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Combining laboratory-based learning with problem-based learning in undergraduate PLC course at Technical Colleges

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ABSTRACT

The necessity of accomplished engineers and technicians, who are competent in handling the problems of the emerging industry, brings the conventional teaching approaches into question. Engineering technology students should be skilled to confront the technical challenges they will come across in their professional careers by using innovative teaching methods based on projects and real industrial applications. In this study, Teaching-Learning Environments for PLC Program was enhanced, as it is taught to the Electrical and Electronic department students in the Technical Colleges. The emphasis is on the content of a course unit, particularly the choice of the learning methods and its effect on the students. This complete PLC program combines laboratory-based learning with a problem-based learning (PBL) approach. It is also aimed to develop the students' practical skills and meet the requirements of the labor market. Data collected from the labor market and discussed with the academic experts guided us to set our approach, develop the program and improve the students' practical skills. Coming into practical, we have received a lot of positive feedback from students after carrying out a survey and before determining its educational effectiveness

Keywords— *Laboratory-Based Learning, Problem Based Learning, Technical Colleges, Labor Market, PLC Course*

1. INTRODUCTION

Education in many different engineering fields demands laboratory work in order to provide practical knowledge and skills to students and to demonstrate different real-life processes [1]. This is an effective educational way to achieve this purpose, nevertheless, the students will find themselves in a real problem when they get down to the job market due to the huge gap between what is taught in the lab and what is faced in the work.

"Moreover, very structured laboratories generally do little to develop student design, project management, and communication skills [2].

Numerous studies and research have focused on the application of Howard Barrows Experience Problem Based Learning (PBL), as in paper of W. L. Tse [3], which stated that this experience is very effective in learning the technological sciences and improve students design, practical skills, project management and communication skills, also it is an inexpensive method and can achieve the goals that traditional learning methods fail to achieve. The result of this study is also similar to the research of Frank [4], and Doppelt Y [5].

However, one disadvantage of this method is that it doesn't provide the students with the basics needed for the educational subjects, which means that "Knowledge acquired through PBL being less organized than knowledge acquired through traditional learning" [6]. And, as the project needs more time to be achieved, it put the students under unbearable pressure. Moreover, it is difficult to achieve the desired interest with large numbers of students under these conditions and so time wastes on poor ideas.

We have enjoyed the study of Tom Wanyama [7] which integrates the traditional learning process (Laboratory-based learning) and the Problem Based Learning (PBL). It proves that the integration between them is more effective where students are able to design and manage their projects effectively in a practical workgroup.

Programmable logic controllers (PLCs) are widely used in manufacturing to coordinate a wide variety of complex tasks, including security monitoring, energy consumption management, control of machines and automatic production lines [8]. For this reason, qualified personnel is needed to work in the industry. Higher education institutes are the resources for these candidates, Electrical and Electronic Engineering students are employed in control systems area concerning manufacturing process applications. Control and Automation, to work cooperatively with the engineers, to be properly prepared for such positions, so it is desirable that these students be exposed to the topics of process control, discrete logic control, and the fundamentals of manufacturing [9].

A PLC practical program is developed to provide students with the basics needed in dealing with its programming language and explains actual applications to allow them to realize how to use a microprocessor in control. It is based on the combination of

Laboratory-based learning and Problem Based Learning (PBL) and it is also non-overlooked methods of teaching technical engineering subjects. It introduces the basics to the students in the laboratory section aiming to develop their practical skills to meet the requirements of the labor market, besides achieving the largest amount of benefits and avoiding the negatives mentioned for each method.

This paper is arranged as follows; section 1, presents the background of PLC and its learning approach; section 2, introduces methods used and led to detailed PLC course; section 3, covers the course contents; section 4, results and discussions; while section 5 introduces the research conclusion.

2. BACKGROUND

2.1 PLC Background

PLC is used to control the function of the machine automatically. It is a computerized industrial microprocessor-based controller that was originally developed to replace the mechanical relay, timer, and counter. A PLC has an integrated programmable microprocessor that is programmed with a dedicated computer language (Ladder Diagram). After writing the PLC program it is downloaded to the non-volatile memory of Programmable Logic Controller directly through a cable connection via Serial or USB ports.

2.2 PBL Background

Howard Barrows experience in leading Problem Based Learning (PBL) at McMaster University in Canada was widely accepted after achieving resounding success in giving students well practical learning skills, when traditional educational methods have failed to be achieved.

