The Construction and Efficiency Evaluation of the Instructional Packages on Pneumatics Control System by using PLC

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Abstract - The objective of this research is to construct and Efficiency Evaluated of the instructional packages on pneumatics control by using PLC. The researcher has used the constructed instructional package to test with the purposive sampling group of 22 people who are the 4th year, student in mechanical engineering Faculty of Industrial Education at Rajamangala University of Technology Suvarnabhumi. The experimental process was done by using pre-test to test their basic knowledge, and then teaching them with instructional package. During the learning process, they had to do the exercises and practice of experiment. After finishing each job topic, they were tested theory and practical again. The exercises score, post-test, lap sheet score and practical test were calculated in order to measure the efficiency of the instructional package.

The results showed that the instructional package had the theoretical efficiency 84.39/80.15 and the practical efficiency of 85.23/82.73 which was higher than the expected criteria at 80/80.

Keywords — instructional package, pneumatics, PLC

I. INTRODUCTION

The National Education Development Plan (2017–2036) aims to build the expertise and excellence of educational institutions in the production and development of manpower to meet the needs of the labor market and national development including the dynamic challenges of the 21st century world [1]. According to the Thailand 4.0 policy, human development is an important factor that the government prioritizes. This is to strengthen Thai people's readiness to learn endlessly and to develop their creativity and potential to support new information technology and innovations. However, the major weakness of Thailand is the lack of sufficient skills and expertise [2].

Faculty of Industrial Education, Rajamangala University of Technology Suvarnabhumi aims to produce qualified graduates, professional teachers and technologists with the development of manpower in accordance with the needs of the country. Professional and technologically advanced education focuses on the practice and identity of students to become practical graduates to meet the demands of the labor market and national development [3]. Therefore, the Bachelor of Industrial Education program must develop the curriculum in accordance with the changing innovations and technologies to provide graduates with competitiveness in the labor market and the ability to meet the needs of entrepreneurs and the economic needs of the country. There is a focus on producing professional teachers because when they graduate, they will go to careers as teachers, professional advisors in schools or trainers in the workplace. A professor is a person who provides knowledge and guidance so the recipient can use it for their careers. Importantly, it is part of the country's development towards stability in terms of economy, society and culture. This course aims to have the ability to effectively transfer professional knowledge to learners and industrial personnel [4].

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However, Applied Hydraulics and Pneumatics is designated as one of the subjects in the Bachelor of Industrial Education, Mechanical Engineering Program. The course description includes the study of hydraulics and pneumatics and electrical components and equipment as control signals along with a study on how it works and functional analysis. The circuit design is connected to a computer or programmable logic controller, etc. From the study of teaching and learning management in such courses, it was found that most of the instructors used the theoretical teaching method and applied the theory they have learned to analyze, design the circuit and test the operation using FluidSim program. After that, an experiment was made to connect the designed circuit in the workshop to confirm that whether the student's thinking and design results can be applied in practice according to the specified conditions or not. The study also found that students were able to learn and workshop on the basics of pneumatics and hydraulics and electrical control. For the pneumatic control system with PLC found that the learners did not understand the working principle of the control system and also unable to program commands to control the interaction with the device according to the specified conditions but control commands can be programmed only in basic commands. The students were asked the reason for the lack of understanding of the matter, found that students who study in Industrial Education, Mechanical Engineering graduated with a vocational certificate (vocational certificate) in the field of automotive mechanics and high school. Therefore, students lacked the basic knowledge of electrical control and had never learned PLC commands before, they did not understand the application of commands for controlling the operation of equipment as well as lack of media used in teaching and learning. Consistent with Suchitra, C. [5] who encountered problems in teaching and learning management in industrial control systems in the sense that lack of basic knowledge of learners prevents them from understanding the working principles of control systems, thus making them unable to design and write industrial control programs. There was also a lack of teaching materials to create a situation for students to experience and see the nature of work clearly. However, PLC control was a technology used to control the operation of machines and equipment. Mechanical engineering students needed to learn and be able to program commands to control the operation of machines and equipment. This was very important and very useful to students. Therefore, it was important to find ways to solve learning problems of learners in order to be able to complete learning according to the curriculum. Instructional packages on pneumatic control system using PLC were developed for use in teaching in the course. Instructional Packages were teaching processes that rely on mixed media related to the content and experiences of each unit to help transform learners' learning behaviors effectively [6]. Consistent with Watcharin, R. [7] that instructional packages were an educational technology. Technical or engineering teaching, in particular, required a medium to facilitate effective communication between learners and instructors.

