยุทธวิธีการเรียนรู้โดยใช้ทักษะการแก้ปัญหา และกลุ่มควบคุมเรียนรู้ด้วยวิธีการเรียนรู้แบบปกติ เครื่องมือที่ใช้ในการวิจัย คือ แบบทดสอบระบบเบรกแบบแมคคาทรอนิกส์ก่อนเรียนและหลังเรียนชนิดข้อสอบปรนัย จำนวน 40 ข้อ มีค่าความเชื่อมั่นเท่ากับ .83 และค่าความยากง่ายเท่ากับ .67 แบบทดสอบยุทธวิธีการเรียนรู้โดยใช้ทักษะการแก้ปัญหาในระบบแมคคาทรอนิกส์ยานยนต์เป็นแบบตอบสั้นเพื่อสรุปประเด็น จำนวน 20 ข้อ ประกอบด้วย 4 ด้าน ได้แก่ การประมวลบริบทของปัญหา การจำแนกอาการและข้อบกพร่อง การวินิจฉัยข้อบกพร่อง และการกำหนดวิธีการแก้ปัญหา สถิติที่ใช้ในการเปรียบเทียบ คือ ค่าเฉลี่ยส่วนเบี่ยงเบนมาตรฐาน การทดสอบค่าที และการทดสอบความแปรปรวนสองทาง โดยกำหนดค่าระดับนัยสำคัญในการทดสอบทางสถิติที่ .05 ผลของการวิจัยพบว่า คะแนนเฉลี่ยในการทำแบบทดสอบก่อนเรียนไม่มีความแตกต่างอย่างมีนัยสำคัญของทั้งสองกลุ่ม และในการทำแบบทดสอบหลังเรียนกลุ่มทดลองมีคะแนนเฉลี่ยสูงกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ และข้อค้นพบจากการทำแบบทดสอบระหว่างเรียนด้วยยุทธวิธีการเรียนรู้โดยใช้ทักษะการแก้ปัญหาในระบบแมคคาทรอนิกส์ยานยนต์พบว่ากลุ่มทดลองมีคะแนนเฉลี่ยสูงกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติจำแนกออกเป็นรายด้าน ประกอบด้วย การจำแนกอาการและข้อบกพร่อง การวินิจฉัยข้อบกพร่อง และการกำหนดวิธีการแก้ปัญหา ผลจากการวิจัยได้จัดทำเป็นข้อเสนอแนะเพื่อการประยุกต์ใช้ในสาขาวิชาชีพอื่น ๆ และการศึกษาในระดับอาชีวและเทคนิคศึกษาที่เกี่ยวข้อง

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## The Effects of Problem Solving Skills Strategy on Automotive Mechatronic Systems for Undergraduate Mechanical Technology Students

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### Abstract

The purpose of this study was to investigate the effects of problem-solving skills strategy on automotive technology systems for undergraduate mechanical technology students. Thirty-five undergraduate mechanical technology students in 5592103 Machine Design I course offered in semester 1/2013 at the Mechanical Technology Program of Faculty of Industrial Technology (FIT) at Nakhon Si Thammarat Rajabhat University (NSTRU) were chosen to be the participants. Learners' were simple randomly assigned to experiment group ( $n = 18$ ) and control group ( $n = 17$ ). The pre-test and post-test of the theoretical mechatronic brake systems, which was adapted to undergraduate mechanical technology students context was used along multiple with a 40-item multiple choice developed by the researcher. The reliability of the tests was .83. The difficulty levels of the tests were .67. The problem-solving skills strategy short-answer items test of the mechatronic brake systems consisted of 20 items covering four processes: construct problem space; identify fault symptoms; diagnose fault(s); and solutions. Descriptive statistics were used Two-way analysis of variance (ANOVA) were conducted to investigate. The interpreting significance of the results, the statistically significance was set at .05. On the pre-test, there was no significantly difference between these two groups. On the post-test, there were significant differences between the experimental group scored higher than the control. The finding found that the scores have statistical significantly in each aspect: identify fault symptoms, diagnose fault(s), and solutions have statistical significantly in the experimental group were discussed.