Learning while practicing is our aim at this process, as it assigns a practical problem - or project – to a group of students before giving them the information required in solving the problem. Students supposed to discover their need to know and learn something new. As a result, they will cooperate to gain more information needed in their mission to reach the solution, and then use this information to reach their aim and solve the problem.

2.3 Course Background

In our approach, which combines Laboratory-based learning with Problem-based learning (PBL), we firstly guide the students to the basic information to be sure that they will follow the right steps. Students are supposed to work in groups of three or four and introduce to a number of laboratories for a period of ten weeks. These lab experiments were collected after asking many engineers in the labor market about the Knowledge and skills required from the PLC technician, and after consulting Academic Experts about the most proper, effective and simplest method to display to students.

After that, the students will be asked to group projects to work in an approved project proposal for four weeks, and then they will present their work at the end of the fifteenth week.

We designed our PLC course by the Arabic Language to be taught according to our approach and to meet the student learning value.

3. METHODS

The methods used in this research to build the PLC course are shown in fig. (1). We applied the foundations of the construction and development of study programs, to active the Objectives of the Egyptian Technological Colleges, by collecting data from the labor market and discussed it with Academic experts to guide us to develop the program by using the teaching methods used in teaching practical skills. We focused on the important recommendations of the studies on their way to development and the global trends to prepare these technical programs (industrial). As a result, our PLC curriculum philosophy comes out and includes (Objectives - content - educational activities). We worked on that curriculum with Academic experts to implement a Detailed PLC course and associated it with industrial exercises. Once it is approved, we examined the detailed course by teaching it. Then we asked students to develop group projects and work on the approved project proposals. Knowing that we have received a lot of positive feedback from students about this program and its learning approach after carrying out a survey to determine its educational effectiveness.

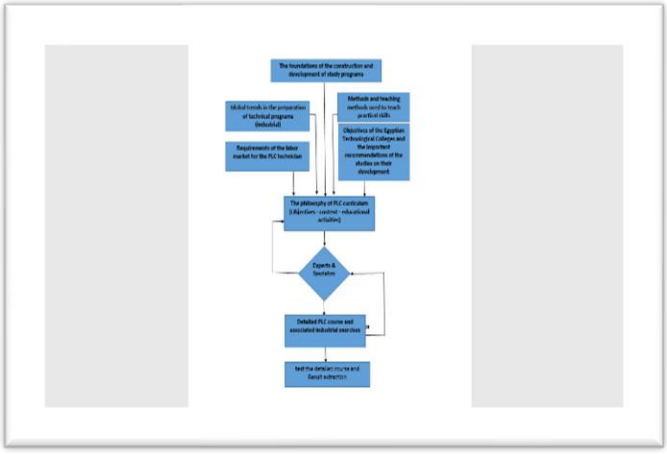

Fig. 1: Methods leads to build the PLC course

4. COURSE CONTENTS

We built our course hoping to be taught to Electrical and Electronic department students in the Technical Colleges in two sections:

The first section is a laboratory section that introduces PLC basics and concepts. In this section, we introduce many applications taken from real applications from factories. The main objective of this section is to upgrade the students' skill with hands-on-training by giving them the chance to program a control task, to make the I/O wiring, and edit the user programs.

The second section is the PLC projects which are real problems in the industrial environment and are required to be solved by students' cooperation and efforts aiming to improve the students' project management, communication and design skills that are needed in the labor market.

4.1 PLC Basics and concepts with hands-on training

This section is based on Siemens S7-300 PLC devices and software with the following headlines:

- PLC concepts and systems.
- PLC I/O devices and its classifications.
- Manipulation with PLC I/O devices.
- PLC programming languages and LAD diagram.
- Bit Logic Instructions and its applications.
- Dealing with Siemens counters and comparators with real applications.
- Dealing with Siemens Timers with real applications.
- Manipulation with analog modules.
- Designing safe systems

The main object of this section is to let students know, practically through using the laboratory, how to use the software, sensors,

actuators, and controllers by introducing real sample systems with its solutions. This will enrich the student with PLC knowledge. Also, a student will spend these ten weeks preparing for their projects.

4.2 Course projects

In this section, we ask students to develop group projects and work on the approved project proposals. While we are testing our course many projects were carried out on a wide range with the flowing topics:

- Sliding gate control project.
- Fire fitting control for three petroleum tanks project.
- Mixing system control project.
- Filling system control project.
- Airport bag Belt control project.

The students achieve the projects with great familiarization and activity.

