การใช้ผังมโนทัศน์เป็นยุทธวิธีการฝึกอบรมเพื่อเสริมสร้างทักษะการแก้ปัญหาระบบแมคคาทรอนิกส์ยานยนต์

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บทคัดย่อ

การวิจัยครั้งนี้นำเสนอผลของยุทธวิธีการฝึกอบรมด้วยการใช้ผังมโนทัศน์เพื่อเสริมสร้างทักษะการแก้ปัญหาระบบแมคคาทรอนิกส์ยานยนต์ และการประเมินผลทักษะการแก้ปัญหาโดยใช้ผังมโนทัศน์แบบกลุ่มกับผู้เข้ารับการฝึกอบรม การเก็บข้อมูลกระทำโดยการกำหนดปัญหาจำนวน 5 กรณี จากการสำรวจข้อมูลความต้องการการแก้ปัญหาระบบแมคคาทรอนิกส์ยานยนต์จากศูนย์บริการรถยนต์มิตซูบิชิ กลุ่มตัวอย่างที่ใช้ในการวิจัยประกอบด้วย ช่างซ่อมรถยนต์ นักศึกษาระดับประกาศนียบัตรชั้นสูง และนักศึกษาระดับปริญญาตรี สาขาช่างยนต์และเทคโนโลยียานยนต์ของสถาบันการศึกษาในจังหวัดนครศรีธรรมราช จำนวน 78 คน โดยทำการฝึกอบรมร่วมกันเพื่อพิจารณาผลลัพธ์ทางทักษะการแก้ปัญหาเป็นสำคัญ การเก็บข้อมูลใช้วิธีการเขียนผังมโนทัศน์สำหรับการแก้ปัญหาระบบแมคคาทรอนิกส์แบบกลุ่ม และวิเคราะห์ปัญหาตามเกณฑ์ของ Gowin ผลการวิจัยพบว่า คะแนนเฉลี่ยจากการทำแบบทดสอบก่อนเรียนและหลังเรียนของกลุ่มทดลองมีความแตกต่างอย่างมีนัยสำคัญทางสถิติ และเมื่อวิเคราะห์คะแนนวิธีการเขียนผังมโนทัศน์สำหรับการแก้ปัญหาระบบแมคคาทรอนิกส์แบบกลุ่มพบว่ามีค่าคะแนนเฉลี่ยของกลุ่มทดลองมีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ จำนวน 2 กรณี ได้แก่ กรณีที่ 1 วาล์วดูดน้ำมันเชื้อเพลิงดีเซลไม่ทำงาน และ กรณีที่ 5 ครัชแม่เหล็กไฟฟ้าของระบบปรับอากาศรถยนต์ไม่ตัดต่อ ผู้เข้ารับการฝึกอบรมมีทักษะการแก้ปัญหาที่เพิ่มขึ้น โดยประเมินจากผังมโนทัศน์และทักษะการปฏิบัติงานที่นำเสนอเชิงข้อค้นพบ ตลอดจนข้อเสนอแนะที่เกี่ยวข้องกับการเพิ่มประสิทธิภาพการแก้ปัญหาระบบแมคคาทรอนิกส์ยานยนต์ของรถยนต์มิตซูบิชิ

คำสำคัญ: ผังมโนทัศน์ ยุทธวิธีการฝึกอบรม ทักษะการแก้ปัญหา ระบบแมคคาทรอนิกส์ยานยนต์

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Using Concept Mapping as a Training Strategy for Enhancing Problem-Solving Skills on Automotive Mechatronics Systems

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Abstract

This study presents the use of concept mapping to enhance problem-solving skills for implementing Automotive Mechatronics Systems (AMSs) as a training strategy for training and subsequently evaluating the group concept maps (GCMs) among automotive service technicians. Data collected a five case concept map allows Mitsubishi Automotive Mechatronics Systems that creates how design the GCMs. The participants were (*N* = 78) authorized and local automotive service technicians, diploma students and undergraduate automotive technology students. Data analysis examined for training strategies, and subsequently for developing a knowledge representation tool by Gowin criterion. The results showed that there was significant difference in the experiment group; the researchers employed the independent sample *t*-test to analyze the results of the pretest and posttest within the 5 cases. There was significant difference in case 1 SCV SCV valve of supply pump does not operate and case 2 Magnetic clutch of compressor is not connection between the experimental group and the control group. On the GCMs, there were significant differences between the two groups. Stakeholders tended to apply the GCMs training strategies. They were gained generate ideas in this study. The problem-solving skills are illustrates its practical use through GCMs strategic problem-solving skills in Mitsubishi AMSs example. Moreover, benefits of this study are also discussed, supporting the overall utility of this implementation technique to provide the standard problem-solving skills in AMSs.