**Keywords:** Automotive Mechatronic Systems, Problem Solving Skills Strategy, Learning Innovation, Mechatronic Brake System

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## 1. Introduction

Currently, many technical processes and products in the area of mechanical, electrical, electronics, and control engineering have widely implemented an increasing integration of mechanics with digital electronics, computer and information processing. This application is between the components (hardware) and the information-driven functions (software), resulting in integrated systems called Automotive Mechatronic Systems (AMS) [1]. AMS have integrated mechanical electronic systems emerge from a suitable combination of mechanics, electronics and control/information processing. Thereby, these fields influence each other mutually.

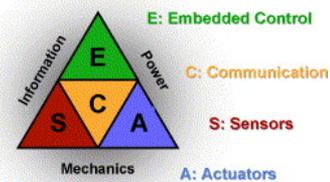
With development, AMS involves finding an optimal balance between the basic mechanical components, sensor and actuator implementation, and automatic information processing for the overall control. In modern automobiles the increase of comfort, safety, and reliability is the main goal together with the improvement in driving performance, fuel consumption, emissions, but also production processes [2]. Therefore, the high demands for developing manpower in mechanical technology to foster advanced technicians required by industrial are put forward.

By examining the relationship between cognitive demands and instructional approaches in the context of technology education, Kim & Hannafin [3] identified cognitive demands for problem-solving in technology that enhance technology advances have afforded researcher unique opportunities to foster learners' critical thinking and problem-solving skills. Jonassen [4] described that problem dimensions included internal factors that address problem solvers' individual characteristics (e.g., problem solvers' prior experience, domain knowledge, reasoning skills, and epistemological beliefs) and external factors that reflect how problems are formed and represented (e.g.,

complexity, structuredness, dynamically) and situated (e.g., cultural expectations).

For this reason, the Mechanical Technology Program of Faculty of Industrial Technology (FIT) at Nakhon Si Thammarat Rajabhat University (NSTRU) have been promoted problem-solving skills for inquiry, which affects for technology-rich multidisciplinary studies such as AMS has proven especially provide. While researcher interest in improving problem-solving skills with mechatronic systems has been long-challenging, progress has been emerged.

In this research, the essential knowledge on AMS for undergraduate mechanical technology students are real-world functions possible that able to learn about embedded digital computers as shown in Figure 1. The integrated process and control of AMS is mutual optimization of process and control performance, model-based control, adaptive and learning control strategies.



**Figure 1** The integrated process and control for AMS [2]

Researcher has reviewed the evidence of effects problem-solving teaching and learning using AMS to solve mental multiplication problems has not been studied in Thai mechanical technology area. Whereas researcher regard problem-solving skills in AMS as critical for engage learners domain knowledge as shown in Figure 2, this research have afforded learning innovations to scaffold students' problem solving in AMS, absolutely.

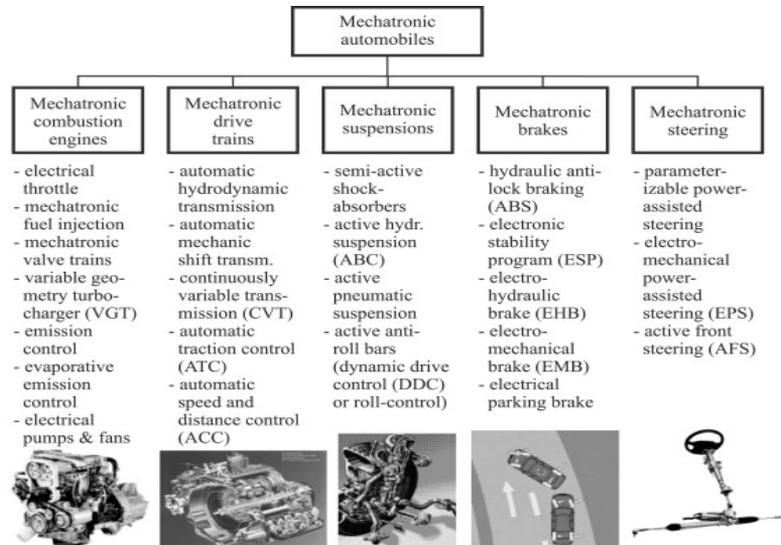


Figure 2 AMS mental multiplication problems [1]

