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The Effectiveness of PLC Programming and Simulator Using Factory I/O

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Abstract

This paper presents the effectiveness of teaching and learning process of Programmable Logic Controllers (PLC) Programming and Simulator subject. The Mechanical Engineering Diploma course at Polytechnic has begun to introduce this subject using a software known as Factory I/O to students. In a recent year, PLC programming has been extensively used in various industries especially in the automation and manufacturing industry. Therefore, this subject is crucial for students to learn before they graduate and enter the working world. However, during the Movement Control Order, the students were having difficulties in implementing the practical task for the assessment of this subject. Due to that matter, this study was conducted in order to assist students in performing their practical work. In this research, case studies have been used a method of research and questionnaires were distributed in collecting the data. There are three main activities involved: switch Windows applications, PLC programming and testing. The results obtained from this work has proved that PLC programming and simulation using Factory I/O are able to help students in gaining better understanding of the subject and doing their practical assessments. With the study conducted, it is hoped that it can be a starting point for all Malaysian polytechnics to use Factory I/O for PLC programming module and further bringing a better quality of this course.

Keywords: - Factory I/O, PLC programming, simulator

1. Introduction

The PLC Programming & Simulator teaching aid module using Factory I/O has been introduced to students enrolled in the Programmable Logic Controller course of the Mechanical Engineering Diploma course beginning in the December 2020 session. It is a method of online practical implementation during the Movement Control Order where the students were not allowed to attend the study center. It also aims to provide exposure and as an added value of knowledge in the field of PLC programming. Indirectly, it increases the marketability of students when they graduate from the Polytechnic. This module has been used by all lecturers involved with the PLC programming course. Fig. 1 shows PLC Programming & Simulator equipment using Factory I/O.

The module is divided into 2 parts that need to be completed by each student who is divided into specific student groups. Each group of students needs to understand the use of PLC and know the basic concepts of PLC and then produce a programming using Cx-Programmer software (Version 9.7) model OMRON PLC CP1E in order to test the level of understanding of the students.

Fig. 1. PLC programming & simulator using Factory I/O

Fig. 2 shows the interface display on a smartphone when this application is running.

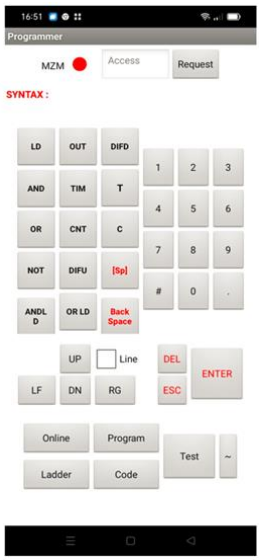

Fig. 2. Display of the interface on a smartphone

This PLC Programming & Simulator teaching aid module is an ongoing effort made to ensure that the practical evaluation for the Programmer Logic Controller course for students can be implemented according to the plan that has been set and can have a positive impact on learning. Fig. 3 demonstrates the conveyor control simulation after the program is set and moved through the control.

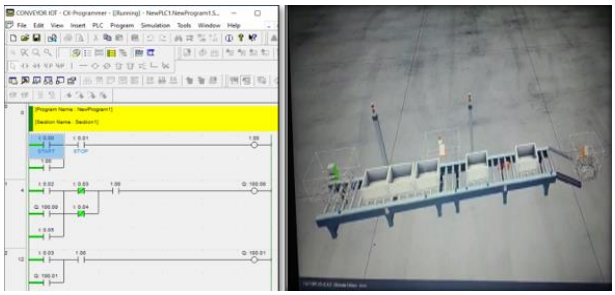

Fig. 3. Program and simulation of conveyor control

The problem faced by the students when following the practical course for the Programmable Logic Controller is the difficulty in understanding work procedures and performing practical tasks during the implementation period of the Movement Control Order (MCO). This is because during that period, the learning process is required to be conducted online as students are not allowed to attend the study center. Where it requires students to be able to build programs using the Cx-Programmer software (Version 9.7) model OMRON PLC CP1E in practical exercises related to the course.

