PROGRAMMABLE LOGIC CONTROLLER TRAINING MODULE FOR POSITIONING AND SORTING

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To my beloved mother Hajah Nurhajati, father Haji Anuar, mother-in-law Hajah Rasenah, my wife Fauziah, my son Muhammad Faris and Muhammad Fitri, and my daughter Faezah and Fatiha. Thank for all your support.

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ABSTRACT

In this project, a prototype of a Programmable Logic Controller (PLC) training module for positioning and sorting was designed and developed. The design was based on Programme Educational Objectives (PEO) and Program Learning Outcomes (PLO) for Diploma in Industrial Mechatronics Engineering Technology and Course Learning Outcomes (CLO) for Automation course (HFC4033) in Kolej Kemahiran Tinggi MARA Balik Pulau. The prototype consists of two main parts that are: i) Plug and Learn PLC Controller, and ii) Positioning and Sorting Training Kit. Plug and Learn PLC Controller was developed using the Siemen S7-200 CPU 226 as a controller and EM 253 was used as positioning wizard module. Positioning and Sorting Training Kit used standard automation components namely conveyor, sensor and others as input/output (I/O) to the prototype system. The learning activities were conducted using two approaches that is Teacher Centred Learning (TCL) approach and Student Centred Learning (SCL) approach. The effectiveness of the learning approach and the PLC Training Module was evaluated using rubric marking scheme and qualitative survey questionnaire. Based on this evaluation, two group taught in SCL approach managed to complete assigned tasks faster than the group taught using TCL approach. Group from the TCL approach completed the task in procedural stages (structured) compared to the groups from the SCL approach that completed the task in less structured (unstructured). However not all groups using SCL method scored high marks in evaluation criteria for project functionality, design skills and level of understanding. Finding also suggests that SCL approach does not guarantee better performance among passive student. With this PLC training module using SCL approach, the finding shows that the learning strategy can better prepare student to solve real industrial problem. However, it does not necessarily motivated passive student.

ABSTRAK

Dalam projek ini, prototaip modul latihan PLC untuk memposisi dan menyusun telah direka dan dibangunkan. Rekabentuk ini berdasarkan Objektif Program Pendidikan (PEO) dan Program Hasil Pembelajaran (PLO) untuk kursus Diploma Kejuruteraan Teknologi Mekatronik Industri dan Kursus Hasil Pembelajaran (CLO) bagi kursus Automasi (HFC4033) di Kolej Kemahiran Tinggi MARA Balik Pulau. Prototaip ini terdiri daripada dua bahagian utama iaitu i)"Plug and Learn PLC Controller" dan ii)"Positioning and Sorting Training Kit". "Plug and Learn PLC Controller" telah dibangunkan menggunakan PLC Siemen S7-200 CPU 226 sebagai pengawal dan EM 253 digunakan sebagai modul bestari kedudukan. "Positioning and Sorting Training Kit" menggunakan komponen piawai automasi iaitu penghantar, sensor dan lain-lain sebagai masukan/keluaran (I/O) kepada sistem prototaip. Aktiviti – aktiviti pembelajaran dijalankan menggunakan dua pendekatan iaitu Pembelajaran Berpusatkan Guru (TCL) dan pendekatan Pembelajaran Berpusatkan Pelajar (SCL). Keberkesanan pendekatan pembelajaran dan Modul Latihan PLC dinilai menggunakan rubrik pemarkahan dan soal selidik kajian kualitatif. Berdasarkan penilaian ini, dua kumpulan diajar dalam pendekatan SCL berjaya menyiapkan tugas yang diberikan lebih cepat daripada yang diajar menggunakan pendekatan TCL. Kumpulan daripada pendekatan TCL melengkap tugas berstruktur berbanding dengan kumpulan dari pendekatan SCL melengkap tugas kurang berstruktur. Walau bagaimanapun tidak semua kumpulan menggunakan pendekatan SCL mendapat markah tinggi dalam kriteria penilaian untuk fungsi projek, kemahiran reka bentuk dan tahap pemahaman. Penemuan juga menunjukkan bahawa pendekatan SCL tidak menjamin prestasi yang lebih baik di kalangan pelajar pasif. Dengan modul latihan PLC menggunakan pendekatan SCL, kajian menunjukkan bahawa strategi pembelajaran yang lebih baik boleh menyediakan pelajar untuk menyelesaikan masalah industri sebenar. Walau bagaimanapun, ia tidak semestinya dapat memotivasikan pelajar pasif.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATATIONS

i.	Programmable Logic Controllers	PLC
ii.	Direct Current	DC
iii.	Alternating Current	AC
iv.	Central Processing Unit	CPU
v.	Liquid-Crystal Display	LCD
vi.	Plug And Play	PNP
vii.	Earth Leakage Circuit Beaker	ELCB
viii.	Miniature Circuit Breaker	MCB
ix.	Problem-Based Learning	PBL
x.	Student Centred Learning	SCL
xi.	Teacher Centred Learning	TCL
xii.	Light Emitting Diode	LED
xiii.	Kolej Kemahiran Tinggi MARA Balik Pulau	KKTMBP
xiv.	Input/Output	I/O
xv.	Dominant Reset / Dominant Set	RS/SR
xvi.	Programme Educational Objectives	PEO
xvii.	Program Learning Outcomes	PLO
xviii.	Course Learning Outcomes	CLO