While the AMS, which are able to solve technological problems using interdisciplinary knowledge consisting of mechatronics elements. To solve these problems, traditional technologists used knowledge provided only in one of these areas (for example, a mechanical technologist uses some mechanical technology methodologies to solve the problems). Additionally, to improve learners' solving the AMS problems, effective accurately and quickly strategies are being widely implicated. The problem-solving skills (PSS) strategy [5] [6] is establishment as follow as: 1) Construct problem space; 2) Identify fault symptoms; 3) Diagnose fault(s); and 4) Solutions implicated other possibilities and discuss experiments as shown in Figure 3.

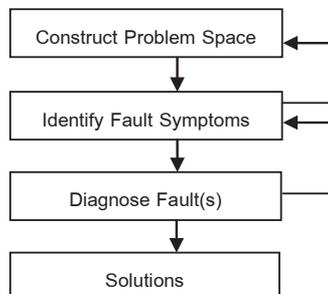


Figure 3 The PSS model [5] [6]

The purpose of this study was to investigate the effects of problem-solving skills strategy on automotive technology systems for undergraduate mechanical technology students. The research question was: Did the problem-solving skills strategy affect learners' use on automotive technology systems?

## 2. Theoretical Background

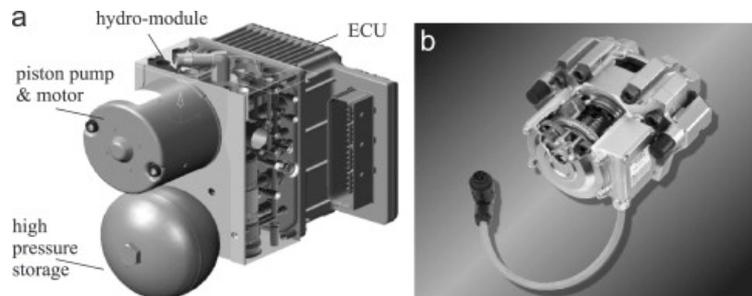
### 2.1 Automotive Mechatronic Systems

Iserman [1] stated mechatronic products are especially advanced in the field of automobiles. Therefore, this area is considered to show some concrete examples. Figure 2 presents the AMS mental multiplication problems realized mechatronic components and systems. In AMS has proven the value of electronics, electrics and mechatronics of today's cars is about 20–25% of the total price, with a tendency towards 30–35% in 2010. A higher-class passenger car contains about 2.5 km of cables, 40 sensors, 100–150 electro-motors, 4 bus systems with 2500 signals and 45–75 micro electronic control units (ECUs) [7].

### 2.2 Mechatronic Brake Systems

In this research, researcher has conducted the ABS and ESP systems in this study. The research design is specifically, during implementing the PSS strategy, the students should be know in order to increase the functionality further, to save space and

assembling costs and to increase the passive safety, two types of mechatronic brake-by-wire systems were developed, the electrohydraulic brake (EHB), since 2001 in series production (Mercedes SL and E-class), and the electromechanical brake (EMB), for which prototypes exist [1] [7], as shown in Figure 4.

