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ผลของยุทธวิธีการเรียนรู้แบบผสมผสานด้วยการใช้ปัญหาเป็นฐานและการใช้ฐานสมรรถนะเพื่อเสริมสร้างผลสัมฤทธิ์การฝึกอบรมงานตรวจสอบระบบแมคคาทรอนิกส์ควบคุมเครื่องยนต์แก๊สโซลีน

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของยุทธวิธีการเรียนรู้แบบผสมผสานด้วยการใช้ปัญหาเป็นฐานและการใช้ฐานสมรรถนะเพื่อเสริมสร้างผลสัมฤทธิ์การฝึกอบรมงานตรวจสอบระบบแมคคาทรอนิกส์ควบคุมเครื่องยนต์แก๊สโซลีน การออกแบบการวิจัยใช้กลุ่มทดลองและกลุ่มควบคุมด้วยการทดสอบก่อนเรียนและหลังเรียน กลุ่มตัวอย่างที่ใช้ในการวิจัยครั้งนี้ คือ นักศึกษาระดับปริญญาตรี สาขาวิชาเทคโนโลยีเครื่องกล คณะเทคโนโลยีอุตสาหกรรม มหาวิทยาลัยราชภัฏนครศรีธรรมราช ปีการศึกษาที่ 2/2558 เข้ารับการฝึกอบรมในหัวข้อ งานตรวจสอบอุปกรณ์และชิ้นส่วนระบบแมคคาทรอนิกส์สำหรับควบคุมเครื่องยนต์แก๊สโซลีน โดยแบ่งออกเป็น 2 กลุ่ม กลุ่มละ 15 คน ด้วยเทคนิคการสุ่มอย่างเป็นระบบ โดยเรียงลำดับตามผลคะแนนสอบทักษะพื้นฐานการตรวจสอบชิ้นส่วนอุปกรณ์อิเล็กทรอนิกส์ยานยนต์ และกลุ่มควบคุมจัดการเรียนการสอนแบบปกติ รวมกลุ่มตัวอย่างทั้งสิ้น 30 คน เครื่องมือที่ใช้ในการวิจัยประกอบด้วยแบบทดสอบก่อนเรียนและหลังเรียนและแบบวัดผลสัมฤทธิ์ด้วยการใช้ปัญหาเป็นฐานและการใช้ฐานสมรรถนะ ผลการวิจัยพบว่า กลุ่มทดลองที่เรียนด้วยรูปแบบการผสมผสานด้วยการใช้ปัญหาเป็นฐานและการใช้ฐานสมรรถนะหลังจากการเรียนรู้มีค่าคะแนนเฉลี่ยสูงกว่าการสอนด้วยวิธีปกติ ข้อค้นพบที่สำคัญพบว่า กลุ่มทดลองมีผลคะแนนทดสอบที่สูงกว่ากลุ่มควบคุมโดยใช้ยุทธวิธีการเรียนรู้ด้วยการใช้ปัญหาเป็นฐาน ประกอบด้วย ทักษะการหาข้อสรุปในการกำหนดขั้นตอนการแก้ปัญหาแบบอนุมาน ทักษะการกำหนดสมมติฐานการแก้ปัญหา และทักษะการให้เหตุผลแบบนิรนัย โดยข้อค้นพบที่ได้สามารถนำไปประยุกต์ใช้ในการจัดการเรียนการสอนรายวิชา 5591501 ปฏิบัติงานเครื่องยนต์ต้นกำลัง ได้อย่างมีประสิทธิภาพ

คำสำคัญ ระบบแมคคาทรอนิกส์ยานยนต์ / นวัตกรรมการจัดการเรียนการสอน / การเรียนรู้โดยใช้ฐานสมรรถนะ / ยุทธวิธีการเรียนการสอน / การเรียนรู้โดยใช้ปัญหาเป็นฐาน

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The Effects of Hybrid Problem-Based Learning and Competency-Based Learning Approach to Enhance the Training Achievement in Automotive Mechatronics System of Gasoline Engine Controls

Weerayute Sudsomboon [1*] Tanaporn Muangnungkhun[1] Roipimjai Petchkul [1] and Wilawan Jinwan [1]

Abstract

This study investigated the effects of hybrid problem-based learning (PBL) and competency-based learning (CBL) approach to enhance the training achievement in automotive mechatronics system of gasoline engine controls. Participants were undergraduate mechanical technology students' at the Mechanical Technology Program, Faculty of Industrial Technology, Nakhon Si Thammarat Rajabhat University in the semester 2/2015. The pre- and post-test experimental and control group design was conducted in this study. Participants have been training in the "Inspection of Automotive Mechatronics Elements for controls of gasoline engine course" entirely with practical setting. Students were divided into two groups, experimental group and control group. The participants involved with 15 students in each group, 30 students in total with systematic sampling according to preliminary test scores on fundamentals of automotive electronics devices skills. Data collection tools consisted of a pre- and post-test in automotive mechatronics system and the hybrid PBL and CBL approach achievement test. The results revealed that the hybrid PBL and CBL approach did have a significant effect on both the pre- and post-test and achievement scores, which were higher than the traditional method.
The finding found that experimental group was higher yield scores than the control group on NISSAN Automotive Test (PBL) in three aspects as follow as: inference, recognitions of assumptions, and deduction, respectively. Finding were given this exploration in the use of PBL and CBL, the reality in teaching of automotive mechatronics system that there were many knowledge domain applications of its that could be described as hybrid instructional strategies. The finding suggested that be able to conduct the effective teaching and learning in 5591501 automotive technology professional practice.