Due to the mentioned problem, this study is conducted in order to:

i. Identify the effectiveness of the teaching and learning process of practical assessment from the aspect of using *PLC programming* in Factory I/O.
ii. Identify the effectiveness of the teaching and learning process of practical evaluation from the aspect of using *PLC simulator* graphically simulated.
iii. Identify the effectiveness of the teaching and learning process of practical assessment from the aspect of learning effects

2. Methodology

IR 4.0 is an emerging technology which involves Artificial Intelligence (AI), Big Data Analytics, Internet of Things (IoT), Cloud Computing, Augmented Reality, Simulation, Cyber Security, Systems Integration, Additive Manufacturing, and Robotics & Autonomous Systems by organizations (Othman, 2021). The recent development of IR4.0 technology has further increased the role of PLC use in the automation and manufacturing industry, particularly in developed countries (Khairudin et al., 2019). IOT-based PLC control is widely used to control machine functions automatically and semi-automatically. It is a computerized microprocessor-based controller that implements discrete or sequential logic in an industrial environment. Online PLC control for mechanical relay functions, timers and counters where each function is integrated in one PLC controller unit can be done with internet facilities. It is widely uses in the industry using several programming languages such as ladder diagram (LD), instruction list (IL), sequence function chart (SFC), function block diagram (FBD) and structured text (ST) (Yakimov et al., 2019). The process of uploading the completed program is done online, using the Factory I/O. Once uploaded, the movement simulation can be seen by the students using Arduino and Factory I/O software through the Open Platform Communication (OPC) server. This clearly helps the students to understand better upon seeing the results on the consequences of every command first-hand. Therefore, the use of PLC at an early stage, especially for students, is important before entering the real world of work (Rusimamto et al., 2019). The rapid transitioning into the IR4.0 combined with advancement of simulation technology have been widely utilized in the military and medicine fields. The success of such implementation proves that education field can equally benefit from such technology. This will evidently make teaching and learning interesting and ultimately more

effective without involving the purchase of expensive equipment.

PLC simulation is also an important aspect in learning. The Factory I/O software has been backed by major international players, thus makes it a viable option to consider. The development of computerized simulation technology has changed the learning method to obtain various information as well as their interpretations (Spayde et al., 2019). By using simulation, students gain access to information from various sources quickly and easily (Tun et al., 2021; Ziden & Rahman, 2014). Under normal circumstances, the preparation of suitable building materials must also be considered, taking into account the cognitive level of students for all levels; high, medium and low students alike (Ziden & Rahman, 2012). The use of computers as a medium of interaction between students and instructors in the teaching and learning process for practical sessions makes it easier and more interesting. Visual aids such as simulations are the best tools for teaching and learning (Chernikova et al., 2020; Rasul, Bukhsh & Batool, 2011). Simulations produced with images that resemble the real situations allow students to obtain real results even if they do not involve the real equipment or machines. This allows students to evaluate the results that will be collected as a result of the experiment carried out. Virtual simulations can provide a better learning experience for students about how theories or concepts are applied in real situations (McGarr, 2020; Alessi, MS & Trollip, 2001).

The architecture of the proposed system is shown in Fig. 4 where there are three main activities involved: switch Windows applications, PLC programming and testing.