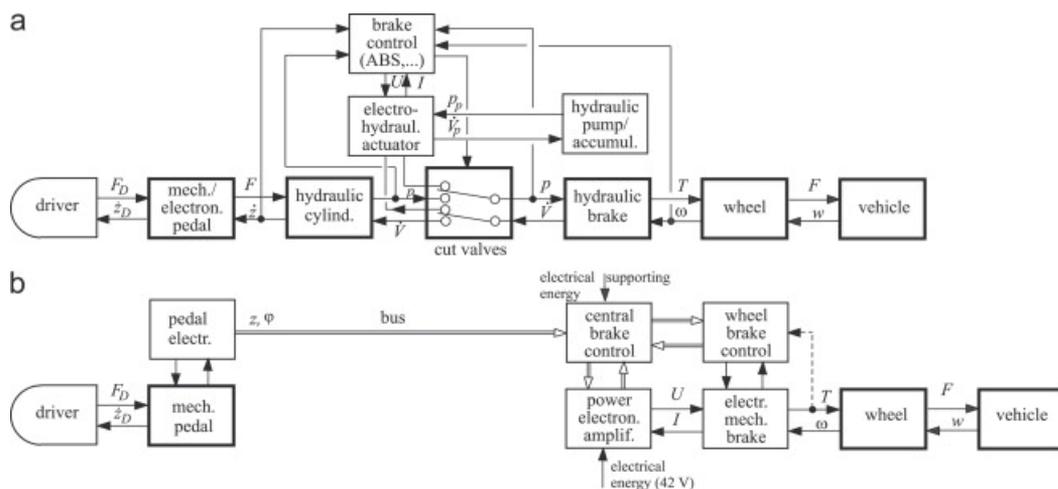


**Figure 4** Illustration of brake-by-wire-systems [1]:

(a) Electrohydraulic brake control (EHB), Bosch; (b) Electromechanical brake (EMB), Continental Teves.

The signal flow diagram as shown in Figure 5 have been proposed, reflecting diverse problem-solving skills in order to investigate the effects of

PSS strategy on AMS of undergraduate mechanical technology students [7].



**Figure 5** Signal flow diagram for different mechatronic brake systems of passenger cars [1]:

- (a) Electrohydraulic brake (EHB) with hydraulic brake;
- (b) Electromechanical brake (EMB) without mechanical backup



### 2.3 Conceptual Framework

In order to use mechatronics to solve mental multiplication problems of AMS, the PSS strategy begins by reviewing existing conceptions. While learners' solve the mechanical brake systems problems [6], performers as shown in Figure 3:

- use many observations in a sequence of simple decisions;
- use general search procedures that are not dependent on actual system or fault;
- search to find components; and
- search thorough systems to identify appropriate sub-system, state or component.

#### 2.3.1 Construct Problem Space

The Construct problem space is the first step in solving problems [8] [9]. The problem space of AMS as the mechanical brake systems problems is the mental model of the task environment that learners' constructs. That model should represent the solution of the system, the normal various fault states. For example, the AMS are represented as wiring diagrams, exploded views of sensors locating, and signal flow diagram of diagnostic actuators.

#### 2.3.2 Identify Fault Symptoms

Learners' use strategic knowledge (signal flow diagram) about which procedures and conditions, which based on service manual procedures to perform in order to identify discrepancies. Recognizing symptoms of faulty components is also aided by learners' experience. The likelihood of symptoms becoming apparent is a function of previous experience and background knowledge.

#### 2.3.3 Diagnose Fault(s)

After construct problem space, learners' begins the diagnosis process by examining the fault system and comparing the system states to similar problems has solved. If a previous problem is

recalled, the problem space is reduced immediately to include a description of the old problem.

Learners' experienced categorize problems based on prior experiences. Throughout the process of "hypothesis generating and testing" cycles [8] are generated to provide possible explanations for the causes of the system fault. Learners' can be performed iterative processes.

#### 2.3.4 Solutions

The process of solution is evaluation as similar to hypotheses generation, although it has not been researched nearly as extensively. Learners' perform to generate one or more solutions for solving the CRDS based on the results of tests. The simplest solution is to fix or replace a part or module. In this research, that is the preferred solution because it requires the least time. As with diagnosis, learners skilled rely first on their experiences. Lecturers treated learners know the most plausible solution from the set of solutions generated and determine which best meets all the constraints (e.g., effectiveness, efficiency, system-specifics, and economic specification) as the code of conduct [9] [10].

Thus, learners are recursive throughout the four processes with adjustment or modification as contextual change. The solution process is an essential attributes in effective problem-solving skills strategy.

## 3. Methodology

### 3.1 Design

A pre-test and post-test experimental design was employed in this study.

### 3.2 Participants

Thirty-five undergraduate mechanical technology students who using a PSS strategy application in 5592103 Machine Design I course offered in semester 1/2013 at the Mechanical Technology Program of Faculty of Industrial Technology (FIT) at



Nakhon Si Thammarat Rajabhat University (NSTRU) were chosen to be the participants. Learners' were simple randomly assigned to experiment group ( $n = 18$ ) and control group ( $n = 17$ ). In order to make the research more consistent, the experimental and control groups were instructed by the researcher.

