Development of An Elevator Simulator to Support Problem-Based Electric Motor Control Practicum for Vocational High School Student

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Abstract

Workers who can control electric motors are currently needed. Therefore, knowledge about controlling electric motors should be taught in vocational high schools. Installation and control of electric motors in the industry are generally used in various devices related to the production process such as controlling the motor driving conveyor belts, controlling pumps on factory pipes, and controlling freight elevators. The problem that arises is the lack of knowledge about electric motor control in vocational school teachers and insufficient facilities for the learning process of electric motor control. Also, Vocational High School (SMK) has not been able to change the old learning patterns to the new learning patterns required in the 2013 curriculum. One of the changes in the curriculum is a change from teacher-centered learning to student-centered learning. In this service program, learning the installation and control of electric motors in the simulator of elevators was developed using the Problem Based Learning (PBL) approach for students of SMKN 1 Cipatat. The first step in implementing this program is to study the curriculum and syllabus applied to the two partner vocational schools, then design a learning process for the installation and control of electric motors using the PBL method. The PBL method was chosen because this method can simultaneously be used to increase students' soft skills such as the ability to innovate, discipline, and the ability to convey ideas both in writing and orally. Besides, the PBL method can also support changes to learning patterns as required in the 2013 curriculum.

Keywords: Problem Based Learning, electric motor control, elevator simulator.

1. Introduction

The use of the Problem Based Learning (PBL) method in the learning process has many benefits, one of which is that graduates will be more creative, innovative, and have high competitiveness. Changes that start at school will have a broad impact on social conditions. The problem-based learning process that will be used in learning Electric Motor Installation and Control is expected to produce graduates who are innovative and have positive attitudes such as creative, disciplined, open and able to convey their ideas both orally and in writing [1].

In addition, the use of the PBL method in the learning process is also expected to produce graduates who have strong self-motivation in the learning process. This motivation is needed both for graduates who will continue to higher education levels and for graduates who will enter the world of work. Instilling self-motivation in the process of seeking knowledge is a fundamental thing that needs to be addressed in the education system in Indonesia. This service activity is expected to help the government and the wider community in the process of instilling this motivation.

In the 2013 curriculum, it is also expected that there will be improvements in the form of the Teaching and Learning Process activities as follows:[2]

a. the form of teacher-centered Learning Teaching Process/*Proses Belajar Mengajar* (PBM) activities into student-centered learning;
b. the form of one-way teacher-student communication PBM activities becomes more interactive;
c. the form of PBM activities is fixed into PBM networking;
d. the form of PBM activities that were previously passive to become more active PBM (searching);

e. form of personal learning into team-based learning;

f. the form of PBM activities from one media to PBM based on multimedia tools;

g. the form of general-based PBM activities becomes the special needs of customers (users), namely by strengthening the development of the special potential of each student;

h. the form of PBM activities in one discipline (monodiscipline) into PBM in multi disciplines (multidisciplines);

i. the form of passive PBM activities into more critical learning.

One of the ways to improve this mindset can be implemented by applying problem-based learning methods [1], [3], dan [4]

2. Methodology

In the method section, it is explained in detail how the research was carried out related to the place, time, method of measurement and data collection, materials and equipment used, accompanying boundary conditions and so on [5]. The materials and equipment written in the manuscript are the most significant used and the most influential in the research process. If possible, the method section is accompanied by pictures, series of experiments, organigrams/flowcharts that can make it easier for readers to understand the research process.

2.1   Situation Analysis

Partners in the implementation of this community service are SMK Negeri 1 Cipatat Bandung Barat. In general, SMK Negeri 1 Cipatat is a school that was only established in 2015 and has not yet had a graduate. Currently, SMK Negeri 1 Cipatat has 383 students. In the 2015/2016 Academic Year, SMK Negeri 1 Cipatat opened a new skill study program, namely Electrical Power Installation Engineering. One of the subjects in the expertise study program is the Installation and Control of Electric Motors.