Keywords: Concept Mapping, Training Strategy, Problem-Solving Skills, Automotive Mechatronics Systems

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1. Introduction

Automotive Mechatronics Systems (AMSs) are integrating of mechatronics element that control of automobile functionally represent its devices (e.g., electronically fuel injection control system, vehicle dynamic integrated management system, intelligent transmission control system, etc.). By promoting the use of concept mapping as a knowledge representation tool to facilitate automotive service technicians in the diversity of change, the problem-solving skills are developed competitive advantage through the group concept maps approach. Group Concept Maps (GCMs) are specifically described, interpreted and utilized through points, cases, links, and relationships [1], [2].

In order to distinguish the group concept maps (GCMs), this research reports the new ideas of problem-solving approach for solving ill-structured problems. The idea represents individual thinking as focus as "group concept mapping" on AMSs. Since the GCMs are challenging the procedural knowledge to enhance stakeholders problem-solving skills (e.g., automotive service technicians, students, instructors, and training instructors), whose describe and visually represent its ideas and their interrelationships on a problem posse or case with the real-world situations. Additionally, concept mapping is a problem-solving method to promote novice practitioner as a knowledge representation tool that facilitates qualitative group thinking processes in the diversity of change [3], [4].

Recently, AMSs are the integration of mechatronics element that control of automobile functionally represents its devices (e.g., electronically fuel injection control system, vehicle dynamic integrated management system, intelligent transmission control system, etc.). Stakeholders' diverse problem-solving approaches to describe, analyze, synthesize and interpret AMSs problems with reference to points, symptoms and their visual and sensitive causes on the previous experiences [5]. Thus, the GCMs attributes the accuracy describes and interprets concept maps with reference to points, clusters, and their relative problem-solving skills within the practical and theoretical value of describing. This study is focusing on how groups think about the problem-solving approach accepted, and has been implemented in the context of AMSs.

The GCMs has also been described as a problem-solving approach that can be used to represent systematic thinking on AMSs. Stakeholders' represent the knowledge, skills and perspectives on a given problem posse, and allow them to hypothesize about the concept maps articulated by clusters through relate to generate points, cases, links, and relationships. They concerned network structure are typically understood and represented problem-solving approach as the spatial arrangement of concept mapping elements, within which patterns relate to experts' concept maps of interdependencies and interrelationships among entities are analyzed [6].

2. Objective

The objective of this study was to report the use of concept mapping to enhance problem-solving skills for implementing AMSs as a training strategy. For training, the subsequently was evaluating the group concept maps among automotive service technicians.

The research question was: Did the GCMs training strategy affect stakeholders' use of

solving automotive mechatronics systems problems?

3. Methodology

3.1 Phase I: Construction of expert-constructed concept map

3.1.1. Participants

This study involved 11 participants from four automotive stakeholders (Mitsubishi dealers, Nakhon Si Thammarat Technical College, Sichon Technical College, and Nakhon Si Thammarat Rajabhat University), which were chosen to exemplify in training needs analysis.

3.1.2. Interviewees

The stakeholders were identified and suggested 'how to enhance the problem-solving skills in automotive mechatronics technology and representatives of highly automotive service technicians' competency views. During the discussions, stakeholders were encouraged to adopt broad finding of stakeholders i.e. anyone in their organization who is likely to use or be affected by automotive competency-based training programs through a case-based reasoning approach.

3.1.3. The semi-structured interview and observation

A semi-structured interview was developed by researcher.

The interview questions were organized as follow as:

- Workplace and work environment;
- Automotive mechatronics technology problem-solving skills training program.

A total of 10 participants were involved in the interviews during 21 April to 30 May 2015, of which 2 participants (Service manager and foreman) were from Mitsubishi Chookiat Nakhon Si Thammarat (MCNST), 3 participants (Service manager, foreman, technicians) were from J.Vinit Mitsubishi Nakhon Si Thammarat (JVNST), 3 participants (Vocational education administrators and instructors) were from Sichon (STC) and Nakhon Si Thammarat Technical college (NSTC), and 2 participants were from Mechanical Technology Program and Electronics and Telecommunication Technology Program, Faculty of Industrial Technology, Nakhon Si Thammarat Rajabhat University (NSTRU).

The semi-structured interviews lasted approximately one hour, with one stakeholder being interviewed together. Due to concerns over benefit of technology transfer project sensitively and the resource available for involved, analysis, responses from participants were mainly recorded through handwriting and taking photos.