### 3.3 Instruments

#### 3.3.1 Problem-Solving Skills Material

The PSS material included by (a) Electrohydraulic brake control (EHB), Bosch; (b) Electromechanical brake (EMB), Continental Teves [1]. The material represented the goal state of the EHB and the EMB systems, the normal states of the system and system components; various fault states, the system structure, and the control system. The EHB and EMB service manual was chosen as the textbook not only in consideration of the PSS strategy are novel and lively. It was not necessary for the learners to have any prior experience and prior knowledge of any specific domain before they could understand the experiment.

#### 3.3.2 Problem-Solving Strategy Application Tests

The pre-test and post-test of the theoretical mechatronic brake systems, which was adapted to undergraduate mechanical technology students context was used along multiple with a 40-item multiple choice developed by the researcher. The reliability of the tests was .83. The difficulty levels of the tests were .67. Both instruments were implemented before and after the treatment. Completing the pre-test and post-test took 60 min.

The problem-solving skills strategy short-answer items test of the mechatronic brake systems consisted of 20 items covering four processes, 5 of which addressing the construct problem space, 5 of which addressing the identifying fault symptoms, 5 of which addressing the diagnose fault(s), and 5 of which

addressing the solutions developed by the automotive experts from well-known automotive company and vocational and technical education instructors. The reliability of the tests was .88. The difficulty levels of the tests were .59, and a five point rubric score is divided: outstanding, good, pass, fair, and fail.

The higher the score is, the greater the agreement to the statement is. In these 20 questions, four PSS strategy applications – 1) Construct problem space; 2) Identify fault symptoms; 3) Diagnose fault(s); and 4) Solutions – are covered. Example for Questions 1 and 2 are about the construct problem space strategy (Q 1: Please represent the feasibility failure state of the EHB and EMB in passenger cars underlying the signal flow diagram, Q 2: Please derive the normal states of the EHB and EMB with system components; if the pneumatic actuator fails and The hydraulic cylinder acts on two independent hydraulic circuits).

#### 3.3.3 Problem-Solving Strategy Instruction

There were five key points made in the PSS strategy instruction procedures: (1) choose mechatronic brake systems for the experiment; (2) find the main problems and the supporting problems of the EHB and EMB with system components; (3) exclude irrelevant the PSS strategy of the EHB and EMB with system components; (4) map out the PSS strategy of the EHB and EMB among the problems, and (5) connect the best solutions with presentation and reporting. It teaches learners to focus on the EHB and EMB with system components, integrate that concept with the PSS strategy concepts and details, and extend outward from their cognitive demands.

#### 3.4 Procedure

The experiment lasted for five days, and every day period was three hours. Before the experimental process was carried out, the participants were given a pre-test that participated



collectively in the pre-test during the before instruction could be collected. The researcher chose participants from the 3<sup>rd</sup> years as the experimental group ( $n = 18$ ), and students from the other class as the control group ( $n = 17$ ).

For the experimental group, the researcher adopted PSS strategy instruction (e.g., training material in PSS strategy, automotive problem analysis work sheet, service manual for teaching of mechatronic brake systems). Learners' studied the different stages for brake systems of passenger cars or lightweight trucks. In the case of the conventional hydraulic brake, the mechanical linkage between the pedal and the hydraulic main cylinder is paralleled by the power supporting pneumatic actuator (booster). If the pneumatic actuator fails, the mechanical linkage transfers the (larger) pedal force from the driver. The hydraulic cylinder acts on two independent hydraulic circuits in parallel. That means the brake system is fault tolerant with regard to a failure of one of the two hydraulic circuits.

Failures in the electronics of brake control systems as ABS bring the hydraulic actuators (e.g., magnetic valves) into a fail-safe status such that the hydraulic brake gets the pressure from the hydraulic main cylinder directly. The ABS functions are realized by switching valves, which have three positions for lowering, holding or increasing the fluid pressure and thus allow only a discrete actuation of the brake torque, with strong oscillation

The signal flow diagram as shown in Figure 4 have been proposed, reflecting diverse problem-solving skills in order to investigate the effects of PSS strategy on AMS of undergraduate mechanical technology students. As for the control group, the instructor used traditional instruction (e.g., text book and learning material) in class.

