An industrial machine prototype for learning PLC at vocational high school

Syaad Pathmantara, Aji P. Wibawa & Sri Rahayu

Universitas Negeri Malang (State University of Malang)
Malang, Indonesia

ABSTRACT: Indonesian industries gladly accept skilful vocational high school (VHS) graduates. One of the important skills that should be mastered by students is a programmable logic controller (PLC). However, at some schools, there are no adequate media that can be used to present the use of PLC to control industrial machines. This article explains the development of a PLC-based industrial machine control system as a learning medium for VHS students. The media development model is the ADDIE model, which consists of 1) analysis; 2) design; 3) development; 4) implementation; and 5) evaluation. The validation process was done by media and materials experts and media try-outs. The evaluation shows that the developed media are valid (89.9%) and could be implemented in the learning process.

Keywords: Programmable logic controller (PLC), vocational high school (VHS) education

INTRODUCTION

Vocational high school (VHS) graduates should have appropriate competence in productive subjects. In the process of learning, productive subjects must be supported by adequate learning media infrastructure. The media can be used to stimulate learning perception, attention and ability, and should encourage the students' learning interests [1]. Furthermore, the comprehension of the learning material will lead to maximisation of the desirable learning results [2].

Programmable logic control (PLC) is one of the productive subjects that must be mastered by VHS students of electric power installation. It is a system of equipment used to control a device using a logic circuit that can be programmed as required [3]. PLCs resemble easy-to-use electronic computers that have a control function for the various difficulty levels. It is used in several industrial control contexts, such as in tobacco industry, automotive, petrochemical, paper production and mining industry conveyors [4].

The lack of PLC learning media, which can represent real industrial conditions, may mean that the purpose of the learning process is not achieved optimally. As a result, only a small number of VHS graduates may be employed by industries. The objective of this article is to discuss the development of a prototype of a PLC-based industrial machine control system as a learning medium for VHS students. The controlled object in this article is a conveyor, which is used to provide indoor transport that can be installed and adjusted based on a desired distance [5].

METHOD

The selected media development, ADDIE stands for analysis, design, development/production, implementation and evaluation [6][7]. This method is able to create an innovative, authentic and effective student-based learning experience [8]. This model can be used for a variety of forms, such as a model of product development, learning strategy, learning methods, media and teaching materials.

In the analysis stage, observation generates information about the learning process, tools and materials. For PLC as observed, students still do not know about the industrial PLC. As a result, development of PLC as learning media is critically needed.

The next step is design. Based on the analysis, this medium consists of two conveyors (see Figure 1), controlled by Omron CPM2A. CX-ONE 9.3 is used to program the ladder diagram of the operational process and transfer it to the PLC. The working process is described as follows:

- When the *ON* button is pressed down, the conveyor belt (DC motor 1), roller (DC motor 2), cutter machine (AC motor) are *ON*.
- When the pipe is detected by the first sensor (1 logic), the pipe holder (DC motor 3) moves downwards and DC motor 4 pushes on as the AC motor cuts the pipe. While the pipe is cut (first sensor = 0 logic), DC motor 3, DC motor 4 and the AC motor move back to their first position. DC motor 4 is switched off by the fifth sensor while the AC motor is still *ON*.
- After cutting the pipe, the cut pipe glides to the first box activating the second sensor (at the pipe glider), as well as the counter. While the counter is less than four the second process is repeated.
- When the counter reaches four, the second conveyor (DC motor 5) moves the first box on to the end of the belt. After that, the second box is moved and stopped right at the glider. The stopping process is done by the third sensor.