Observation at the workplace and work environment lasted one hour. The observation complemented the results of the semi-structured interviews regarding the details of workplace and work environment.

3.1.4. Data analysis

The interview and observation results were analyzed by protocol analysis. Stakeholder analysis has been recognized as important to ensure the effectiveness of automotive mechatronics technology problem-solving skills training program [7]. In this study, the stakeholder analysis described to identify and examine highly automotive service technicians' competency that are likely to be somewhat affected by implementation and integration of a technology transfer project as follow as:

- *Hierarchical Task Analysis* (HTA) is a form of task analysis to study performance and cognitive domains that are required by

stakeholders in order to complete the automotive mechatronics technology problem-solving skills training program.

- *Thematic Analysis* (TA) provides a descriptive presentation of qualitative data by identifying common topics and categories with protocol analysis of the qualitative data under suitable themes [8], [9].

3.2 Phase II: Construction of expert-constructed concept map

3.2.1. Participants

One hundred seventy-five participants can be classified in four group were: 18 automotive service technicians from authorized dealers of Mitsubishi Motors and local and community setting; 31 vocational teachers and trainers from Southern Vocational and Technical Education Institute 1 and Department of Skill Development Region 11, Nakhon Si Thammarat ; 67 undergraduate mechanical technology students from Faculty of Industrial Technology at Nakhon Si Thammarat Rajabhat University; 20 undergraduate automotive technology students and 21 diploma students in automotive mechanics from Nakhon Si Thammarat Technical College.

The total participants were 157, and hosted at Automotive Division, Nakhon Si Thammarat Technical College during 5-7 August, 2015.

Participants were selected by preliminary tests on AMSs. Afterward they were passed 85 stakeholders underlying the criterion yield at 70 %. Afterward researchers was tested pretest 38 stakeholders passed yield at 70% as an experimental group, and 40 stakeholders were observation as a control group and 7 stakeholders was missing data. The 72 stakeholders were observer. This study was one group pretest-posttest design.

3.2.2. Instruments

Five cases included in the highly automotive service technicians' competency level of AMSs was selected as the training materials in this study. The problem posses were:

Case 1) SCV valve of supply pump does not operate;

Case 2) Crankshaft position sensors leaked ground;

Case 3) ABS almost often locked (spoon valve did not release);

Case 4) ETACS is damaged; and

Case 5) Magnetic clutch of compressor is not connection.

The sample of ''expert-constructed concept map" see Fig. 1. The cases were chosen as the AMSs problems needs from Mitsubishi customers not only in consideration of the articles are novel and lively, but also they are validated to different AMSs competency levels [10].

Moreover, the training material included pre-test and post-test, trainer materials, operation sheets, operation manual, demonstration set, multimedia training material, and electronic training software. On the preliminary test item was a 20 multiple choices on AMSs theoretical, and the pretest and posttest was 20 short answer questions on AMSs practical. The tests time in preliminary test, pretest and posttest was 30 min.

The reliability of the test items and the difficulty of the test items level was performed by standardization of Mitsubishi Motors tests.