The facilities that have been owned by SMK Negeri 1 Cipatat in the learning process of installing and controlling electric motors are PLC modules. This module has not been equipped with a plant/system that can be used to support the learning process of installing and controlling electric motors. As it is known that PLC is a control module which in its learning process requires a controlled plant/system. In addition, the learning process for the installation and control of electric motors that will be implemented has also not been planned properly due to limited insight into the plant from prospective teachers.

2.1.1   General Partner Problems

A common problem with partners is the delay in anticipating technological developments used in the industry. The role of universities through the third dharma, namely community service, is needed by vocational schools so that vocational schools can continuously adapt to technological developments, especially technology used in industry.

In general, partners also still use old learning patterns that are not in line with the demands of learning patterns in the 2013 curriculum. Partners experience difficulties in implementing new learning patterns because of the limited facilities and insights of teachers in modern learning methods.

2.1.2   Special Partner Problems

In learning the installation and control of electric motors (IPML) partners face problems:

- Limited knowledge of IPML

- Teaching staff who are not ready to deliver IPML material

- Limited equipment that supports IPML learning

- Not yet available plant for IPML practicum

- Lack of understanding of the PBL method

Based on the analysis of the situation and the background of the problem, partner problems can be identified as shown in Table 1. These problems are expected to be resolved through community service activities carried out.

2.2 Solution and Outcome Target

Solutions to problems faced by partners can be seen in Table 2.

Table 1. Partner Problems Identification

Partner	Problems
Facilities	1. Do not have plants/systems that support IPML learning yet
	2. Do not have IPML practicum guide yet
Learning	1. The Problem Based Learning method has not been applied to the learning process in the Electrical Engineering expertise study program.
	2. The teacher does not understand the IPML practicum well
	3. Teachers do not understand PBL yet

Table 2. Solutions to Partner Problems

No.	Partner Problems	Solutions	Outcome
1	Do not have plants/systems that support IPML learning yet	Designing and realizing systems for IPML learning	Plants/systems that support IPML
2	Do not have IPML practicum guide yet	Compile IPML practicum guidelines according to the syllabus	IPML practicum guide as sylabus
3	The PBL method has not been applied to the PBM	Applying PBL to IPML learning	IPML practicum guide as PBL
4	The teacher does not understand the IPML practicum well	Implement training for teachers on IPML learning	The training implementation contains IPML learning using PBL
5	Teachers do not understand PBL yet	Implement training for teachers on PBL	

3. Results and Discussion

3.1 Selection of Problem Type

Types of problems for the implementation of problem-based learning must meet several criteria, namely:

1. Can be done by students with the support of knowledge of the subjects that have been taught;
2. Meet the learning syllabus;
3. Meet the criteria set out in the PBL;
4. Can be done using available tools and components;
5. Can be done within the specified time.

Specific requirements for problems in IPML learning in SMK are as follows: [5]

1. Can be used for learning in IPML programming
2. Can be controlled with many variations making it possible to test various types of programs
3. Not too complex because it is intended for SMK level
4. The plan chosen is reliable and cheap
5. The time for programming and testing does not exceed the practicum time provided
6. Plans can be explored on the programming side as a team so as to stimulate students to be creative

Based on these criteria, the elevator system was chosen as a plan in the IPML learning process. The emphasis of the problem is on programming the PLC to control the lift and not building the lift system.