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is introduced and consist of the Background of Study, Characteristics of Design Project, Problem Statements, Objectives of Study, Scopes of Study and Important of Study.

1.2 Background of Study

Well know, the Personal Computer (PCs) is popular used for process control (Rullån, 1997). However, PCs is commercial-grade controllers are not normally designed to tolerate the shock, vibration, temperature, and electrical noise frequently found on the manufacturing floor (Gee, 1995). Therefore to overcome this problem a Programmable Logic Controller (PLCs) are been used widely. The use of PLC equipment has been increasing day by day being parallel to progress in the systems of controls nowadays. Besides having technological advantages of using PLC, it also decreases the prices in the advanced level and complex control systems.

Petruzella, F. D. (2005) defined Programmable Logic Controller (PLCs) is a specialized computer used for the control and operation of manufacturing process and machinery. It uses a programmable memory to store instructions and execute functions including on/off control, timing, counting, sequencing, arithmetic, and data handling (Johnson, 2007). Where older automated systems would use hundreds or thousands of electromechanical relays, a single PLC can be programmed as an efficient replacement (Hassapis, 2003; Kamen and Gazarik, 1997; Anderson, 2002). The functionality of the PLCs has evolved over the years to include capabilities beyond typical relay control. Sophisticated motion control, process control, distributive control systems, and complex networking have now been added to the PLC's functions (Saygin and Kahraman, 2004). Therefore, PLCs provide many advantages over conventional relay type of control, including increased reliability, more flexibility, lower cost, communication capability, faster response time and convenience to troubleshoot (Rehg, 2002).

PLC can be a part of an automated system in manufacturing company (Barrett, 2008). The automation systems use electro-pneumatic technology. Electro-pneumatic technologies are formed mainly by three kinds of elements: actuators or motors, sensors or buttons and control elements like valves. Most of the control elements used to execute the logic of the system was substituted by the Programmable Logic Controller (PLC). Sensors and switches are plugged as inputs and the direct control valves for the actuators are plugged as outputs. An internal program executes all the logic necessary to the sequence of the movements, simulates other components like counter, timer and control the status of the system (Świder *et al.*, 2005).

With the use of the PLC, the manufacturing lead time will be reduced. Because it is possible to create and simulate the system as many times as needed. Therefore, time can be saved, risk of mistakes reduced and complexity can be increased using the same elements.

For the reason and advantage of PLC as main control device used by the industry, thus the learning model or tool must be design and develop to prepare students knowledge and experience to the real-world situation. In Kolej Kemahiran

Tinggi MARA Balik Pulau (KKTMBP), the automation course, which is done by practicing PLC simulation in the laboratories, will increase the knowledge of the students in this subject. However, the successful of it will decrease if the PLC education module is not suitable for the education purpose. For this concern, the PLC education module, which is the subject of this thesis, is considered.

1.3 Characteristics of Design Project

The topic of this project named as: Programmable Logic Controller Training Module for Positioning and Sorting. A small scale (prototype) positioning and sorting machine will be developed and it was fully automated and controlled by programmable logic controller (PLC). The prototype of project will be designed for education purpose in Kolej Kemahiran Tinggi MARA Balik Pulau. The observation of the education module will be done to measure it effectiveness and it deficiencies.

The aim of this project is to develop a training module that will be used on training courses, education lectures or lab sessions to show the application of automation in industry and bear out ease of use of automation in processing and production line. The training module will be used as a demo to show how a mechanical system aided by programming system to enhance its functions without human intervention. By development of training module, this will provide convenience for trainer or lecture do their presentation to trainee or students and they easy understand by observe the demo executed by training module. The purpose of this project is to fulfil requirements in market especially high education institutes, manufacturing industries and semiconductor industries because these areas needed different types of small scale automate machine as training module for their automation and PLC curriculum.

In this project, stepper motor, electro-pneumatic, sensor and conveyer were used for PLC education. These all elements are fixed in the training module. So, students will be given education about programming of PLC, PLC wiring and setting the stepper motor into Programmable Logic Controller. Inside the module S7-200

CPU 226 PLC was used that the SIEMENS firm manufactured, this PLC is enough for the education at the basic level (Yilmaz and Çobantepe, 2010).