Keywords: Automotive Mechatronics System / Competency-based Learning / Instructional Strategies / Problem-based Learning / Training Achievement

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1. Introduction

According to the implementation of the 1999 National Education Act, has prompted a revise in the education sector in terms of both teaching and learning methods, as well as in learning environments and authentic assessment [1]. Currently, the aim of Thai skills labour development in automotive service technicians is how to produce higher level technicians, and they require specific skills based on career path. The higher level technician is a highly skilled worker; in other words, such a student gets an intermediate level education between engineer and specialized worker, and this define of education can be given only by a vocational institution and university. In spite of National Council for Peace and Order (NCPO) efforts to promote highly skilled worker for enhancing the national skills competitiveness, provides a policy framework that guides country on how to produce higher level technicians for supporting functions and boosting economic growth [2].

In the context of the higher level technicians' crisis, the highly skilled workers have to contribute to these revised as follow as:

(1) Developing the specific skills for the knowledge-based economy such as critical thinking skills, decision making and problem-solving skills;

(2) Incentivizing the participation of industrial sectors in the labour market through retraining; and

(3) Fostering skills standards that contribute in detailing attributes and characteristics for measuring competence. The main problems in automotive technology teaching and learning is transferable troubleshooting skills [3], and the social demand standards have driven competence assessment from contribute in detailing attributes and characteristics for measuring competence. As a result, the study of competency-based learning is a key factor for up-skilling in teaching and learning of the higher level technicians'. It provides the measuring learning outcomes to be competent in providing skills with a competency-based framework.

Despite requirements for both Problem-based learning (PBL) and Competency-based learning (CBL) is the new feature to promote highly skilled worker through regulation and practice in automotive service technicians. This study can be utilized within any vocational and technical education and university context [3], [4], [5].

The automotive service industry or after sale service is predominantly a service sector which dependent on business activity across a range of automotive dealerships. Compliance with higher level technicians' and business competitions are major costs to automotive businesses particularly smash repairers, specialist repairers and tyre retailers [6]. Access to new automotive technology is a high priority across this business sectors in an increasingly competitive market largely controlled by automotive manufacturers.

Automotive dealerships and specialist troubleshooters' have access to automotive product technology and repair specifications through their respective manufacturing networks underlying competence and competency. With consideration, competency is described as an underlying characteristic of performance based on automotive dealerships and supporting employers in the creation of highly skills functions [7], [8] . Both meanings of competence and competency are similar in that 'multiple attributes' and 'performance' are frequently used inconsistently. As summarize, competency defined a person's ability to perform those tasks within the context of professional practice [8].

The practice of competency-based educational assessment is viewed as a teaching and learning process that emphasizes learning outcomes, in which an individual must know and be able to complete certain tasks. There are the cognitive, psychomotor, affective, and attribute aspects to enhance an individual's performance [9]. This study towards competency-based educational assessment proposed the development of new ways of evaluating learning outcomes in automotive technology education.

Jonassen and Hung [4] defined that "troubleshooting is a common form of problem solving. Automotive service technicians diagnose faulty systems and take direct, corrective action to eliminate any faults in order to return the systems to their normal states".

Constructive strategies were required to identify the measurable criteria; with key performance indicators throughout the process of 'hypothesis generation and testing' cycles, classified specific skill acquisition for a profession could be evaluated into five levels: system, sub-system, device, component, and evaluate. Therefore, the TTS-ATE competency-based framework with explicit measurement criteria is important in facilitating the measurement tools through the generic 5-procedures competency-based framework model.

With development, automotive technology has evolved often shift from using conventional control system to incorporate automatic control system of the vehicle mechanics [10]. This shift has been observed in many systems, including engine control

system, transmission system, suspension system, and electrical system, to name a few. Understanding the mechatronics by which students abandon old pedagogies in favor of newer, better pedagogies is one of the new challenges in the modern automotive technology study of cognitive development. A good example is the mechatronics system and can be noted by the complexity of operation, consisting of a large number of sensors, electronic control module, and actuators under computer control.

Sudsomboon [4] found that the advances in Automotive Mechatronics System (AMS) increase the need for highly skilled technicians capable of practice these control systems. One reason students may use incorrect or inefficient strategies to solve problems is that they unable to accurately represent the problems. In the present context, the Industrial Education and Technology education converges to establish the highly training instructors' achievement that support into the social demands.