3.2 Design and Realization of Practicum Modules

The elevator system used in the IPML learning process is designed to move like a real elevator. The design, wiring diagram, and realization of the elevator simulator system can be seen in Fig. 1 and Fig. 2.
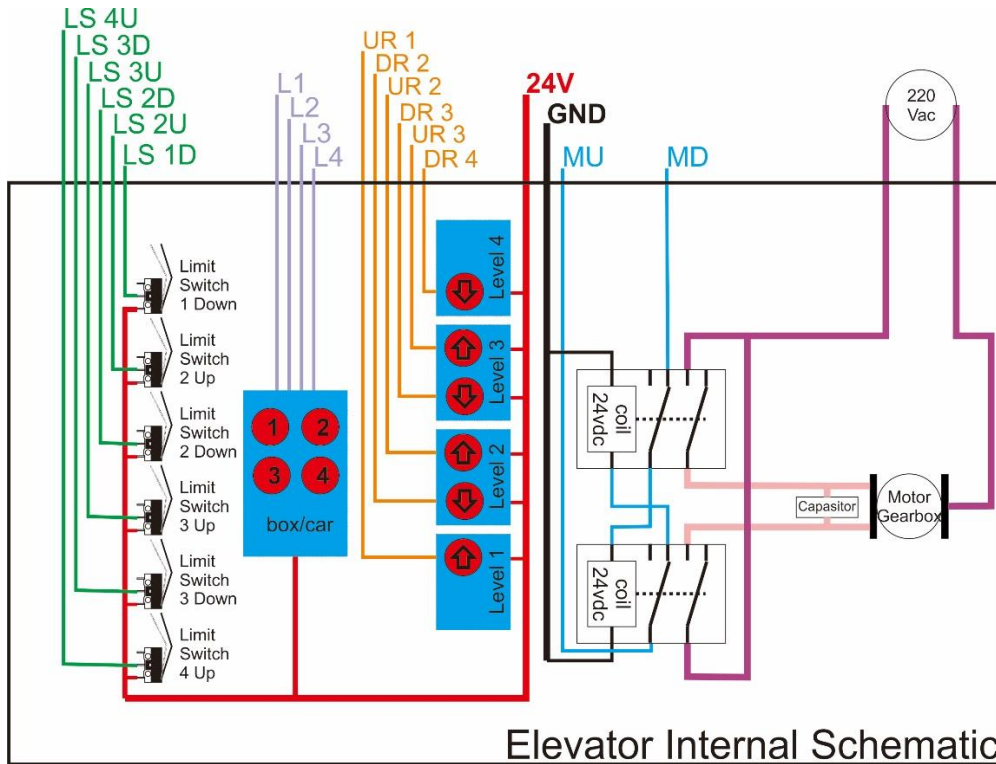

Figure. 1 Wiring diagram

Table 3. Input-Output Table

No.	Name	I / O	Bit Code	Address	Status
1	Limit Switch 1 Down	Input	LS 1D	00.00	NO
2	Limit Switch 2 Up	Input	LS 2U	00.01	NO
3	Limit Switch 2 Down	Input	LS 2D	00.02	NO
4	Limit Switch 3 Up	Input	LS 3U	00.03	NO
5	Limit Switch 3 Down	Input	LS 3D	00.04	NO
6	Limit Switch 4 Up	Input	LS 4U	00.05	NO
7	Up Request Level 1	Input	UR1	00.06	NO
8	Up Request Level 2	Input	UR2	00.07	NO
9	Up Request Level 3	Input	UR3	00.08	NO
10	Down Request Level 2	Input	DR2	00.09	NO
11	Down Request Level 3	Input	DR3	00.10	NO
12	Down Request Level 4	Input	DR4	00.11	NO
13	Level 1 Position Request	Input	L1	01.00	NO
14	Level 2 Position Request	Input	L2	01.01	NO
15	Level 3 Position Request	Input	L3	01.02	NO
16	Level 4 Position Request	Input	L4	01.03	NO