Based on these issues, the researcher was interested in constructing and evaluating the effectiveness of instructional packages on pneumatic control system using PLC. This was to ensure the effectiveness of instructional packages and could be used to develop knowledge and skills in the learners' pneumatic control system using PLC in terms of further application of professional knowledge and skills

II. RESEARCH OBJECTIVES

To construct and evaluate the effectiveness of instructional packages on pneumatic control system using PLC.

III. RESEARCH METHODS

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This research was an experimental study to construct and evaluate the effectiveness of instructional packages on pneumatic control system using PLC. There were steps as follows.

1. The sample group used in the research

The research sample consisted of 22 students in the Bachelor of Science Program in Mechanical Engineering, 4th year of Rajamangala University of Technology Suvarnabhumi. A purposive sampling method was used.

2. Research tools

The tools used in this research were instructional packages on pneumatic control system using PLC, which consists of teacher manuals, content sheets, exercises, lab sheets, teaching materials, theoretical tests and practical tests. There were details in the creation process as follows.

2.1 Study data and analyze the curriculum of applied hydraulics and pneumatics in the Bachelor of Industrial Education program in 2016 to provide learners with the knowledge and skills that are specified in the curriculum.

2.2 Analyze the work by studying from various sources such as documents, books, textbooks, experts and teachers' experience. The information obtained was analyzed in accordance with the course curriculum, along with the analysis of operating procedures, as well as the knowledge and skills required in each task. This was to define the scope of content that would be used to create a teaching set [8], [9], [10]. There were 8 topics as follows:

2.2.1 Programming tasks using LOAD/LOAD NOT commands
2.2.2 Programming tasks using AND/AND NOT commands
2.2.3 Programming tasks using OR/OR NOT statements
2.2.4 Programming tasks using the OUT command
2.2.5 Programming tasks using TIM (Timer) commands
2.2.6 Programming tasks using CNT (Counter) commands
2.2.7 Programming tasks using SET/RSET commands
2.2.8 Programming by applying automatic control commands

2.3 Assess the suitability in detail of the job list based on job analysis, work procedures, knowledge and skills required in each job. There were 5 experts who had experience teaching pneumatics and PLC control to get the scope of content used to construct instructional packages, then applied suggestions to improve to make it more complete.

2.4 Establish behavioral objectives to define the scope of content, media, measurement and evaluation, as well as to organize teaching and learning activities in accordance with behavioral objectives.

2.5 Create instructional packages which include teacher manuals, content sheets, practice, lab sheets, teaching materials, theory tests and practical tests.

2.6 Assessed instructional packages by 5 experts who had experience teaching in the course of Pneumatics and PLC Control. The details of the assessment were as follows:

2.6.1 Assess the suitability of instructional packages, including teacher manuals, content sheets, exercises, lab sheets, teaching materials and practice tests along with using the information and suggestions from experts to improve the instructional packages to be more suitable.

2.6.2 Evaluate the test based on the Index of Consistency between the behavioral objectives and the test (IOC), it was found that the conformity index was between 0.6–1.00, which is higher than the benchmark of 0.5.

2.7 Instructional packages were tested with an experimental group of 5 people to study deficiencies in teaching, content, media and language used as well as teaching and learning.
activities along with the information obtained to modify the instructional packages before further use.

