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Development of Experimental Set for Pneumatic Control Basics by Using Microcontroller

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Abstract
This paper presents the development of an experimental set for pneumatic control basics by using a microcontroller, and compares learners' performances on the pre- and post-tests. The experimental set was used to teach the course on fluid power technology in the field of Automotive Technology at Siam Technology College in 2017. The experimental set comprised a testing tool, instruction manuals, a quality evaluation form of the experimental set used by experts, an achievement test, and an evaluation sheet for index of item-objective congruence (IOC). The subjects were fifteen second-year students of the Automotive Technology Program in the second semester. The test results showed that the average score during the course was 86.80% and after course completion at 83.33%, which were greater than the criterion at 80/80. The t-test result showed that the learners attained better achievement which was statistically significant at the .01 level.

Keywords: *Pneumatic control, microcontroller, performance of experimental set*

1. Introduction

The economic growth of Thailand has caused high competition in both quantity and quality in industries. The expansions of various industries require the process technology to adjust production rates according to the market demand (Pratumsuwan, 1997). Microcontrollers are small semiconductor devices. Each consists of a central processing unit, memory, port, bus and clock signal. Nowadays, microcontrollers are widely used to control the operation of electrical appliances and industrial control because they are low power devices; they are small and cheap (Smart Learning Team, 2012).

In this regard, workmen's skills development to keep up with the change of technology is very important; especially in upgrading technicians' knowledge and skills to work effectively. The course instructors in fluid power technology need to teach pneumatic control basics by using microcontroller to undergraduate students. This is a requirement in the Bachelor of Technology Program in Automotive Technology. They have found limitations in teaching media and students' achievements are rather low.

For this reason, the researchers were interested in teaching students with the use of the experimental set to help them learn faster. Such a teaching method was to create interest and enthusiasm in learning. With good motivation, students will be willing to acquire and apply knowledge for future work in the industrial sector.

2. Objectives

There were two objectives in the study:

2.1 To develop and find the performance of students with the use of the experimental set of pneumatic control basics by a microcontroller.

2.2 To compare learning achievements in the pre and post-test by t-test.

3. Literature Review

Phontioue (2005) reported on construction and efficiency of an experimental kit with microcontroller MCS-51 application. The researcher developed an experimental kit on microcontroller MCS-51 Applications and studied learning achievements of students. The instruments were (1) the experimental kit on Microcontroller MCS-51 Application (2) laboratory sheets (3) a questionnaire for the learning achievement test. The subjects were twenty students in their second year in the higher vocational education certificate program in the field of Electronics at Chayaphum Technical College. They were tested before and after the experiment. Their achievement scores were compared by t-test. The students' achievements showed good gain in their post-test significant at the 0.01 level. Efficiency of the kit was assessed by E1/E2 The result was that the efficiency of the experimental kit on Microcontroller MCS-51 Application was at 82.25/80.75, which was higher than the set criteria at 80/80 (Phontioue, 2005).

Pimargeam (2011) reported development and testing of the performance of microcontrollers. The researcher worked on efficiency in the new module by comparing the users' achievements before and after the study and assessing their satisfaction. The users were nineteen students in the High Diploma Program in Electronics Department at Uttaradit Technical College. The research instruments were a newly developed module, a pre-test, a post-test and a satisfaction questionnaire. The results showed the module of good quality (mean=4.49). The students were satisfied with the module at a high level.

Muangjarean (2016) reported on the development of an experimental set for a microcontroller with separated objects. The research instruments were an experiment set, a performance evaluation form for experts and a satisfaction evaluation form for students. The subjects were sixteen students in the course on Microprocessor and Interface in Science Education Program at Rajamankala University of technology Suvarnabhumi. The results showed efficiency of experiment set at 81.875/91.25--higher than the standard criterion of 80/80. Five experts evaluated the experimental set at a high level and the participating students were highly satisfied with the use of the experimental set. The results clearly support the use of the experimental set for learning Microprocessor and Interface in Science Education.