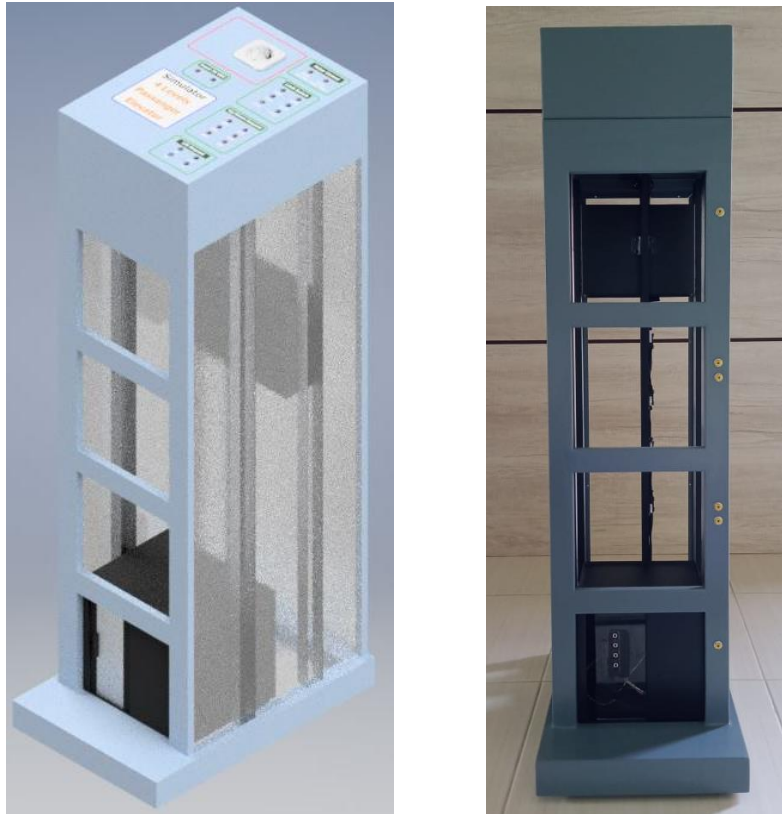| 17 | Start Push Botton | Input | S1 | 01.04 | NO |
18	Stop Push Botton	Input	S0	01.05	NO
19	Motor Up	Output	MU	10.00	NO
20	Motor Down	Output	MD	10.01	NO

Figure. 2 Design and Realization of elevator simulator system

The IPML Practicum Module Box Panel for managing elevators can be seen in Figure 3.

Figure. 3 Elevator Control Box Panel

3.3   Compillation of Practical Guide

The implementation of IPML practicum is done by programming the PLC to regulate the elevator driving motor. The IPML practicum guide is divided into two major parts, there are:
1. PLC basic programming part
2. PLC application programming section

In the PLC Basic Programming Section, PLC programming is taught which will be the basis for students to work on PLC programming projects at the next stage. The materials taught at this stage are:
- Programming the direction of motion of the elevator cage
- Elevator cage motion sequence programming

The PLC programming process begins with making a ladder diagram. Students must be able to make ladder diagrams before programming.

In the PLC Application Programming Section is taught with a number of problems (problems) that must be solved by students. The types of problems that must be solved by students are as follows:
- Elevator settings to go up/down
- Elevator arrangement to go to requested floor.

3.4   Suitability of Learning Activities with 2013 Curriculum Demands

The suitability of the activities carried out with the demands of the 2013 curriculum can be seen in Table 4.

Table 4. 2013 Curriculum Learning Pattern

2013 Curriculum learning pattern	Implementation of the activities carried out
teacher-centered learning patterns become student-centered learning;	The use of the elevator simulator system in PLC practicum and the application of PBL is expected to make students the center of learning. The teacher will function as a facilitator.
one-way learning pattern (teacher-student interaction) into interactive learning;	This problem-based learning will create interaction between teachers and students because students will be encouraged to discuss with the teacher and discuss with fellow students.
isolated learning patterns into networked learning;	Through the problem approach, students are required to seek information from outside to solve problems in this way, so the learning process will develop in a networked manner.
passive learning patterns into active-seeking learning;	Students will be encouraged to be active so that problems can be solved
self-study patterns into group learning (team-based);	Problem solving is done in teams so that the pattern of self-study will shift to group learning.
single-tool learning pattern into multimedia-tool-based learning;	In the implementation of the practicum, teachers can be creative by presenting real problems using elevators with videos so that students will be more enthusiastic and understand problems better.
Mass-based learning patterns become the needs of customers (users) by strengthening the development of the special potential of each student;	Problems can also be developed by means of students who formulate problems and then solve them themselves. This method will give students the opportunity to get additional knowledge according to their needs.
the pattern of learning single sciences (monodisciplines) into learning multiple sciences (multidisciplines);	The problem that is solved can involve other sciences such as social science related to the habits of drivers and road users in Indonesia.
passive learning patterns into critical learning.	The problem approach is expected to encourage students to be more critical because students must be active if the problem is to be resolved quickly and the results are as expected.