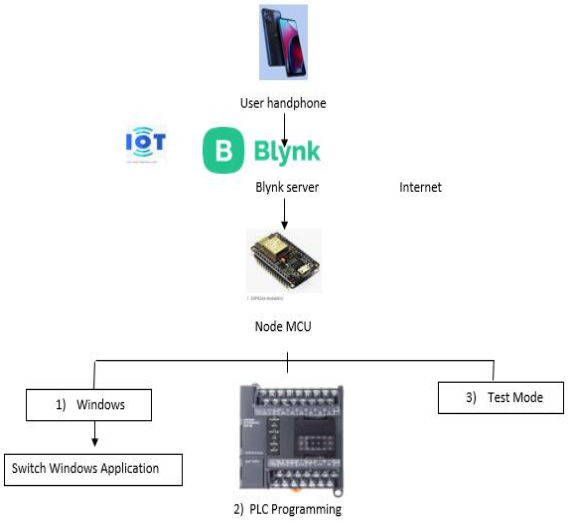

Fig. 4. System Architecture

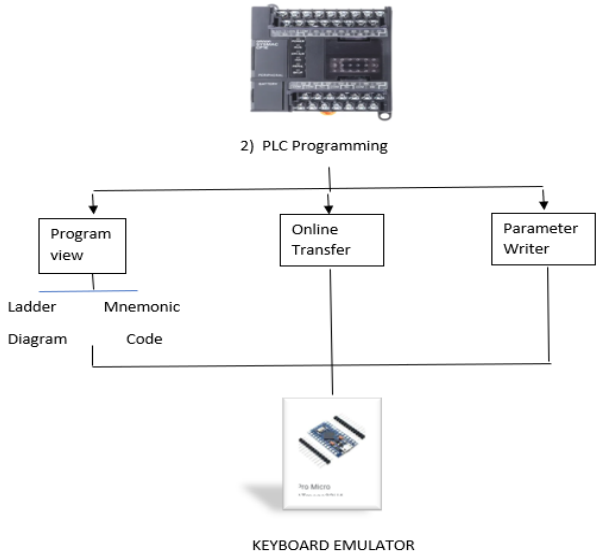

Fig. 4. (*continued*)

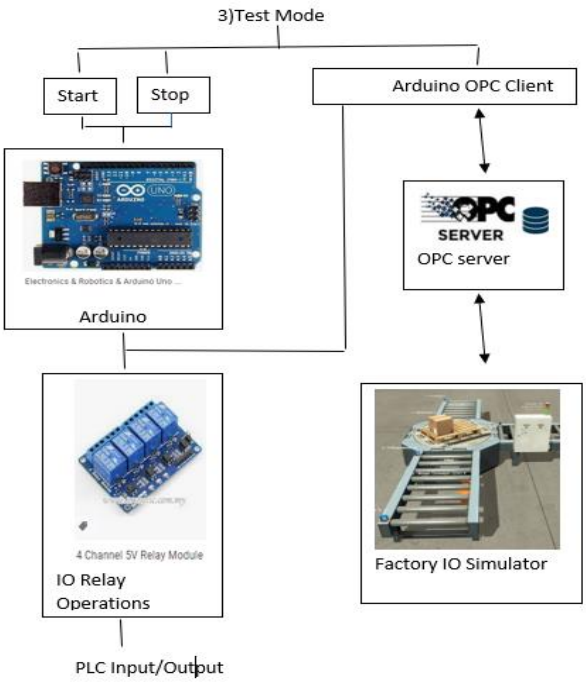

Fig. 4. (*continued*)

This is a quantitative study in the form of a case study to identify the effectiveness of teaching aids "PLC programming & simulator using Factory I/O" in the Department of Mechanical Engineering, POLIMAS. The sample of this study consists of 30 out of 51 students from the Department of Mechanical Engineering, POLIMAS (Feb/2022 session). The instrument for this study is using a questionnaire through google form. According to Konting (1990), questionnaires are more practical and effective because their use can increase the accuracy and truthfulness of responses given by the sample. Tuckman (1993) pointed that questionnaire method is easier to get

cooperation from respondents. For this study, questionnaires containing 2 parts of questions are distributed immediately after the end of the Teaching and Learning session for practical classes conducted online using teaching aids PLC programming & simulator using Factory I/O. The first part of the questionnaire requires students to fill in information related to the course and the second part contains 3 evaluation elements. These assessment elements are part A, to assess the students' perception of the use of software applications on smart phones; part B, to assess the students' perception of the use of simulation at the IO factory and part C, to assess the impact of learning on students. A 1-5 Likert scale is used to measure the students' responses to each question presented. The questions in parts A and B are measured according to the following scale: 1 = Strongly disagree (STS); 2 = Disagree (TS); 3 = Uncertain (TP); 4 = Agree (S); and 5 = Strongly agree (SS).

The data obtained is processed using SPSS software (Statistical Package for Social Science version 22.0). This study uses descriptive statistics by using the mean score value for the purpose of data interpretation. The researcher has determined that the criteria for analysis and interpretation of the mean score are divided into three levels as suggested by the Universiti Teknologi Malaysia Student Self-Development Committee (Azmi et. al, 2018). The interpretation of the mean score value used are low, medium and high (Landell, 1997).