1.4 Statement of Problems

The trend toward automation of production equipment is putting great demands on people since the early of 1970s. The manufacturers have worked to increase productivity, capability, reliability, and flexibility by using technologies. In order to achieve these are making use more and more automation in manufacturing. PLC is one of the solutions. PLCs remain the tool of choice for end-users as they are designed specifically for use in industrial environments and are guaranteed long-term support by vendors (Hajarnavis and Young, 2008). At this point, understanding PLC system, PLC programming and PLC connections and briefly PLC education are important for the student (Bayrak and Cebeci, 2012) especially student that involved with automation, manufacturing and mechatronics engineering discipline.

The PLC education, which is done by practicing in the laboratories, will increase the success of the students in this subject who attends to vocational high school (Yilmaz and Katrancioglu, 2011). In Kolej Kemahiran Tinggi MARA Balik Pulau, the PLC courses were taught to semester three students for Diploma in Manufacturing Engineering Technology programme and Diploma in Industrial Mechatronics Engineering Technology programme. At the middle of this course, the student will practically do a laboratory exercises. Generally, teacher will give a short introduction of experiment scheme, and then tell students how to connect input and output ports of PLC to a simulation I/O (input/output) panel. The simulation I/O panels provide switches for input into the PLC and light emitting diodes (LEDs) for output from the PLC. The LED were arranged to meet the suitability of the simulation mask for example a traffic light simulator. Experiment result is only checked with LED effect. Thus, students not have experience in a real industrial situation. From author's experience, this traditional approach resulted in:-

a) Many students do experiment by copying other student's program because doing a same simulation I/O. Then, program ability of PLC does not be trained.
b) Student will have a problem to understand the integration between PLC and connecting the I/O based on the real situation in the industry
c) Less experience because the existing training system is too simple and does not meet the requirement in the manufacturing industry
d) Student will have a problem to start programming the PLC controller if the problems are slightly different.

1.5 Objective of Study

The main objectives of this project are:-

a) To design Programmable Logic Controllers training module for positioning and sorting as an input/output (I/O)

b) To develop a PLC training module towards Student Centred Learning (SCL) approach for teaching and learning of the:-
    i) Integration between controller (PLC) and its I/O (positioning and sorting).
    ii) Setup and configure the I/O
    iii) PLC Logic programming (software structure)

c) To evaluate effectiveness of the designed training module by comparison between Teacher Centred Learning approach and Student Centred Learning approach.

1.6 Scope of Study

The main aim of this study is to design and development of PLC training module for positioning and sorting. At this stage basic there is important to recognize the scope of study. The scope consists five main section stated below: The scope of the study is:-

a) the PLC training module is using for student mechatronics semester four undertaking the automation course at KKTMBP of January - June 2014 session
b) student will not involve in hardware development but focusing on integration between controller and input/output and setup and construct a PLC logic programming using prototype develop in the study
c) for student understanding in the knowledge, comparison between existing approach (Teacher Centred Learning) and Student Centred Learning approach based on achievement in technical knowledge (problem solving skill – quality and timing) and soft skill (team work and presentation skill)
d) conduct a questionnaire survey to identify the effectiveness and deficiencies of the both approach and the developed prototype

1.7 Important of the Study

Consumer product manufacturers increasingly rely on the cooperative development of multi-disciplinary technical systems that often span the electrical, mechanical, and industrial engineering domains. Design and production engineers are frequently organized into cross-functional teams in which members bring critical skills to the assembled group (Wagner, 1999). To facilitate multi-disciplinary teams, engineers must develop their teamwork, problem solving, synergistic design, and communication skills as well as the traditional technical competencies (Slivovsky *et al.*, 2003; Simpson *et al.*, 2001). Further, it is increasingly presumed that competitive engineering graduates will have these skill sets in place and be able to contribute immediately to their assigned teams (Steiner, 2004). In essence, the expanding

implementation of sensors, actuators, and digital control across all engineering systems suggest that students need a mechatronic systems perspective (Grimheden and Hanson, 2001) with an opportunity to develop leadership, communication, and interpersonal skills. The availability of mechatronic courses within the engineering curriculum can help prepare students for the global workplace. In order to make this happen, the study for design and development of PLC training module for positioning and sorting are importance. In this training module, student will be able to:-

a) Learn the basic operation of positioning and sorting.
b) Structure of input and output (switches button and components) and their address.
c) Identify the positioning and sorting components on PLC training module.
d) Describe the function of PLC logic programing such as position and timer function.
e) Design a ladder diagram and function block diagram program structure and learn how to program then minimize the program language to be a simple network program.

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