Breakthroughs in the traditional approach of teaching of AMS, it generally curricula design upon teacher decision problems that are not supported in the real-world problems based on current technologies under the social demand condition. The traditional approach could also reflect students' competency and metacognitive skills; because also provides to afford teacher center, learning with text book, and lack of contextual information, which is critical to their competencies of the automotive subject knowledge [11] [12] [13]. This paper is adapted ignore in traditional approach that teachers must think aloud and apply innovative instructional approach to gain students' capacities and performance. In recent year,

Past research suggests one of the strengths in teaching of AMS is Problem-based Learning (PBL), PBL curricula utilize most significant innovation instructional method [14] [15] implemented in education. It is increasingly needed for today's learners to enhance students' application of knowledge, problem solving skills, higher-order thinking, and self-directed learning skills [16] [17] [18] [19]. Hung [18] stated that the pros of PBL is a need for advocates knowledge maintain to meet the employing more effective than traditional methods in alleviating students' problem of inert knowledge.

The growing is as well as encouraging students' problem solving and self-direct learning skills. However, the cons of traditional approach of teaching, a problem solving approach could not support the use of capacity different cognitive goals such as identifying the problem needs, sorting out the relevant information resources, explore solutions through looking at alternatives, and extracting the strategies to solve problem [20]. The establish achievement goals necessitates the provision of powerful learning environments that motivated teachers to improve of teaching of AMS employed by the 3C3R PBL design model (three C's components - content, context, and connection - the three R's components researching, reasoning, and reflecting) which support the cognitive processes of problem solving skills and self-directed learning [18] as shown in Fig 1.

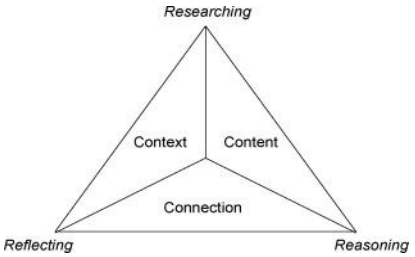

Fig. 1 The 3C3R PBL design model
Hung [18]

Inspired by these studies, the AMS course is an integrative engineering science that contributions of participating disciplines such as mechanical engineering, electronic engineering, simulation technology, control engineering, and informatics as shown in Fig 2.

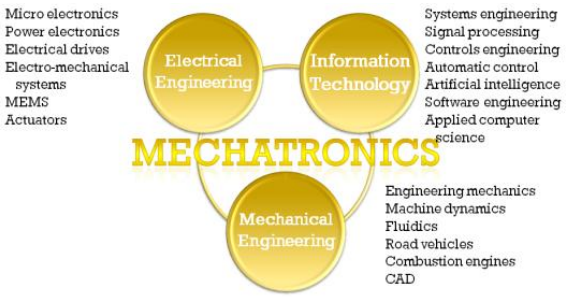

Fig. 2 The integration science in automotive mechatronics system
Guderjahn [21]

Its aim to study optimal system behavior for specified objectives, benefit from synergy effect, tool-based development control system, and reduced overall development time and costs [22] [23]. The main issues of 5591501 automotive technology professional practice subject of the Mechanical Technology Program, Faculty of Industrial Technology at Nakhon Si Thammarat Rajabhat, which focused on concept of the fundamentals of electronically fuel injection control system (EFI).

Students' learn the control system components have the following: 1) The control process; 2) The computes control system process; 3) Output of the actuators; and 4) determinate the optimal control system on EFI. The effects of achievement has been gained by innovative instructional method such as PBL, which emphasize that empowers learners to think critically; analyze and solve system integration, real-time problems; find, evaluate and use appropriate learning resources; work collaboratively; demonstrate effective performance skills; and promote lifelong learners [8], [9].

2. Background

2.1 Traditional Teaching VS. Problem-based Learning

Traditional pedagogies employed that demonstrating solutions to problems, very often result in students being capable of solving "textbook problems" in automotive technology education, but unable to apply the knowledge to solve real-time problems [24] [25]. PBL is one of the existing instructional methods that have been developed to solve the problem.

PBL is underpinned with the constructivist framework that views learning and teaching as the active and meaningful inquiry and building of knowledge by learners. Both inquiry - and knowledge-based approaches to problem solving underlying PBL. As an inquiry-based approach, its focus is on helping learners through authentic, complex problems or cases [4] [18].

Knowledge of PBL also presumably affects collaborative identify learning situation; therefore, facilitators knew what needs to be learned to resolve the problem [5] [19]. Establishment in the context of their domain, the group must engage in a problem-solving sequence of underlying information from a variety of sources, justifying their discussions, discussing findings, and weighting consequences in order to build even innovative solutions.