The researcher outlined in detail four analyses used in the study: (1) quality analysis of the experimental set, (2) analysis of consistency of the test form with behavioral objectives, (3) analysis of the learners' performance on the experimental set, and (4) analysis of achievement.

(1) Quality analysis of the experimental set. The quality was evaluated by five experts on a rating scale of 1-5 (Boonyaritipong, 2009):

4.50-5.00	very good
3.50-4.49	good
2.50-3.49	adequate
1.50-2.49	poor
1.00-1.49	very poor

(2) Analysis of consistency of the test form with behavioral objectives. The researcher obtained IOC from the scores of +1, 0, -1 (Boonyaritipong, 2009).

$$IOC = \frac{\sum R}{n}$$

IOC = Congruence index of opinion level score.
$\sum R$ = *Sum of all opinion score of* experts.
n = Number of experts.

The congruence index interpretation of experts' opinion level score.

$IOC \geq 0.50$ Opinion are consistent.
$IOC < 0.50$ Opinion are not consistent.

(3) Analysis of the learners' performance on the experimental set. The researcher calculated percentage of the average scores during and after the study to compare with those of the set criteria 80/80 (Boonyaritipong, 2009).

Efficiency = E_1 / E_2

$$E_1 = \frac{\sum X/N}{A} \times 100$$

$$E_2 = \frac{\sum F/N}{B} \times 100$$

Efficiency = Performance of experimental set
E_1 = Percentage of average score during learning
E_2 = Percentage of average score after learning
$\sum X$ = Total score of student from doing exercise during learning
$\sum F$ = Average score after learning
N = Number of student
A = Full score of exercise
B = Full score of exercise after learning

The interpretation of performance on the experimental set:

$E_1 / E_2 > 80/80$ The experimental set has higher performance than the set criteria.

$E_1 / E_2 < 80/80$ The experimental set has lower performance than the set criteria.

(4) Analysis of achievement. The score results from the learners' performance on the pre- and post-test mean scores were used to analyze differences in their learning achievement. The level of statistically significant difference was set at the .01 level.

$$t = \frac{\sum D}{\sqrt{\frac{n\sum D^2-(\sum D)^2}{n-1}}} \quad : df = n-1$$

D = score after learning – score before learning.
n = Number of student.

The interpretation of performance from experimental set:

$t < t_{0.01,14}$ the score results from the pre-test and the post-test show no significant difference at the 0.01 level.

$t > t_{0.01,14}$ the score results from the pre-test and the post-test show significant difference at the 0.01 level.

4. Research Methodology

The research was to find the performance or quality of an experimental set of PLC programming by using function block language. There are details as follow.

4.1 The Subjects

There were two groups of the subjects: (1) three experts with at least 5-year experience in teaching Automatic Control System, who were to evaluate the quality of the experimental set, and (2) fifteen second-year students majoring in Automotive Technology at Siam Technology College, who voluntarily participated in the study.

4.2 The Instruments

There were four instruments in the study: (1) an experimental set (2) instructional manuals (3) a quality evaluation form of the experimental set for the experts, and (4) an achievement test form with behavioral objectives.

4.3. Construction of the Instruments

The researchers studied the scope of contents in the course on Fluid Power Technology (PLC programming by using function block language). The following steps were used:

4.3.1 Study the scope and contents of course 220-202 Fluid Power Technology in the Bachelor of Technology Program in Automotive Technology at Siam Technology College.