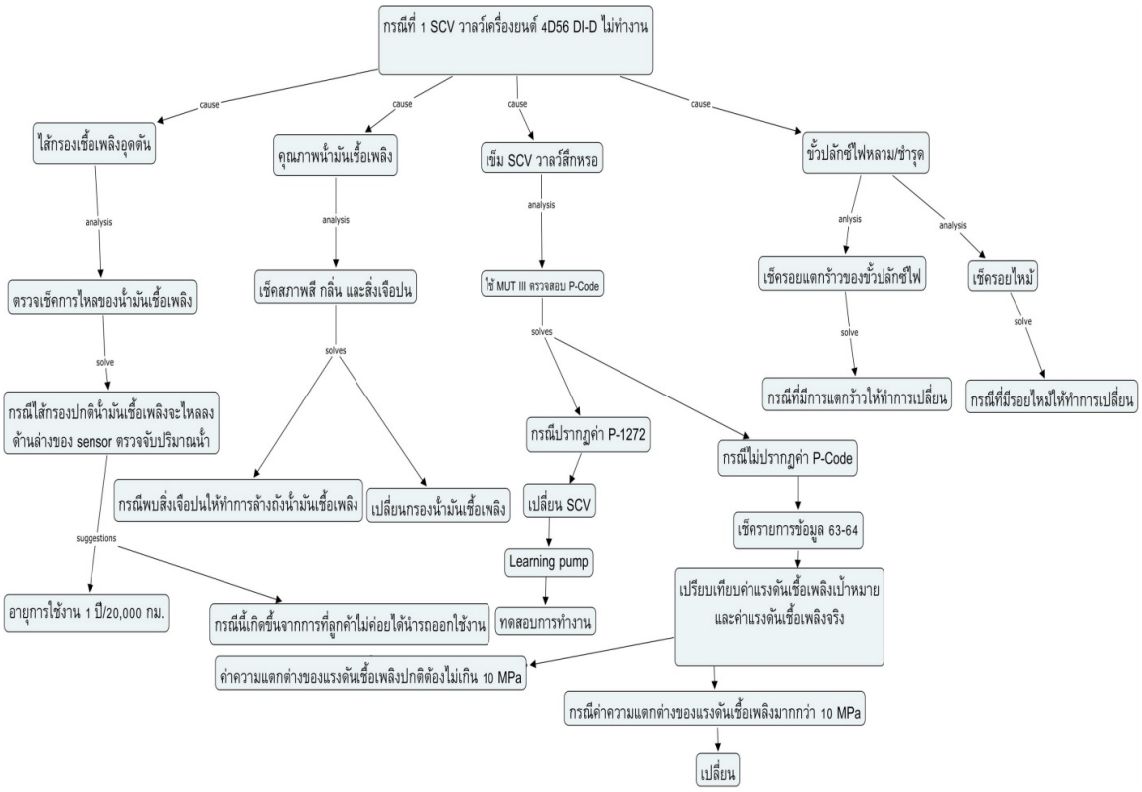

Figure 1 The sample of ‘‘expert-constructed concept map”

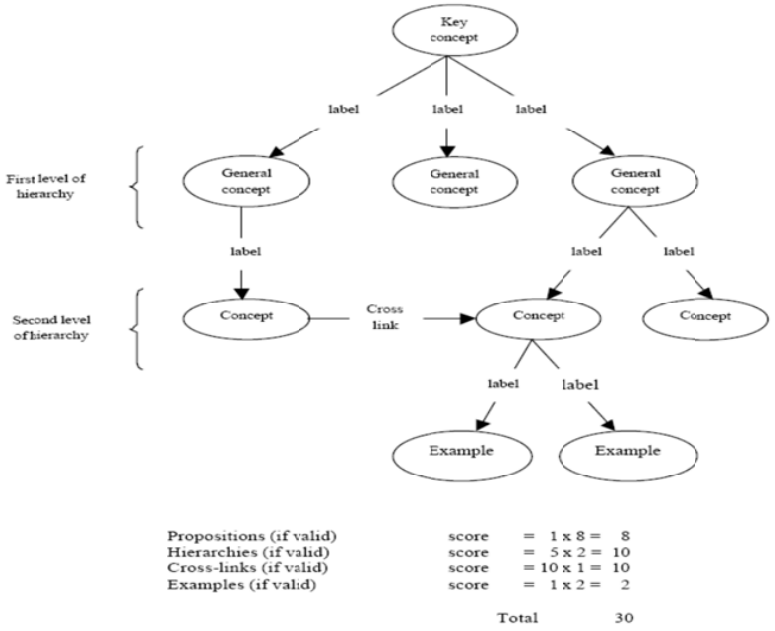

Figure 2 Assessment of the GCMs by the structural scoring method [2]

3.2.3 The GCMs instruction

There were five key points made in the training strategy: 1) select one topic for the AMSs problem; 2) find the main idea and the supporting ideas as hierarchical structure; 3) exclude irrelevant ideas as concept-links; (4) map out the hierarchical relationship among the ideas as cross-links, and (5) connect the ideas with lines and markings as examples.

The researcher demonstrated for the tests was mainly the ''Concept map linked with related nodes" that Novak and Gowin [2] proposed (see Fig. 3). It trained participants to focus on one central concept, integrate that concept with the related concepts and details, and extend outward from the center to form their concept maps [11].

3.2.4 Procedures

The experiment conducted for three days, and every case period was two hours.

Before the experimental process was carried out, the stakeholders were given a preliminary test and completed a pretest of stakeholders. A total of 157 highly automotive service technicians' competency, participated collectively in the pretest the first day so that information about the training materials on AMSs training strategy application could be collected.

The researchers chose stakeholders from the experimental group (*N* = 38) and the control group (*N* = 40). For the experimental group, the researchers employed paper-pencil concept mapping training strategy. The researchers introduced the idea of the concept map and the function to create underlying as similar as ''expert-constructed concept map" in the experimental group.