These performances are vital in viewing perspective teachers to design their knowledge bases and analyze the underlying current and issues in their workplace environment. The cases also simulate real-time situation in the workplace that affect to perform decision making, including considering multiple perspectives, warranting solutions, assessing consequences, and reflecting on decisions [26]. The innovative instructional method was represented by the 3C3R PBL problem design model.

2.2 The 3C3R model

The core categories of the 3C3R model are concerned with structuring content knowledge, contextualizing domain knowledge, and building a conceptual framework [18] as shown in Figure 1. The first core category is content. The content component aims to reconcile the issue by addressing the essence of a sound content design of a PBL problem. The second core category is context.

Also, AMS is current situating learning in a practical context. More importantly, context often influences problem solvers' reasoning processing and solutions because of their professional primary concerns [27]. In case, contextual validity, the degree of contextualization [28], and motivation are three important aspects in considering context category of PBL learning environment.

The third core category is connection. PBL is a collection of cases or problems, the students can effect to retrieve the relevant knowledge to solve problems encounter. Even though, the students are not able to learning the subject conceptually if the problem cases are all independent of each other in their knowledge bases.

2.3 Transformation categories of the 3C3R model in PBL model

Researchers chose to provide instruction about three transformation categories of 3C3R model are researching, reasoning, and reflecting. The process conducts (1) direct the students toward the intended learning goal(s); (2) adjust the level of cognitive processing required in accordance with the cognitive readiness of the learners; and (3) alleviate the initial discomfort students must experience with PBL. The 3C3R guides learners toward the problem solving process.

The first category is researching necessary information with the knowledge domain. This component guided learners toward the intended content and then prevents them from the indented objective to solve ill-structured problems.

The second category is reasoning that illustrates the application of knowledge acquired from the research process and the development of the learners' problem solving skills.

The third category is reflecting. It guides the learner to assess the effectiveness and efficiency of their own learning as a whole.

Students must gain practice with combination the knowledge domain and the competency, which is the opportunity to systematically and conceptually and highly competency and integrate their knowledge.

2.4 The Hybrid of PBL and CBL Approach Learning Environments

The Competency-based Learning (CBL) can be defined as the student learning outcomes, objectives, skills, and ultimately the focus of this volume, competencies. To connect implies, this research applies, and a *competency* is "a combination of skills, abilities, and knowledge needed to perform a specific task" [29].

The term *CBL* is also used in this research as an associate framework for PBL. To aid the idea, Fig 3 depicts the hierarchical relationships.

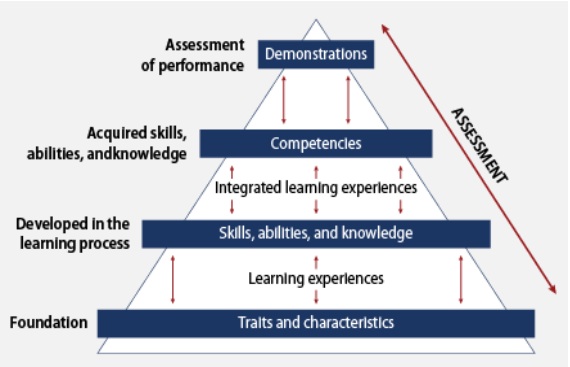

Fig. 3 Competency-based Learning Model
U.S. Department of Education [30]

The first rung of this pyramid consists of *traits and characteristics*. These constitute the foundation for learning and depict the innate makeup of learners on which further experience. It is content context, and connection relatively in 3C PBL. The second rung consists of *skills, abilities, and knowledge*. These are articulated 3R PBL, broadly defined to includes: researching, reasoning, and reflecting.

Hence, the 3C3R, PBL and CBL approach can be linked to show hybrid synergy approach as shown in Fig 4.