4.3.2 Analyze teaching documents and textbooks on the PLC programming by using function block language.

4.3.3 Divide knowledge into 3 levels: recalled knowledge, applied knowledge and transferred knowledge.

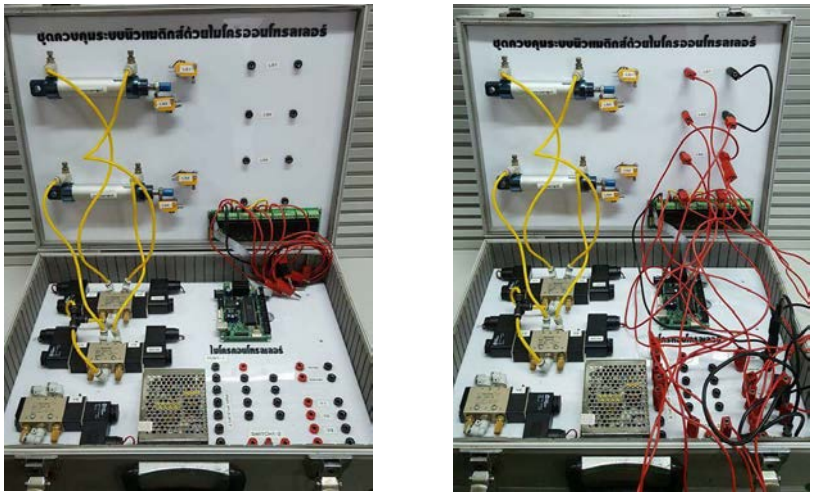
4.3.4 Define the behavioral objectives for students to achieve after teaching.

4.3.5 Define the learning activities to be consistent with the intended behaviors.

4.3.6 Design an experimental set to support the learning activities according to the behavioral objectives.

After those six steps, the researchers constructed the experimental set of PLC programming by using function block language.

Figure 1: Experimental Set of Pneumatic Control Basics by Using Microcontroller



In constructing the experimental set, the researchers created (1) manuals for instructor and learners, (2) a quality evaluation form, (3) a test form, and (4) a consistency evaluation form, as shown below:

(1) Manuals for instructor and learners

The Instructor's manual consisted of guidelines to the use of the experimental set and evaluation of practice, content sheet, laboratory sheet, laboratory answer sheet, exercise sheet, post-test sheet, post-test answer sheet and evaluation sheet of practice. The manual for learners contained content sheet, laboratory sheet, and exercise sheet.

(2) A quality evaluation form

The quality evaluation form of the experimental set was for three experts in automotive technology. There were five sections: content, laboratory sheet, experimental set, test sheet, and open-ended questions. The experts were to evaluate items on a rating scale of 1-5 in sections 1-4 under Part 1, and answer open-ended questions or give suggestions as relevant under Part 2.

(3) A test form

The test form was to measure learning achievements in the pre- and post-tests. The tests were in a multiple-choice format of four options.

(4) A consistency evaluation form

The consistency evaluation form for the test form with behavioral objectives was for Item Objective Congruence (IOC). The evaluation form carried 3 options for each item.

5. Data Collection

The researchers collected data in the following steps:

5.1 Contact and send letters to experts to evaluate the experimental set and the tests.

5.2 Invite the experts to observe the demonstration of the experimental set with the use of the laboratory sheet. The experts were to evaluate the experimental set and the use of the laboratory sheet, and give advice.

5.3 Submit the consistency evaluation form to experts to obtain IOC scores and make adjustments as suggested.

5.4 Use the experimental set with the subjects in the study. After being taught in each topic, the subjects were asked to do the exercises for a score percentage.

5.5 Give the post-test to the subjects to obtain a score percentage.

5.6 Use all score results to analyze the quality of the experimental set.

5.7 Evaluate learning achievements by using the subjects' mean scores on the pre- and post-tests to check statistically significant difference at the level of .01 level.

6. Data Analysis

The researchers analyzed the obtained data in four parts: (1) quality of the experimental set. (2) consistency of the test form with behavioral objectives, (3) the students' performance on the experimental set, and (4) learning achievements.

6.1 Quality of the experimental set by the evaluation results from the questionnaire on the rating scale of 1-5.

6.2 Consistency of the test form with behavioral objectives by results from consistency evaluation or IOC.

6.3 The students' performance on the experimental set by comparing their obtained percentage with the set percentage of 80/80.

6.4 Learning achievements by the pre- and post-test scores obtained by the subjects in the study. The statistically significant difference in obtained mean scores was set at the .01 level.