The researcher introduced the idea of the PSS strategy after the pre-test finished to the participants in the experimental group. Also, as part of the PSS strategy teaching, the participants practiced their first the EHB and EMB with system components with four processes after the first practice of PSS strategy was complete, the researcher administered post-test in the five day.

While the experimental group adopted the PSS strategy, the control group used the conventional learning as teaching materials. In addition, when the experimental group did the PSS strategy practices, the control group taught reviews on the problems.

#### 3.4 Data Analysis

Descriptive statistics were used Two-way analysis of variance (ANOVA) were conducted to investigate. The interpreting significance of the results, the statistically significance was set at .05.

## 4. Results

Research question have showed on problem-solving skills strategy affect learners' use on automotive technology systems by using both experimental and control groups' on the pre-test and post-test mechatronic brake systems items test. To obtain that there was no significant difference before the experiment, the researcher used the independent sample t-test to analyze the results of the pre-test.



**Table 1** The independent *t*-test of pre-test and post-test of the two groups

		<i>n</i>	<i>Mean</i>	<i>SD</i>	<i>t</i>	<i>P</i>
Pre-test	Experimental group	18	22.68	3.66	-1.93	.42
	Control group	17	23.17	3.58		
Post-test	Experimental group	18	31.85	2.37	-2.58	.01*
	Control group	17	28.66	2.82		

\*  $p < .05$

On the pre-test, there was no significant difference between these two groups ( $t = -1.93$ ,  $p = .42$ , as shown in Table 1). On the post-test, there were significant differences between the two groups ( $t = -2.58$ ,  $p = .01$ ); the experimental group ( $Mean = 31.85$ ) scored higher than the control group ( $Mean = 28.66$ ).

As a result, Table 2 found that the independent *t*-test of the post-test of the experimental group and the control group. The results showed that the scores as follow as: identify fault symptoms, diagnose fault(s), and solutions have statistical significantly in the experimental group.

**Table 2** The independent *t*-test of the Problem-Solving Strategy Application Tests of the two groups

		<i>n</i>	<i>Mean</i>	<i>SD</i>	<i>t</i>	<i>P</i>
Construct problem space	Experimental group	18	2.86	.79	-2.34	.62
	Control group	17	3.14	.63		
Identify fault symptoms	Experimental group	18	3.53	.59	-1.58	.03*
	Control group	17	2.98	.82		
Diagnose fault(s)	Experimental group	18	3.46	.54	-2.01	.00*
	Control group	17	3.05	.73		
Solutions	Experimental group	18	3.12	.68	-1.35	.00*
	Control group	17	2.75	.95		

\*  $p < .05$

As a result, Table 2 found that the independent *t*-test of the post-test of the experimental group and the control group. The results showed that the scores as follow as: identify fault symptoms, diagnose fault(s), and solutions have increased significantly in the experimental group. Learners tended to apply various reading strategies once they were trained in the mechatronic brake systems on PSS strategy instruction.

## 5. Discussions

Mechatronic brake system items test was completed by learners' before and after the PSS strategy instruction. Comparison of the data indicated that the learners' more effectively utilized such as identify fault symptoms, diagnose fault(s), and solutions after they received instruction in the PSS strategy instruction strategy. The PSS strategy plays problem dimensions included internal factors that address problem solvers' individual characteristics.



The finding found that cognitive demands in illustrating to enhance, and transforms problem-solving skills into a conceptual framework that enables the learners to integrate experiential, domain, and device knowledge based on mechatronic brake systems. To enables learners, diagnose fault(s) throughout the process of "hypothesis generating and testing" for experimental group they take, the PSS strategy relate to a conceptual model of the mechatronic brake system, and query experienced about what they would do [5] [8] [9] [10].

Moreover, the diagnose fault(s) on their learners' were prior experience, domain knowledge, reasoning skills, and epistemological beliefs about the cause once a discrepant symptom is found. Those beliefs are based on experience that the most common reason for taking a particular action during construct problem space was essentially tested. Kim and Hannafin [3] stated that problem identification embodies learners' activities, such as making observations of natural phenomena by reading and utilizing visualizations in technology-enhanced classrooms. During this state, learners find or generate problems and externalize them by recording ideas or communications or communicating with others and retrieve information conveniently.