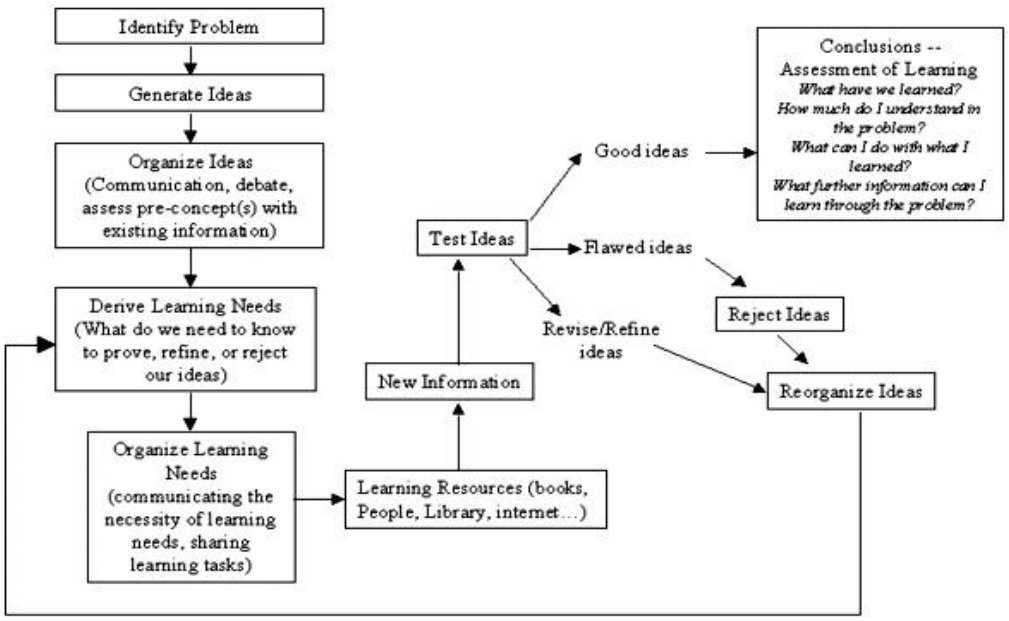

Fig. 4 The hybrid synergy based on the 3C3R, PBL, and CBL approach
Savin-Baden [31]

Furthermore, the hybrid PBL and CBL approach has affected to gain students' problem-solving skills is conceptualized as knowledge acquisition, and students' competency is defined as knowledge application respectively. In order to accomplish, the undergraduate mechanical technology students at Faculty of Industrial Technology, Nakhon Si Thammarat Rajabhat University must analyze information and generate idea and test hypotheses and determination and suggest solutions to the problems, they will have to integrate their knowledge and skills into practice. Moreover, when engaging in the cognitive abilities required in the reasoning process, the learning process of solver the somewhat raw knowledge into meaningful, applicable, and conceptually integrated knowledge could be generated the effective solution to solve their AMS problems.

For effectiveness, Researcher have modified the Watson-Glaser classification of Critical Thinking Skills (CTS) involves NISSAN Service Technical Education Program (N-STEP) in Electrical and Electronics defining a problem, determining possible solutions and strong assumptions, drawing valid conclusions regarding the solution and evaluation these conclusions [3] [9] [11] [12].

As a whole, the hybrid PBL and CBL approach is an integration hands-on skills involving analysis, synthesis, interpretation, evaluation and noticing assumptions. Additionally, AMS needed the effectiveness problem solver that articulated put it all together regarding PBL and CBL. This approach helps learners achieve optimal learning outcomes and become self-directed, gainful competencies.

3. Objectives

This study investigated how the hybrid problem-based learning (PBL) and competency-based learning (CBL) approach to enhance the training achievement in automotive mechatronics system for controls of gasoline engine.

4. Research Question

The research questions were to answer the following questions:

1) Is there a significance change in the students' pre- and post-test scores after participating in the hybrid PBL and CBL approach?

2) Is there a significance difference in the achievement scores for experimental and control group students after participating in the hybrid PBL and CBL approach?

5. Methodology

5.1 Design

Researcher as a course designer is provided gainfully. The AMS course aimed to enable the students to undertake introduction to automotive mechatronics system, and focused on mechatronics elements to real workplace ones by the end of course. The treatment to achieve this learning outcomes had the following objectives were specified: (1) provision of practical real-world problem, gasoline electronically fuel injection control system (EFI) and service manual information: (2) preparing students to perform for fixing information and analog & digital multimeter; (3) encouraging individual paces to develop performance skills and competency for expertise knowledge construction and finding [32].

For the development of the course model, the following preparations were made: Firstly, the hybrid PBL and CBL environment was prepared. Secondly, asynchronous service manual and worksheets were used. Thirdly, Teachers helped students to demonstrate and guide their knowledge, which case (s) (problems) obtained consultancy and guidance.

Next, 8 weekly synchronous sessions were held in 5591501 Automotive Technology Professional Practice. These idea enabled students to perform excellence with their knowledge and competency at real-time. Finally, real-world researches were examined. The experimental and control students' achievement scored were compared.

5.2 Participants

Participants were taught the "Inspection of Automotive Mechatronics Elements for controls of gasoline engine." course entirely in the semester 2/2015 with practical setting. Students were divided into two groups, experimental group and control group. The participants involved with 15 students in each group, 30 students in total with systematic sampling according to preliminary test scores on fundamentals of automotive electronics devices skills.

5.3 Task Analysis

5.3.1 Stage I:

The AMS course introduced the operating fundamentals of the EFI system. First of all, teacher taught and motivated students *'how the electronic fuel injection system works*'. The content will be guided students get to know the categories of the system. The EFI system can be divided into three

function systems: the fuel delivery system, the air induction system, and the electronic control system.

As whole, students must understand and retrieve knowledge to refer *'what does majority systematic approach components'*. This stage is seen the method of increasing concern on AMS learning environment. In spite of the important of constructing knowledge and skills via the hybrid PBL and CBL approach with problem-solving skills and competencies, the outcomes of students' within this capability and challenges. Also, students need to know sensors, computers, and actuators work. The three components is the heart of EFI system [33].