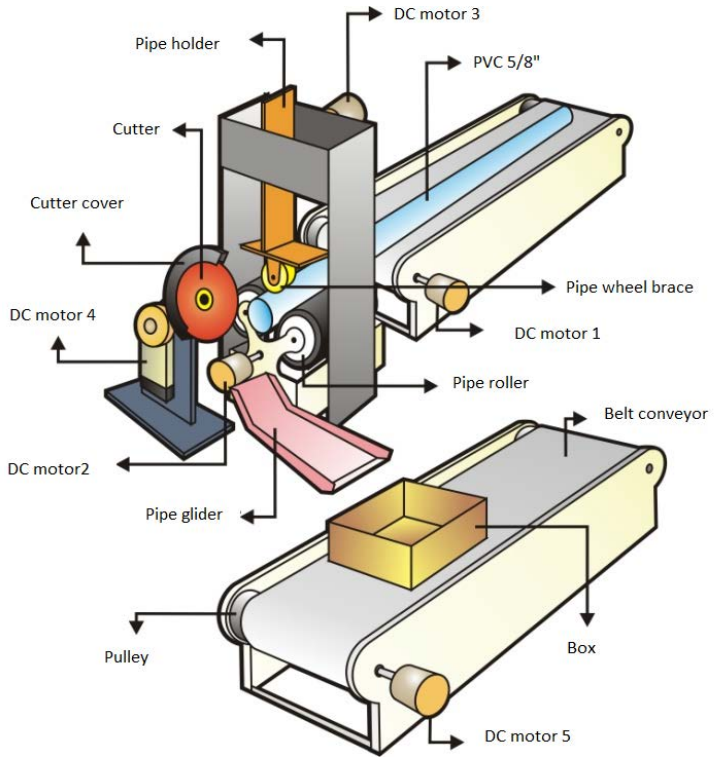

Figure 1: Sketch of the media design.

The third stage is development. The development is the realisation phase of the design and production of a learning medium. The designed medium will be validated by media and materials experts.

The next stage of ADDIE is implementation. This implementation will be carried out if the process of development has been completed and revised by experts. The purpose of the revision is intended to acquire a better result for media perfection. This model is tested by various groups of students, and is detailed as follows:

- Individuals test: three students.
- Small group test of eight students.
- A major group test of 24 students.

Evaluation is the last phase of ADDIE. Media evaluation is addressed to media experts, materials specialists and VHS students. Expert testing should be done before the media are tested by vocational students. The test uses a questionnaire to determine the designed media feasibility.

The obtained data are both quantitative and qualitative data. Quantitative data in this study were obtained from the media expert, materials expert and students. The equation that is used for quantitative data processing for any questionnaire item is in the following form:

$$V = \frac{TSEV}{S-max} \text{ x } 100\% \quad (1)$$

where:

V = Validity/percentage;
TSEV = Total score of empirical validation in one item;
S-max = Expected maximum score/ideals in one item.

The equation used for quantitative data processing items is the expressed as follows:

$$V = \frac{\Sigma TSEV}{\Sigma S-max} x\ 100\% \quad (2)$$

The developed media can be said successful, if the score reaches the minimum value of V and is not less than 70.01% [9]. Qualitative data in this article are experts' responses, critics or suggestions.

Table 1: Validation criteria analysis in percentage.

Category	Percentage level	Validation level
4	85.01% - 100.00%	Can be used without revision
3	70.01% - 85.00%	Can be used with minor revisions
2	50.01% - 70.00%	Cannot be used
1	01.00% - 50.00%	Prohibited use

RESULTS

Based on the ADDIE development model, the test was carried out with the implementation of prototype conveyor media. Figure 2 is a bar chart of the validation results of media experts, materials specialists and VHS students. The picture shows that the designed medium can be used without revision.

The media expert validation result obtained was 79.16% and it may be used with minor revisions. The expert advice was to add the pipe line to conveyor A. It will guarantee that the pipe moves straight forward to the cutter. On the other hand, the materials expert said that the medium can be used for learning without any adjustment. From an individual, a small group and a large group of VHS students, it can be generally concluded that the medium is applicable without modification.

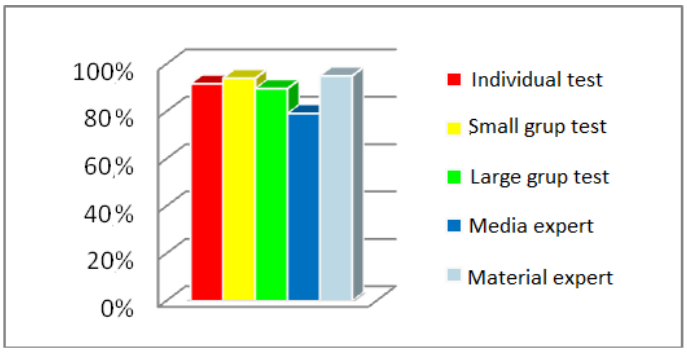

Figure 2. Graph of test results.

ANALYSIS

Media expert validation average percentage is shown in Table 2. It shows the quantitative analysis of the media expert. The data collection obtained different percentages of the measured indicators. It shows that the medium appearance and attractiveness obtained the highest percentage (88%) compared with other indicators. It is because of the neatness of packaging cables, as well as the colour and cover design, picture, and clarity of the manual book.

Table 2: Quantitative data of media expert.

