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Development of Learning Media (Programmable Logic Controller) as a Case Study of Sorting Machine Applications on Electronics Engineering Education Study Program Faculty of Engineering Universitas Negeri Yogyakarta

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Abstract. ***Today many industries use sophisticated controller technologies such as Programmable Logic Controller (PLC). The PLC Practicum course in the Electronics Engineering Education Study Program of Universitas Negeri Yogyakarta (Yogyakarta State University) requires learning media that can provide real experience in operating an industrial control. The research employed Research and Development with development procedures including: (1) potential and learning problems, (2) data collection, (3) product design of the sorting machine, (4) design validation, (5) design revision, (6) product trials, (7) product revisions, (8) expert judgment and users trial, and (9) product revision. The data collection techniques were interviews with PLC lecturers. The instuctional media created include PLC trainer, jobsheets, and manual books as student guidelines. The results of the study revealed that: (1) the PLC learning media consisted of five input and output blocks, namely push buttons, PLCs, sensors, conveyors, and indicator lights and equipped with jobsheets and manual books, (2) the performance of the PLC instructional media worked well on each block and as a whole, (3) the feasibility level of instructional media obtained the percentage of 90.6%, the feasibility level of the material was 88.2%, and the feasibility level based on the user was 83.6%. Based on these results it can be concluded that the media PLC learning is very suitable to be used in PLC practicum courses.***

I. INTRODUCTION

Currently, sophisticated control technologies, such as Programmable Logic Controller (PLC), are utilized by many industries. PLC can be defind as a controlled system that works based on logical instructions according to the desired conditions. It is not only able to control heavy works in the industry, but it is also easy to be used. Another benefit of this system is its affordable price. The functions of PLC in general include: (1) Skuential control that is to process binary signal input into an output for sequential processing and this process will maintain all processing steps in the right order, (2) Monitoring Plant that is to monitor the system status and take necessary actions related to the process being controlled. One of the industry works that certainly rely on PLC in its implementation is sorting machines. This activity can be controlled by PLC and only require a few human roles.

The industrial revolution 4.0 raises the importance to learn the industrial technology among students, especially on PLC. The PLC practicum course has been a cumpulsory course that must for the bachelor students of the Electronics Engineering Education Program, particularly those who majored or concentrated on Industrial Electronics. This course aims at introducing students to what is related to industrial control and how the system control in the industry works. To optimize the learning of the rapid development technology in industy, learning media are required. The media can provide simulations from the concepts and theories given by lecturers in order to make sure it is clearly understood by students. Learning media refres to all things that can be used to channel messages from the sender to the recipient to stimulate the students' thoughts, feelings, attention, interests, and willingness during the learning process in order to achieve learning objectives (Sukiman, 2012).

Based on the observations results in the Electronics Engineering Education Department, Universitas Negeri Yogyakarta (Yogyakarta State University), there are information obtained related to PLC course including (1) the learning media of PLC practicum courses are still in the form of PLC hardware and input-output modules only that is no media that applies on the industrial control system in real terms, (3) the malfunctioning PLC in the I / O section, (4) the limited number of PLC, (5) the limited PLC version, OMRON version only, (6) the broken downloader cable. This circumstance stimulates the low competency among the students in implementing industrial control systems. It arouses the researchers' interst to develop PLC learning media that are expected to enhance the learning process in order to improve the competency among electronics students in implementing PLC-based industrial control systems.

II. RESEARCH METHOD

The product was designed by considering the needs of the PLC practicum course in Electronics

Engineering Education Study Program, Faculty of Engineering, Yogyakarta State University. The program algorithm design, simulation and sensor scheme were designed using CX-Programmer and Proteus version 8.5. Meanwhile, the product graphic design was created using Corel Draw X7 software. The product design consisted of trainers, practical module books and manual books. PLC learning media contained sensor and push button inputs and outputs with servo motors, conveyors and indicator lights. PLC learning media can be programmed using a computer and PLC console. The concept of PLC learning media design can be seen in Figure 2, which explains the PLC learning media briefly.