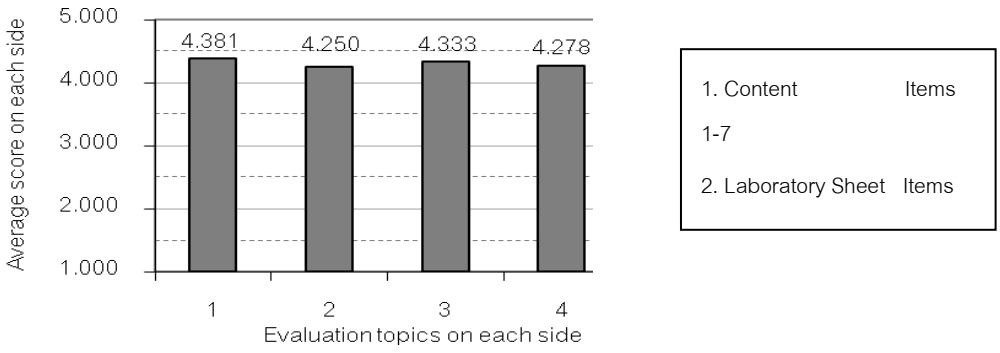
7. Results

The results of the study were in four parts:

7.1 The quality of the experimental set was evaluated by three experts in four aspects: content, laboratory sheet, experimental set and test as shown in Figure 2 below.

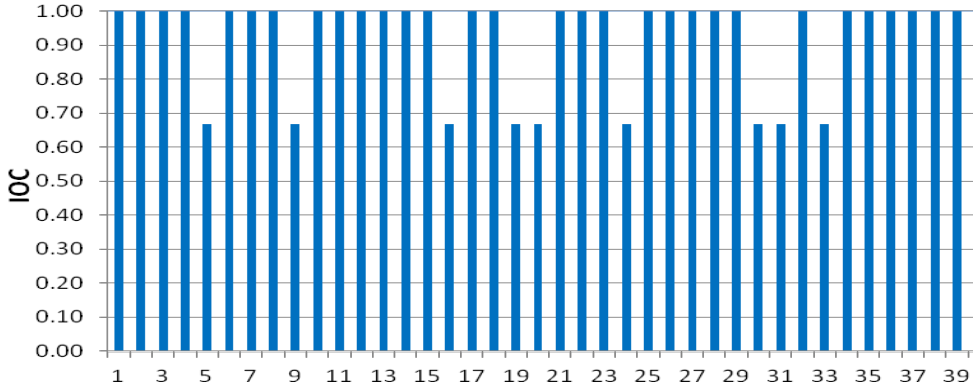
The mean of content was 4.38, laboratory sheet 4.25, experimental 4.33 and the test form 4.27, respectively.

Figure 2: Quality of the Experimental Set



7.2. The consistency of 40 items in the test form with the behavioral objective evaluated by three experts was between 0.67-1.00. The mean value of the test form was 0.92--higher than the set criterion at 0.50. These results are shown in Figure 3.

Figure 3: Consistency Analysis Results of Test form with Behavioral Objective



7.3 The subjects' performance on the experimental set was 86.80/83.33--higher than the set criteria at 80/80, as shown in Table 1.

Table 1: The Subjects' Performance on the Experimental Set

Description	N	ΣX	Full score	$\bar{x}$	Percentage
Exercise scores	15	651	45	43.40	86.80
Test scores	15	375	30	25.00	83.33

7.4. The subjects' learning achievements are shown in Table 2. The subjects performed better on their post-test. The difference in their performance on the pre- and post-tests by t-test was significant at the .01 level.

Table 2: The subjects' Learning Achievement

Description	N	$\bar{x}$	ΣD	ΣD^2	t
Pre-test	15	9.40	222	3362	24.537*
Post-test	15	24.20			

8. Conclusion

The researchers developed an experimental set of pneumatic control basics by using microcontroller to teach the course on Fluid Power Technology in the Bachelor of Technology Program in Automotive Technology at Siam Technology College. The experiment set was constructed for fifteen second year students. The findings pointed to a good quality of the experimental set as evaluated by the experts, consistency between the test form and the behavioral objectives (IOC), and the subjects' performance on the pre- and post-tests higher than the set criterion of 80/80. The researchers were pleased with the subjects' learning achievements from the pre- and post-tests with a statistically significant gain at the .01 level.

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