Then, mechatronics system provided they develop the knowledge domain and competency generated alternative solution to properly diagnose and repair systems.

5.3.2 Stage II:

Teachers clarified to improve the analogical mechatronics reasoning in the EFI system by teaching the principles of EFI system as AMS system [32].

5.3.2.1 Sensor Categories

Researcher designed the input classification (sensor categories) based on the hybrid PBL and CBL to demonstrate the major sensor or input classifications tasks include [24]:

1. Variable Resistor Type Sensor (VRS) changes its internal resistance with a change in a condition; its ohms value may change with temperature, pressure, etc.

2. Potentiometer Type Sensor (PTS) like a variable resistor, it also varies resistance, and the resulting voltage signal with a change in a condition; this type is commonly used to sense part movement with acceleration pedal, throttle position, etc.

3. Switching Type Sensor (SS) works it opens or closes the sensor circuit to provide an electrical signal for the computer; it can sense almost any condition, such as fuel pressure sensor, etc.

4. Voltage Generator Type Sensor can produce its own voltage output internally, such as camshaft position sensor, crank angle sensor, etc.

5. Magnetic Type Sensor uses part movement and induced current to produce a signal for the computer; this type is commonly used to sense speed or part rotation, such as distribution sensor, velocity sensor, etc.

5.3.2.2 Computer Action

There are three stages of computer operation:

1. Input means vehicle sensors convert a condition into an electrical signal for the computer.

2. Processing means computer uses sensor signals or inputs to determine what action should be taken to control vehicle operation.

3. Output means computer produces electrical output so actuators can perform physical actions to alter component operation for better efficiency as shown in Figure 5.

5.3.2.3 Actuator Categories

The ECM also works as a computer system. There are several types of actuators or outputs to control component or part operation. The major actuator or output classifications include:

1. Solenoid Type Output (SO) controls current through solenoid winding forms magnetic field that can move metal core and act upon other components, such as injector, suction control valve, etc.

2. Relay Type Output (RO) controls current flow from computer energizes relay to control larger current flow to another electrical component, such as intelligent power distribution module, etc.

3. Servo Motor Type Output (SMO) controls current that is sent to small DC motor that can produce an output by turning and moving parts, such as idle auxiliary control valve, exhaust gas recirculation valve, etc .

4. Display Type Output (DO) controls current that is sent to vacuum fluorescent or liquid crystal display to provide output data in car dash.

5. Control Module Output (CO) sends electrical signal to electronic control module (ECM); control module then amplifies or modifies signal to operate one of the previous output devices.

5.4 Procedure

5.4.1 Instruments

The both Thai version modified of the National Skills Standard (CBL) Test, which was adapted by Sudsomboon [3] was used along with a 40-item multiple choice, and NISSAN Automotive Test (PBL) developed by the researcher [11]. Both instruments were implemented before and after treatment. Such skills in the both experimental group and the control group was:

Deciding: whether conclusions are credible, learning comes and generates and verifies solutions based on a specific data.

Evaluation of arguments: Determining the strong and weak aspects of inferences. The learning outcomes of students gaining procedural knowledge performed more accurately and conducted more

correct checks than students who received instruction on the traditional teaching.

Inference: Defining a problem involves selecting the most appropriate information piece leading to the solution. The decision-making regarding the credibility of assumptions based on the information, knowledge states (ASM components), workplace safety and constructing a mental problem space provided within problem-solving skills is an inference process.

Recognition of assumptions: Recognizing structured and ill-structured assumptions, and deciding whether an assumption based on identify faulty symptoms diagnosis for system components represented in the problem space. Procedural knowledge is specific to the system and the tools used to solve problems. For instance, they attach engine sensors to computer for testing the engine's functions automatically.

Deduction: Drawing valid conclusions as a strategic knowledge plays an essential perform in making decisions about the relationships among the premises on the hypothesis generating and testing the systems.

5.4.2 The Evaluation of Research Instrumentation

The CBL test aimed to measure learning outcomes of each task analysis through at least one question. Items at the levels of knowledge, skills, attitudes, and application were developed and validated by an expert panel consisting of three instructors at the Department of Mechanical Technology Program at Nakhon Si Thammarat Rajabhat University.

After suggested revision were made, researcher resorted to test-retest to measure reliability. The reliability coefficiency was found sufficient for further administration ($r = 0.89$).

The hybrid PBL and CBL approach achievement test consisted of 100 items covering five constructs, 20 which addressing the construct of inference, 17 items addressing recognition of assumptions, 23 items addressing deduction, 20 items addressing interpretation and 20 items addressing the evaluation of arguments. The tool was also administered to undergraduate the first year students.

As a result, relationship among the construct were between .20 to .54 in the first year student setting. The reliability of the whole instrument was found as .82. Based on these indices, the test was found appropriate for the current study.