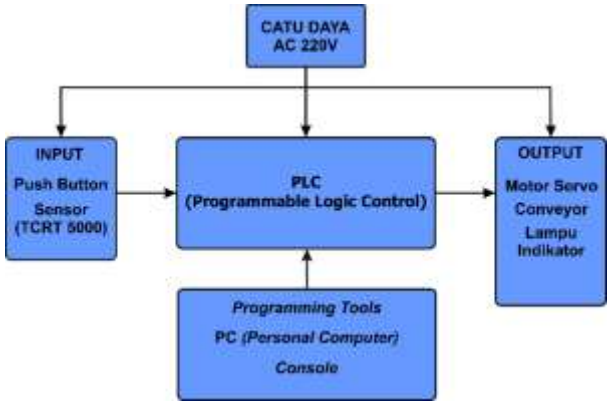

Fig. 1. Diagram Block of PLC Learning Media

The developed product had been validated to determine and evaluate the initial product. In this stage, the validation was performed by lecturers as the experts of media and material of PLC learning in Electronic Engineering Education Study Program, Faculty of Engineering, Unversitas Negeri Yogyakarta. They assessed the design of PLC learning media to reveal the appropriateness of the design for PLC learning courses. The next stage was the design revision to improve some deficiencies in the product produced.

After validating the design and improving the product design, the next was to realize the product design, both hardware and print media for product trials. The initial stage of the trial was carried out by simulating the use of the product in a limited group. The trial was conducted by material and media experts to determine the level of product feasibility. Based on data that had been obtained from the results of product testing, there were errors and limitations of the product. Those were documented and became the guidlines for product revision to improve its feasibility and quality of PLC learning media before it was tested on a higher and broader scope.

After some revision had been made, the broader trial was done to review its deficiencies that may still exist. In this step, the product was directly tested to 39 students who joined PLC practicum courses in the Electronic Engineering Education Study Program, Faculty of Engineering, Unversitas Negeri Yogyakarta. The students completed the jobsheet and applied the job to learning media in groups.

This study describes the actual state of the object under study so that it is not intended to test certain hypotheses. The data analysis technique was descriptive qualitative to present the media product and its design of learning media after the implementation stage and product feasibility test.

The qualitative data obtained was then converted into quantitative data using a Likert scale from very positive to very negative responses that was realized in a variety of answers including “Strongly Agree” (SA), “Agree” (A), “Disagree” (D), and “Strongly Disagree” (SD). Then, those answers were converted in the form of the score as the measurement scale consisting of 4,3,2,1.

TABLE I. ASSESSMENT CRITERIA SCOREES

Asssessment	Explanation	Score
SA	Strongly Agree	4
A	Agree	3
D	Disagree	2
SD	Strongly Disagree	1

The data obtained were converted into quantitative data by analyzing the response criteria for each statement. Then, to formulate the percentage of media feasibility, those were calculated with the formula below.

$$\overline{x} = \frac{\sum x}{n}$$

Explanation:

$\overline{x}$ = Mean scores
n = Number of assesors
$\sum$x = Total score in each item

Meanwhile, the following is the formula to find the percentage of feasibility.

$$Feasibility\ \% = \frac{Real\ scores}{Expected\ scores} x\ 100\%$$

After the feasibility percentage was obtained, the value was changed into the predicate statement referring to the statement of circumstances, i.e. the feasibility quality or the rating scale. With the rating scale, the raw data obtained in the form of numbers was then interpreted qualitatively as presented in Table 2 according to Sugiyono (2017:97).

TABLE II. FEASIBILITY PERCENTAGE

Percentage Score	Category
0 – 25%	Very Unfeasible
>25 – 50%	UNfeasible
>50 – 75%	Feasible
>75 – 100%	Very Feasible

The validity testing of the instrument was done through two stages, i.e. the content and construct validity. In this study, the experts who tested the instrument were the lecturer of Electronics Engineering Education, Unversitas Negeri Yogyakarta who had expertise in PLC materials and media. After consulting with the experts, the following formula was used to find out whether each item was valid or not,

$$r_{xy} = \frac{n\sum X_i Y_i - (\sum X_i)(\sum Y_i)}{\sqrt{\{n\sum X_i^2 - (\sum X_i)^2\}\{n\sum Y_i^2 - (\sum Y_i)^2\}}}$$

Explanation:
n = Number of X and Y data pairs.
ΣX = Amount of X variable
ΣY = Amount of Y variable
ΣX2 = Square of the total amount of X variable
ΣY2 = Square of the total amount of Y variable
ΣXY = Multiplication results from the Amount of Variable X and Variable Y.