For this reason, the signal flow graph diagram as a simulation (diagrams, exploded views of sensors locating, and signal flow diagram of diagnostic actuators) for different mechatronic brake systems of passenger cars was employed. However, learners' should view mental multiplication problems with the computer-based concept mapping, which would be enhanced learners capability to solve re-arrange knowledge usually employed the higher flexibility of the PSS strategy on AMS [11] [12]. Learners' is conceptualized as "the hydraulic cylinder acts" on two independent hydraulic circuits in parallel. Hence, the

PSS strategy is gained identify fault symptoms as a fault tolerant with regard to a failure of one of the two hydraulic circuits. The diagnose fault(s) considered failures in the electronics of brake control systems as ABS bring the hydraulic actuators (e.g., magnetic valves) into a fail-safe status such that the hydraulic brake gets the pressure from the hydraulic main cylinder directly.

In order to extract the construct covered in the research, the learners must do summarizing so that they can concentrate on the diagnosis fault(s), learners skilled rely first on their experiences. The experimental group treated learners know the most plausible solution from the set of solutions generated and determine which best meets all the constraints (e.g., effectiveness, efficiency, system-specifics, and economic specification) as the effectively problem-solving skills [13]. Thus, learners are recursive throughout the PSS strategy with adjustment or modification as contextual change [11].

Both doing diagnose fault(s) and solutions as the brief description of the result helps the learners perform how one part of the article is connected to the mechatronic brake parts. It helps the learners clarify the critical thinking and ideas within the PSS strategy. For example, it helps the learners to discover the main idea and related supporting evidence [14]. In addition, application of the PSS strategy can help learners to identify major and minor constructs problem space, and to connect the related AMS parts or mechatronic elements after finding them.

On the other hand, the PSS strategy presents a cognitive domain representation of the learner's cognitive structure, and therefore, can reveal the myth in the learner's mind. The PSS strategy helps learners through the use of construct problem space and solutions strategies to condense and summarize



experience knowledge and restructure prior experience. In this way, students can gain more accurate understanding of the fundamentals of automotive mechatronic systems [7]. As the analyzed data showed, the learners still have to employ reading strategies like identify fault symptoms, diagnose fault(s), and solutions when they proceed with the PSS strategy. They are solving to increase the flexibility of their thinking so that they can draw the concept map systematically and structurally [15] [16].

To summarize, the PSS strategy is a useful AMS which has positive effects on learners' their application of instructional strategy [17]. The researcher found that they think that the identify fault symptoms, diagnose fault(s), and solutions can be considered important sources for future research [18] [19]. Use of the PSS strategy on AMS for undergraduate mechanical technology students enhances learners' more confidence in reflecting diverse problem-solving skills for undergraduate mechanical technology students' ability [20] [21].

## 6. Conclusion

This study investigated to investigate the effects of problem-solving skills strategy on automotive technology systems for undergraduate mechanical technology students. It was undertaken using a PSS strategy application 5592103 Machine Design I course offered in semester 1/2013 at the Mechanical Technology Program of Faculty of Industrial Technology (FIT) at Nakhon Si Thammarat Rajabhat University (NSTRU) in Thailand. The results indicated that experimental students who worked on PSS strategy on AMS and got higher scores in the post-test when compared to control students.

The current study found that various instructional strategies such as problem-solving skills strategy might enhance students' cognitive demands to their

technology-enhanced learning environment and their achievement scores affects their learning positively. Cognitive demands might sometimes hinder the development of successful learning outcomes due to inactive and dominant students or for some other reason [21].

As there might be some other variables leading to the failure of cognitive demands learners in PSS strategy on AMS, further research are required with other sample groups and controlling other variables such as instructor's guidance, students' individual characteristics and learning styles, or student collaboration and their use of discourse in vocational and technical education and or relate field. This research implemented that the participants were typical undergraduate mechanical technology students, and that the lecturer and course design was representative supplement of 5592103 Machine Design I course. To generalize the findings of the present study would be difficult since the learner characteristics, course content, applied instructional strategy and instructional design might not be fully representative of other lecturers and other technology-enhanced learning environments.

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