5.4.3 Treatment Procedures

In the experimental group, students performed on and were taught with guidance learning material about their PBL and CBL workplace assignments. The asynchronous worksheet of the hybrid PBL and CBL was also used by these students for individual paces. In the control group, students were taught using the traditional method for the course and through synchronous meetings.

Class activities were implemented beginning with the eighth week. Students were informed about the course outlines, objectives, instructional strategies (PBL & CBL), activities, and assessment and evaluation method. The experimental group was exposed to the hybrid PBL and CBL activities involving ill-structures on AMS problem scenarios which were developed through the following steps [4], [5], [18]:

1) Motivation into the introduction of the problem situation:

Ill-structured problems were introduced. The knowledge states was employing as follow as:

1.1 Purpose of the system
1.2 System modeling
1.3 Generalized functions of the system
1.4 Physical functions of the system

2) Identifying potential problems:

Students were referred to the general theories and principles upon which the system or device was implemented.

3) Defining and representing the problem:

Prior knowledge determined about the problem (case). Students explored their prior knowledge on the problem. Students had drawn the systematic flowchart for analyzing the systems.

4) Exploring possible strategies:

Students used information to solve the problem such as electronic service manual, internet, etc. They determined and discussed the term and extend of the location of all of components; the fuel delivery system, air induction system, electronic control system, and electricity through those components; and the functions of those states and reasons for changes in them. The analog and digital multimeter can be solved the root of cause.

5) Acting on those strategies:

They determined an individual study plan addressing the problem situation base on the real-time. The effects of system reflected on their students' plan. CBL guided the step-by-step and information-gathering activities employed the performance skills and abilities to solve the problem.

6) Solution Process:

Establishing their performance skill is confirmed the system completely. The important issue were discussing with members and the instructor. They showed that their own capacities and strategies leading to potential solution for the problem.

7) Looking Back and Evaluating:

The authentic learning experiences conducted and think reflectively. CBL assessment has examined the procedural knowledge. Students is measured and evaluated by the instructor and expert form NISSAN. As whole as, the hybrid PBL and CBL were guided students' generate idea and the performance report. For instance, they brought performance skills measured and recommended generated the new idea to solve following a Fault Isolation Manual that demonstrated guided continuity checks on knowledge representation.

On the other hand, the control group was provided with the traditional teaching each week. By the way, the lecture-based and textbook-based perform is employed.

5.5 Data Collection

The experimental group was exposed to four problem situations in 8 weeks:

1. Pressure drop from the fuel pump outlet.
2. Injectors failed; because of the injection pulse signal is not sent from the ECM.
3. Idle auxiliary valve is not worked.
4. Power balance mode is failed from the 3rd cylinder.

The hybrid PBL and CBL was offered in a 40% theoretical and 60% practical fashion. Particularly the theoretical part was implemented through PBL lecture which enhanced students implement higher order thinking skills, develop creative solutions for problems and realize in-depth thinking regarding the evaluation and use of information and procedural knowledge [34], [35], [36].

5.5.1 Pre- and Post-tests

The same test was applied as a pre- and post-test prior to and after the hybrid PBL and CBL intervention to both experimental and control groups. The CBL test included 50 multiple choice questions, whereas practical scores of four problem situations was scored as 10.0 points per problems, and encouraging in the attitudes was scored as 10 pointed [29] for continuously participations. Each correctly answered question in theoretical was scored as 1.0 points with a maximum score of 50.

5.5.2 Achievement tests

The hybrid PBL and CBL approach achievement test consisted of 100 items covering five constructs.

5.6 Data Analysis

Descriptive statistics were used in this study. A paired-samples *t*-test was employed to see the effects of the hybrid PBL and CBL model. At the inception of interpreting significance of the results, the probability value was set as $\alpha = .05$.

6. Results

6.1 Is there a significance change in the students' pre- and post-test scores after participating in the hybrid PBL and CBL approach?

Table 1 showed that the mean pre- and post-test scores for experimental group. The mean before and after the hybrid PBL and CBL model was *Mean* = 52.80 and *Mean* = 72.43, respectively. Results found that the mean of post-test score was higher than the mean of pre-test score. There was a statically significant difference between pre- and post-test scores of the students' in the experimental group after learning in the hybrid PBL and CBL model.

Table 1 Results of paired-samples *t*-test on pre- and post-test of the experimental group

Group	N	Mean	SD	t	*df*	Sig (2 tailed)
Pre-test	15	52.80	8.15	9.75	29	.000*
Post-test	15	72.43	5.62			

*Note. *p < .05 **p < .001 (Paired sample t-test)*

The control group students' pre- and post-test scores from the same tests were conducted. The results showed that not a statically significant difference between pre- and post-test scores of the students as shown in Table 2.