No.	Indicator	Percentage	Information
1	Simplicity	80%	Can be used with minor revisions
2	Explication	75%	Can be used with minor revisions
3	Appearance	88%	Can be used without revision
4	Attractiveness	88%	Can be used without revision
5	Compatibility	78%	Can be used with minor revisions
6	Effectiveness	75%	Can be used with minor revisions
	Average	81%	Can be used with minor revisions

The results of the media validation by the materials expert (Table 3) obtained a similar percentage rate for all the measured indicators. Based on media simplicity, explication, attractiveness, compatibility and completeness, it can be judged that the designed media can be used without any revision.

Table 3: Quantitative data of materials expert.

No.	Indicator	Percentage	Information
1	Simplicity	100%	Can be used without revision
2	Explication	93.75%	Can be used without revision
3	Attractiveness	100%	Can be used without revision
4	Compatibility	100%	Can be used without revision
5	Completeness	87.5%	Can be used without revision
	Average	96.25%	Can be used without revision

Table 4 shows that all the respondents agreed on the medium's simplicity (92%) and clarity (92%). Media attractiveness was rated at 100%, because of the nice appearance and colour of the manual. Lastly, the respondents agreed that the features of the designed medium were compatible with the learning goals of the PLC subject.

Table 4: Results of student validation testing.

No.	Indicator	A	B	C	Information
1	Simplicity	94%	95%	89%	Can be used without revision
2	Explication	95%	93%	90%	Can be used without revision
3	Appearance	88%	92%	89%	Can be used without revision
4	Attractiveness	100%	97%	88%	Can be used without revision
5	Compatibility	88%	94%	91%	Can be used without revision
	Average	93%	94%	89%	Can be used without revision

Note: A - individual; B - small group; C: - large group

CONCLUSIONS AND RECOMMENDATIONS

This research aimed to develop an industrial machine control using PLC as a learning medium for VHS students of electrical power installation. Based on the results, it can be concluded that the product can be used satisfactorily in PLC learning activities both by teachers and students to achieve optimal learning objectives and goals. In the future, this learning medium can be implemented into a more advanced system, such as automatic sorting mechanism, packaging machine or box stamps. The development of associated teaching materials of this medium, such as handouts, job sheet and a laboratory module, may have tremendous potential to improve the medium's use; hence, it is intended to carry out future research in this area.

REFERENCES

1. Arsyad, A., *Media Pembelajaran*. Jakarta: Raja Grafindo Persada (2014).
2. Nurhasanah, W.F., *Media Merupakan Sahabat Guru Dan Siswa*. Jember: Universitas Jember (2013).
3. Said, H., *Aplikasi Programmable Logic Controller (PLC) dan Sistem Pneumatik pada Manufaktur Industri.* Yogyakarta: C.V Andi Offset (2012).
4. Anahar, W., *Pemanfaatan Programmable Logic Controller dalam Dunia Industri*. Yogyakarta: C.V Andi Offset (1998).
5. Hadiwinoto, H.,. *Alat Angkutan dalam Kegiatan Penembangan*. Jakarta: PT. Binahati (1983).
6. Mulyatiningsih, E., *Pengembangan Model Pembelajaran*, 17 May 2015, http://staff.uny.ac.id/sites/default/files/ pengabdian/dra-endang-mulyatiningsih-mpd/ 7cpengembangan-model-pembelajaran.pdf
7. Pribadi, B.A., *Model Desain Sistem Pembelajaran*. Jakarta: Dian Rakyat (2011).
8. Branch, R.M., *Instructional Design the ADDIE Approach*. London: Springer Science+Business Media (2009).
9. Akbar, S. and Sriwijaya, H., *Pengembangan Kurikulum dan Pembelajaran Ilmu pengetahuan Sosial (IPS)*. Yogyakarta: Cipta Medika (2010).

BIOGRAPHIES

Syaad Patmanthara is a senior lecturer in the Department of Electrical Engineering at the State University of Malang (UM). He received both his Master and Doctoral degrees in learning technologies from the UM. Dr Patmanthara's research interest is application of technology in learning, education and training.

Aji Prasetya Wibawa obtained his PhD in electrical and information engineering from the University of South Australia (UniSA) in 2013. He has been teaching electrical engineering and informatics subjects in the Department of Electrical Engineering at the State University of Malang since 2005. Dr Wibawa's research interests are artificial intelligence, system analysis and design, renewable energy and mobile learning. Recently, he focuses on his main research topic of machine translation for preserving Indonesian traditional languages.

Sri Rahayu was born in Malang in 1992. She has a Bachelor degree in teaching electrical engineering from the State University of Malang (UM). From her undergraduate study, she attended several academic and entrepreneurship seminars as an author, which also indicates her interest in research.