5. RESULTS AND DISCUSSION

We carried out the course in the first semester of 2018 to Electronic department students in the Technical Colleges. First, we accomplished a pretest after discussing the test structure and contents with Academic Experts. After that, we taught the PLC basics for seven weeks. Then we retested the students with the same test to compare students mean. We collected the data and use the SPSS program, Paired Sample T-test, and get the following results;

Table 1: T-Test - Paired Samples Statistics

Std. Error Mean	Std. Deviation	N	Mean		
1.54548	8.46494	30	85.0000	**post**	**Pair 1**
.56311	3.08426	30	4.9333	**pre**	
Sig. (2-tailed)	**df**	**t**			
.000	29	50.352	**Pair 1**	**post - pre**	

The student's mean was 85%, which means that the students gained the basics needed from the study of the course. Also, the project was carried out in the last two weeks, after the preparation of the laboratory work, that laboratory-based project learning allows laboratories to share time with projects. While the practice test is taken through an observation sheet with a scale of 1-5, Score 5 for best conditions. We found that student Projects were carried out with the completion of 100%, with scoring over 75%. This shows their liveliness in learning has led them to build their skills as well as their knowledge in PLC learning [5], also we noticed an improvement and advance in practice problem solving, project management, teamwork and communication skills that are needed in the career field. This means that the integration between Laboratory-based learning and Problem-based learning (PBL) is very effective in the engineering learning field. It can be used as an effort to improve the student learning outcomes which would be set to create qualified human candidates in order to meet future industry demands.

6. CONCLUSION

In this paper, we prepared a PLC course for Electrical and Electronic department students in the Technical Colleges, based on the integration between Laboratory-based learning and Problem-based learning (PBL). Practically, we found that this paradigm harnesses the learning Environments, as it leads to very good results in the paper test; meaning that it gives the students clear PLC basics and concepts. The student Projects were carried out with the completion of 100% scoring over 75%. Moreover, we notice an improvement in students' practical problem solving, teamwork, project management, and systems design.

So, we can say that a well-prepared program with experimental Learning, hands-on training and problem-based learning methods improve the student's basics, practical problem solving, teamwork, project management and system design that is needed in the labor market.

Therefore, it's concluded that the integration of Laboratory-based learning with project-based learning methods is one of the most superior learning methods for PLC courses.

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8. REFERENCES

[1] M. Matijević, M. Stefanović, V. Cvjetković, V. Joković, N. Babajić, M. Ravlić, S. Nestic, The Development and Implementation of a Thermal Process Trainer for Control and Measurement via the Internet, Computer Applications in Engineering Education, DOI: 10.1002/cae.20543, April 2011.

[2] Lee Harrisberger, R. Heydinger, J. Seeley, and M. Talburtt, Experiential Learning in Engineering Education, Washington, DC: American Society of Engineering Education (ASEE), 1976, 1 pp.

[3] W. L. Tse and W. L. Chan. "Application of Problem-Based Learning in an Engineering Course", Int. J. Engng Ed. Vol. 19, No. 5, pp. 747-753,2003.

[4] Frank M, Lavy I and Elata D 2003 Implementing the project-based learning approach in an academic engineering course International Journal of Technology and Design Education 13, 3 273-288.

[5] Doppelt Y 2003 Implementation and assessment of project-based learning in a flexible environment International Journal of Technology and Design Education 13 3 255-272

[6] Davis MH, Harden RM. AMEE medical education guide no. 15: problem-based learning: a practical guide. Medical Teacher 1999; 21:130-140.

[7] Tom Wanyama and Ishwar Singh "Laboratory-Based Project for Experimental In PLC systems Integration and PLC system data Access", CEEA14; paper020.

[8] S.J. Hsieh, P.Y. Hsieh, Web-Based Modules for Programmable Logic Controller Education, Computer Applications in Engineering Education, Vol. 13, no. 4, 2005, pp. 266–279.

[9] E.W. Kamen, M.J. Gazarik, J. Napolitano, A Course in Industrial Controls and Manufacturing for EE Students and Other Engineering Majors, Proceedings of the American Control Conference, June 1997, pp. 3160–3165, New Mexico, Mexico.

[10] Y. Doppelt, Implementation, and Assessment of Project-Based Learning in a Flexible Environment, International Journal of Technology and Design Education, Vol.13, 2003, pp. 255–272.

[11] McLaren S and Dakers J 2011 A Curriculum for Excellence: Review of research literature, Design, and Technology Education.

[12]