Table 2 Results of paired-samples *t*-test on pre- and post-test of the control group

Group	N	Mean	SD	t	*df*	Sig (2 tailed)
Pre-test	15	53.94	7.10	11.46	29	.079
Post-test	15	64.83	6.97			

*Note. *p < .05 (Paired sample t-test)*

6.2 Is there a significance difference in the achievement scores for experimental and control group students after participating in the hybrid PBL and CBL approach?

Table 3 The effects of PBL and CBL approach on the achievement scores

Group	N	Mean	SD	t	*df*	Sig (2 tailed)
Experimental	15	81.13	3.87	1.69	14	.005*
Control	15	72.55	5.30	-3.21	14	.244

**p < .05 (Independent sample t-test)* ***p < .01 (Independent sample t-test)*

The achievement scores were investigated the difference between the control group and experimental group The effect of the hybrid PBL achievement scores for the experimental group in the hybrid PBL and CBL model as shown in Table 3.

The experimental group was higher yield scores than the control group on NISSAN Automotive Test (PBL) in three aspects as follow as: inference, recognitions of assumptions, and deduction, respectively.

9. Discussion and Conclusions

This study investigated the effect of the hybrid PBL and CBL approach on the achievement in AMS course. The results revealed that the hybrid PBL and CBL group and the traditional group did differ in terms of knowledge, problem solving skills, higher-order thinking, and competency. The result did indicate the statistically significance difference in knowledge domain and competency to study in the AMS course of the experimental group, which have potentially affected the achievement scores.

Finding were given this exploration in the use of PBL and CBL, the reality in teaching of automotive mechatronics system that there were many knowledge domain applications of its that could be described as hybrid instructional strategies. In this study, the majority of problems was drawn from real-world or simulated teaching scenarios that the students and instructors could relate to in their teaching practice.

However, students lack of skilled that although this is well decision-making analyzed the context of systems slowly. Hung [18] warned that students must construct compartmentalize knowledge and lose sight of the overview. The hybrid PBL and CBL model critics of application argued that the connections of context and concepts emerges rapidly interval time in a full PBL curriculum [4], [5], [10].

The main strategy was the attention to the PBL and CBL model scores was then checked by an independent sample *t*-test. The independent sample *t*-test was significant for the manner in which the problems were designed in the workplace environment excellently. Researcher brought 3C3R problem-design model which modified the Watson-Glaser classification of Critical Thinking Skills (CTS) and competency [16], [18], [22], [24] were implemented in order to help students with the improvement of the instructional design, using triple an interweaving, experts involved, and an integration approach to the problem design [22], [26], [27].

These were large successful initially with achieving connections and it showed that students needed to gain more attention in encourage to the real-world problem. The finding is predominately a cognitive task that confirmed the search for likely causes of faults through a potentially enormous problem space of possible causes [21]. In addition to gain the hybrid PBL and CBL approach usually involved the learning innovations to serve the students performance skills [36].

In conclusion, both the timing and also the design of this real-world problem achieved greater success. It was designed to be less directive, more real-life and more demand-driven. The students were very positive about this generated problem and strongly supported its skill in helping them to perform the EFI system. It appears that there was quilted a challenge in the design of this instructional strategy, which might required more attention than was realized in the future research.

Even though, both the hybrid PBL and CBL and the traditional group were a little different about the results. In fact, the importance of both the design/timing of the knowledge domain and the competency has had the relationship of other instructional strategies in developing continuously.

This study showed an initial and small step in exploring how this may achieved, but the findings are preliminary, and further research is improved to enhance better insight in the automotive mechatronics system area.

10. Implications

10.1 The theoretical implications

In theoretical implications, this study implements that the effects of the hybrid PBL and CBL approach are crucial model to build a competitive advantage learning environment. According to past studies, there is a competency framework in new findings. The first, traditional methods is not support only one interpersonal skill, but also change as follow as real-world situation and AMS conditions. In addition, it also has a motivation for cognitive domain, gather information, analyze information and generate idea and test hypotheses and determination and suggest solutions to the problems, they will have to integrate their knowledge and skills into practice [16] [17]. The second, problem-solving skills have determining strategy deliberately promoted students performance when engaging in the cognitive abilities required in the reasoning process [20] [26] [27]. Finally, because the hybrid PBL and CBL approach increases knowledge acquisition, sharing, and applications of knowledge, and it continuously improves the group member's intelligence and performance [30]. These findings come from whether on an individual achievement, group level achievement, and or institutional achievement. Toward encouraging teachers' the hybrid PBL and CBL approach, this study proposes a new viewpoint.

10.2 The applicable implications

In applicable implications, students and institutions should provide the hybrid PBL and CBL approach that able to implement teaching of AMS and professional areas are the highest competences. These findings may be applicable to the technical colleges and enterprises with similar fields. Finally, institutions must support environment for fostering high-quality professional vocational and technical education teachers. The support environment should include the hybrid PBL and CBL approach of automotive technology subjects such as engine system, transmission system, suspension system, electrical system, air conditioning etc, toward enhancing students' professional development.

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