2.8 Complete instructional packages on pneumatic control system using PLC.

3. Experiments and data collection to be used to assess the effectiveness of instructional packages

Data collection to be used to assess the effectiveness of instructional packages, the details were as follows.

3.1 Pre-test was used to test the basic knowledge of the learners.

3.2 They were taught using generated instructional packages starting from task 1 through task 8. At the end of each assignment, learners’ complete exercised to measure their progress during the course and then assigned learners to practice on the lab sheets of each assignment.

3.3 Post-test was used after the learner had completed all the tasks. Students were tested on their knowledge with a post-test. After that, the students were allowed to take the next practical test.

3.4 The scores obtained from practice exercises, theory tests, lab sheets and practical tests were analyzed to determine the effectiveness of the instructional packages.

IV. RESEARCH RESULTS

The results of the evaluation of the effectiveness of instructional packages were carried out as follows:

1. The results of the evaluation of the effectiveness of instructional packages in theory found that the average student's practice accuracy was 84.39% and the average quiz was 80.15% as shown in Table 1, which indicated that the theoretical instructional packages created by the researcher were effective at 80/80 criteria. Table 1 showed the theoretical evaluation results of instructional packages.

Table 1 shows the theoretical evaluation results of instructional packages.

<table>
<thead>
<tr>
<th>Score</th>
<th>N</th>
<th>ΣX</th>
<th>$\bar{X}$</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise</td>
<td>22</td>
<td>557</td>
<td>25.318</td>
<td>84.39</td>
</tr>
<tr>
<td>Quiz</td>
<td>22</td>
<td>529</td>
<td>24.045</td>
<td>80.15</td>
</tr>
</tbody>
</table>

2. The practical evaluation of instructional packages found that the students who took the practice alone had a mean score of 85.23% and the students who took the practice exams with practice packages had a mean score of 82.73% as shown in Table 2, which indicated that the practical instructional packages created by the researcher were effective in the 80/80 threshold.

Table 2 shows the practical evaluation results of instructional packages.

<table>
<thead>
<tr>
<th>Score</th>
<th>N</th>
<th>ΣX</th>
<th>$\bar{X}$</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop</td>
<td>22</td>
<td>1500</td>
<td>68.18</td>
<td>85.23</td>
</tr>
<tr>
<td>Practical test</td>
<td>22</td>
<td>364</td>
<td>16.55</td>
<td>82.72</td>
</tr>
</tbody>
</table>

3. The results of the analysis for educational progress showed that the mean score from the post-test was significantly higher than the pre-test at the .05 level as shown in Table 3, which indicated that for the instructional packages, the learners had a statistically significant increase in learning achievement at the .05 level.

Table 3 shows the results of the difference analysis between pre-test and post-test.

<table>
<thead>
<tr>
<th>Test</th>
<th>N</th>
<th>ΣX</th>
<th>$\Sigma D$</th>
<th>$\Sigma D^2$</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>22</td>
<td>336</td>
<td>193</td>
<td>1809</td>
<td>17.52*</td>
</tr>
</tbody>
</table>
**It was statistically significant at the 0.05 level.**