3.5   Questionnaire

At the beginning and end of the training questionnaires were distributed with the aim of knowing the level of success of the training in improving students' abilities. The results of the questionnaire can be seen in Table 5.

Table 5. Questionnaire Result

Question	Very understand/ only know		Understand/ only know		Not well Understand/ only know		Don't Understand/ only know		TOTAL	
	Before	After	Before	After	Before	After	Before	After	Before	After
Do you understand the learning process using Problem Based Learning (PBL)?	-	-	-	9	28	27	22	14	28	45
Do you know the purpose of the Electric Motor Installation and Control practicum?	-	11	23	33	24	6	3	-	70	105
Do you know the function of the electric motor in the elevator?	1	17	22	28	23	5	4	-	70	112
Do you know the function of PLC in elevator control system?	-	14	6	20	35	14	9	2	47	96
Do you know the application of Electric Motor Installation and Control system in industry?	-	11	5	27	35	12	10	-	45	99
									260	457

The results of the questionnaire show that the training can improve students' and teachers' understanding of the Electric Motor Installation and Control practicum. The total score of the questionnaire before the implementation of the training was 260 while after the implementation of the training the score rose to 457. The increase in the score proves that the training that has been carried out can increase the knowledge of the participants.

4. Conclusion

This community service activity is expected to help partner SMKs in changing old learning patterns to modern learning patterns in accordance with the demands of the 2013 curriculum.

The elevator system can be used as a plan in the IPML learning process using the PBL method. Through problems in the form of making programs to regulate elevators through PLC devices, students are expected to be more active, critical, innovative, and have high group collaboration skills.

The IPML learning pattern using PBL is expected to be applied in other vocational schools in Indonesia.

Acknowledgment

Bibliography

[1] N. C. Basjaruddin and E. Rakhman, "Penerapan Metoda Project Based Learning (PBL) pada Praktikum Mekatronika," Politeknik Negeri Bandung, Bandung, 2011.

[2] Permendikbud, "Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 70 Tahun 2013 Tentang Kerangka Dasar Dan Struktur Kurikulum Sekolah Menengah Kejuruan/Madrasah Aliyah Kejuruan," Kemendikbud, Jakarta, 2013.

[3] S. Nurohman, "Pendekatan Project Based Learning Sebagai Upaya Internalisasi Scientific Method Bagi Mahasiswa Calon Guru Fisika," Yogyakarta.

[4] E. Susanti and Z. Muchtar, "Pendekatan Project Based Learning Untuk Pembelajaran Kimia Koloid di SMA," *Jurnal Pendidikan Matematika dan Sains,* vol. 3, no. 2, 2008.

[5] E. Haritman and I. Kustiawan, "Pembelajaran Berbasis Proyek PLC Untuk Meningkatkan Penguasaan Konsep dan Keterampilan Pemrograman Mahasiswa,," in *Seminar Nasional Electrical, Informatics, and It's Edducations*, 2009.

[6] E. Rakhman, Buku Ajar Sistem Otomasi Industri, Bandung: Politeknik Negeri Bandung, 2010.

[7] Perpres, "Peraturan Presiden Republik Indonesia Nomor 8 Tahun 2012 Tentang Kerangka Kualifikasi Nasional Indonesia," Presiden, Jakarta, 2012.

[8] N. C. Basjaruddin, Pembelajaran Mekatronika Berbasis Proyek, Yogyakarta: Deepublish, 2015.

[9] S. Taini, "Perancangan Aplikasi PLC Omron Sysmac CPM1A Pada Traffic Light Di Laboratorium Teknik Kontrol Otomatik Teknik Elektro Universitas Diponegoro," Jurusan Teknik Elektro Fakultas Teknik Universitas Diponegoro, Semarang, 2012.

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

[11] T. Markham, Project Based Learning Handbook, Buck Inst for Education, 2003.