While the control group have wrote reviews and conventional training in each case of AMSs. For the five concept mapping assignments that the stakeholders handed in, the researcher, adopting the scoring system of Novak and Gowin [2], classified scoring according to the topics assigning (one point for a meaningful assigned topic), hierarchical level (five points for a valid hierarchy), cross link (the table has a space between) (ten points for every valid cross link), and examples (one point for every example). The highest possible score for every assignment was 100 [11], [12].

The researchers conducted the troubleshooting learning environment and the demonstration problem-solving skills who were experts' technicians of J.Vinit Mitsubishi to explain the problem-solving approach. In addition, when the experimental did the GCMs practices, the other procedures, time limits, and the content of the ''AMSs test" as well as the ''operation sheets" was conducted [13].

4. Results

4.1 Did the GCMs training strategy affect stakeholders' use of solving automotive mechatronics systems problems?

Table 1 The overall independent *t*-test of pre-test and post-test of the experimental and control groups

Test	Group	*N*	*Mean*	*SD*	*t*	*p*
Pre	Experimental	38	12.94	2.28	-3.86	.41
	Control	40	11.06	4.12		
Post	Experimental	38	18.86	1.66	-1.97	.01*
	Control	40	16.17	3.48		

* $p < .05$.

Table 2 The independent *t*-test of GCMs on AMSs of the experimental and control groups in 5 cases

Case	Group	*N*	*Mean*	*SD*	*t*	*p*
1	Experimental	38	92.94	1.65	-1.37	.02*
	Control	40	76.28	3.56		
2	Experimental	38	88.51	2.49	-2.21	.35
	Control	40	75.02	3.82		
3	Experimental	38	80.58	4.68	-3.47	.59
	Control	40	72.37	6.43		
4	Experimental	38	74.33	5.08	-5.56	.86
	Control	40	70.19	7.13		
5	Experimental	38	96.55	0.65	-2.05	.00*
	Control	40	90.48	1.67		

* p <.05.

There was no significant difference before the experiment; the researchers used the independent sample *t*-test to analyze the results of the pretest. There was no significant difference between these two groups (t = -3.86, p = .41, see Table 1). On the GCMs, there were significant differences between the two groups (t = -1.97, p = .01); the experimental group (*M*ean = 18.86) scored higher than the control group (*Mean* = 16.17).

Table 2 represents the independent *t*-test of the GCMs on AMSs of the experimental and control groups in 5 cases. The results show that the scores of case 1 ‘‘SCV valve of supply pump does not operate” and case 5 “Magnetic clutch of compressor is not connection” increased significantly in the experimental group. Stakeholders tended to apply the GCMs training strategies once they were gained generate ideas in this study.

5. Discussion and Conclusion

The GCMs enhances problem-solving skills in illustrating to use, and generate ideas into an AMSs practical framework. To enables the stakeholders were to retrieve previous experience and information conveniently, the framework includes concept, connect terms, cross linking connections, hierarchy, and example.

In order to extract the generate ideas covered in this study, the stakeholders must do understanding the problem-solving approach so that they can demonstrate on the knowledge construction of information that makes the meaning and ideas of the experimental group was clear. For example, it promotes the stakeholders to discover the main idea and related supporting evidence [3], [4], [5], [14]. In addition, application of the case 1 “SCV valve of supply pump does not operate strategy” and case 5 “Magnetic clutch of compressor is not connection” can promote stakeholders to identify major and minor constructs, and to connect the related parts after finding them.

On the other hand, the CGMs presents a visual representation of the stakeholder’s cognitive structure, and therefore, can reveal the myth in the mental process. In the ‘‘learner-constructed concept mapping initiated concept mapping” that the researchers adopted in this research. The finding related ideas in different concept groups and build new cross links to connect different points of view, but also they have to give examples to interpret the map according to the learners’ experience [7], [8].

Such a strategy, which requires high AMSs competency, can not only stimulate the learners’ meta-cognition perception, but also promotes the stakeholders build up a proper monitoring strategy and their knowledge during the process of mapping [1], [2].

As a result, the researchers found that case 3 and case 4 did not significantly, stakeholders

must train to use and read the schematic diagram, wiring diagram and harness layout. The automotive electricity and electronics would be focused on its step by step prompted the inspection through electronic service manual and advanced diagnosis tools [14].

As the analyzed data showed, the concept mapping is a utilized AMSs problem-solving approach which has positive results. The researchers found that use of concept mapping gives stakeholders more cognitive reasoning in their problem-solving skills [15]. The suggestions of this study could use it in the context of vocational and technical education for greater understanding of articulates the competency to link theoretical and practical as a compatible tool. It is conducted that future research might discuss the process and development of students' concept mapping, and its correlation with learners' on AMSs and or other professional learning environment for technical and engineering education.

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