V. DISCUSSIONS

The results of the research showed that constructing and evaluating the efficiency of instructional packages on pneumatic control system using PLC that the researcher built was considered to be effective according to the 80/80 criteria and consistent with the research hypothesis. In theory, the first efficacy value obtained with an average learner's practice score during the course of study was 84.39%, which was higher than the first criterion of 80. The latter had an average post-test score of 80.15% higher than the specified latter criterion of 80. In practice, the first performance result obtained with an average learner's workshop score during the course of study was 85.23%, which was higher than the specified first criterion of 80. The latter's performance was obtained with an average performance test score of 82.73%, which was higher than the specific latter criterion of 80. In addition, the results of the study progress analysis showed that the pro-test scores were significantly higher than the pre-test scores at the .05 level. It showed that instructional packages on pneumatic control system using PLC could encourage learners to learn more. This was consistent with the research of Surachet, W. [11] that constructs and evaluates the efficiency of PLC packages in industrial computing. The results showed that PLC packages were effective at 81.20/80.50 and the lab sheets were of good quality. It was also consistent with the concept of Suchitra, C. [5] that construct and evaluate the efficiency of instructional packages on pneumatic control system using PLC found that, instructional packages were effective at 82.00/85.25, and learners with the instructional packages created had a statistically significant increase in learning achievement at the .05 level. The results also showed that learners had a greater understanding of pneumatics control using PLC programs than traditional theory-only teaching. Consistent with this research, it was found that teaching management, controlling pneumatics using PLC or automatic control was a subject that required learning in theory and practice in order to understand how to control pneumatics using PLC from real hands-on operation with instructional packages. However, engineering students needed a better understanding of flexible manufacturing and PLC control. Therefore, there should be two components of teaching, which were theory and practice, so that learners could apply theoretical concepts to practice correctly [12]. However, in this research on instructional packages, the researcher had broken down the content into jobs to suit the learner's perception of the content as well as the order of learning to action steps and must allow learners to learn from real practice along with frequent practice exercises and practice of designing programming simulations according to the worksheets and lab sheets that have been set. After that, the data was loaded into the PLC to test in accordance with the conditions of working with the practice set, which is a real device. Operations must be repeated until skill and proficiency were acquired. The results of the experiment would give learners a lot of fun and excitement with the practice set that simulates the work of industrial machines and they took pride in being able to control their work according to the conditions set in the lab sheets. This was to reinforce and motivate students to continue learning about other topics. In addition, the researcher had also conducted teaching and learning by allowing students to learn step by step or learn from the content, instructions and conditions of instruction starting from easy to difficult as well as differentiating content to suit the learner's learning level. Consistent with Pisit, M. [13] that the course content must be broken down or divided into sections and must be arranged in an appropriate order, teaching from simple to difficult level and teaching from the known to the unknown. In line with the research of Krisada, S. and Sayan, C. [14] who developed the PLC
The learning model in industrial control, the theoretical study of the past students would not get the attention they deserve but the shift from model to more practice had created more interest in skill training among students and materials and equipment for training were prepared, as well as continuous follow-up practice. Thus, it showed that the PLC-controlled learning model required learners to learn through experimentation and practice in order to link from theory to practice and the actual results of the experiment. However, the management of teaching and learning on pneumatic control using PLC, learners should have knowledge of basic pneumatics and electrical pneumatics in terms of equipment selection, electrical symbols and electrical pneumatic circuit design as well as basic computer knowledge for starting learning at the same time. If learners were lacking readiness in such subjects, additional tutoring should be arranged before learning so that learners could achieve their educational goals. The results of this research showed that instructional packages on pneumatic control system using PLC created by the researcher could be used in teaching and learning management and learner development effectively. As a result, learners had higher academic achievement.

CONCLUSION

It could be concluded that instructional packages on pneumatic control system using PLC created by the researcher had a theoretical efficiency of 84.39/80.15 and a practical efficiency of 85.23/82.73 which met the 80/80 criteria. In addition, the results from the analysis of educational progress from the post-test mean scores were significantly higher than the pre-test average scores at .05 level. It showed that the instructional packages on pneumatic control system using PLC created by researchers could be used in teaching and learning management and developing skills in pneumatic control system using PLC of learners as well as developing higher learning achievements of learners.

SUGGESTIONS

1. Suggestions from this research, students need to have a basic knowledge of electric pneumatic control work and basic computer usage so that students can start learning at the same time.

2. The recommendation for further research is the development of instructional packages that focus on professional competency and in accordance with the labor skill standards of the Department of Skill Development or professional qualifications standards to give students the opportunity to take a career standard test. This is to increase job opportunities and build more confidence in the establishment.

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REFERENCES