Table 1. Interpretation of the score for the study (Landell, 1997)

Mean Score	Interpretation	Level of Inclination
1.0 to 2.39	Do not agree	Low
2.40 to 3.79	Disagree	Simple
3.80 to 5.00	Agree	Tall

3. Result and Discussion

This study is to identify the effectiveness of the teaching aid module "PLC Programming & Simulator using Factory I/O" for the Programming Logic Controller course. Based on the result shown in Table 2, the item that get the highest mean score of 4.55 is for *the interface format is attractive* and *the command icon layout is attractive/appropriate*. The second highest item with a mean score of 4.50 is for the item *takes a short time to learn*. The lowest item, *the circuit diagram is easy to read and understand*, has a mean score of 4.35. Overall, the average mean score obtained is 4.48 and it is well within high category. This proves that PLC programming using Factory I/O on the phone is within the high category and favorable by the students.

Table 2. Mean score analysis for PLC programming by Factory I/O using the phone

Item No.	Item	Min Score	Level
1	The interface format is attractive	4.55	Height
2	*font* size used is easy to read and clear	4.45	Height
3	The command icon layout is attractive/suitable	4.55	Height
4	The circuit diagram is easy to read and understand	4.35	Height
5	The software application is easy to operate	4.48	Height
6	Takes a short time to learn	4.50	Height
	Overall	4.48	Height

Based on Table 3, the item with the highest mean score of 4.70 is for the *simulated components resemble real components*. The second highest item with a mean score of 4.55 is shared by item No 7 and 12 respectively. The lowest item, *the components meet the requirements of all the practical performed*, get a mean score of 4.15. Overall, the average mean score obtained is 4.46 and is also within the high inclination category. This means that the responses obtained show that the PLC simulator graphically is in a very good level category. This proves that the students are very satisfied with the PLC simulator used during the practical assessment.

Table 3. Analysis of the mean score for the PLC simulator graphically

Item No.	Item	Min Score	Level
7	The simulation component is clear and interesting to students	4.55	Height
8	Simulated components resemble real components	4.70	Height
9	The simulation is easy to understand and operate	4.50	Height
10	Takes a short time to understand/operate	4.50	Height
11	Help students understand practical procedures more easily	4.33	Height
12	Help students to carry out practical	4.55	Height
13	The simulation works well and is satisfactory	4.36	Height
14	The components meet the requirements of all practicals performed.	4.15	Height
	Overall	4.46	Height

Based on Table 4, the item with the highest mean score of 4.90 is for *this practical teaching aid module capable of increasing student achievement in learning*. The second highest item with a mean score of 4.83 is for the *practical teaching aids module helps students to understand the practical implementation*. Finally, the item *this practical module item encourages students to cooperate with each other*, scores the lowest mean score of 4.70. Overall, the average mean score obtained is 4.79,

also within the high-level category. This means that the responses obtained show that overall, the students are very satisfied with the effect of learning on the students after the class is conducted.

Table 4. Mean score analysis for learning effects

Item No.	Item	Min Score	Level
15	This teaching aid module is very useful	4.73	Height
16	The practical module of this teaching aid encourages students to cooperate with each other	4.70	Height
17	This practical teaching aid module helps students to understand the practical implementation	4.83	Height
18	This practical teaching aid module is able to improve student achievement in learning	4.90	Height
	Overall	4.79	Height

4. Conclusion

The findings of the study show that in general, all respondents feel that the effectiveness of using the teaching aid module PLC Programming & Simulator using Factory I/O is outstanding in an effort to help them learn. This can be proven from the data obtained that clearly shows the students are favorable with the PLC Programming item using Factory I/O simulation software on the phone that has recorded a high average mean score reading of 4.48, which is in a high-level category. The same is for the case with the PLC simulator item in a graphical simulation that has recorded a high mean score average reading of 4.46 and for the learning effects that has recorded a high mean score reading as well with a score of 4.79. Based on the findings obtained, it is hoped that this study can be used as a starting point for the production of a practical PLC module that can be used in all Malaysian polytechnics and bring the quality of this course to a greater height.

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