The instrument for reliability test in this study employed the Alpha formula with the following Alpha formula (Arikunto, 2008).

$$r_{11} = \frac{k}{(k-1)}\left\{1 - \frac{\Sigma\sigma_i^2}{\sigma_t^2}\right\}$$

Explanation:
r_{11}= reliability
$\Sigma\sigma_i^2$= number of score variable for each item
σ_t^2= total of variable

III. RESULTS AND DISCUSSION

TCRT 5000 sensor driver was made using components that aim to reduce the voltage and current which exceeded. This driver was made because the voltage from the power supply was 24 volts 5 amperes. The sensor driver layout can be seen in ImageFig. below.

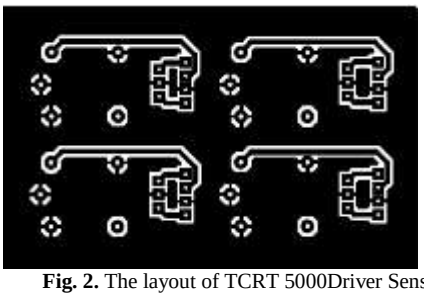

Fig. 2. The layout of TCRT 5000Driver Sensor

The control panel was made using wood and plywood with a thickness of 3mm and it was formed using a laser based on the panel design. The panel consisted of PLC, 24 VDC pilot lamp, push button, motor power window, banana plug, switch and fuse for a safety purpose. The material used to make the conveyor frame was trellis iron with a thickness of 3mm along 90 cm with aheight of 10 cm, while for roll used to support the conveyor belt was 15cm from the axle.

Conveyor belts were used to carry items to be selected, this belt was made from fabric that is sewn 80cm long and 12cm wide. The conveyor belt was driven by a power window motor mounted on the panel, and a belt was used to connect the power window motor to the conveyor. The components in the conveyor frame were the servo motor which was used to throw things to the container, and the TCRT 5000 sensor to read the dimensions of the goods carried by the conveyor

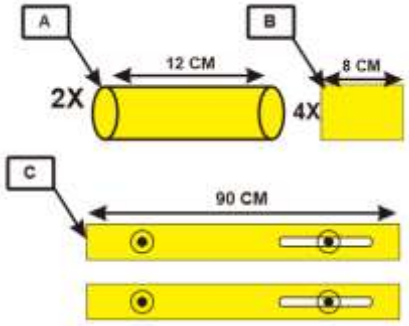

Fig. 3. Conveyor Design

The parts of the above conveyor design including
A: 2 units of 12 cm long conveyor rollers.
B: 4 pieces of 4 cm tall conveyor frame legs.
C: 2 conveyor frames of 90 cm length

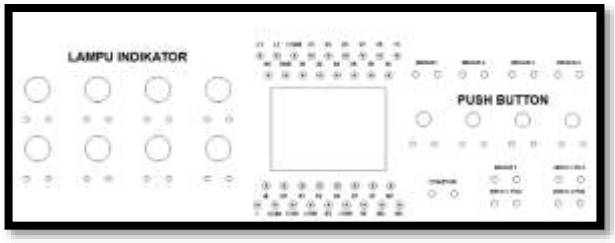

Fig. 4. Control Panel Design

Fig. 5. The appearance of the learning media

The jobsheets or worksheets for students contained assignments or instructions that must be done by students. The assignments consisted of (1) title, (2) competencies to be achieved (3) completion time, (4) tools and materials needed to complete the

task, (5) brief information / theoretical basis, (6) working procedure, (7) tasks (Fery Setyawan, 2014). This jobsheet also showed the instructions to use the learning media including 5 parts, i.e. 1) PLC introduction, 2) Basic PLC instructions, 3) CX-Programmer Software introduction, 4) CX-Designer introduction, 5) Application of industrial sorting machine control.

Fig. 6. Jobsheet of PLC learning media

The learning media trial was done to find out whether the learning media can work well. The tests were performed on the blocks of 1) Power Supply, 2) Pilot Lamp, 3) Conveyor, 4) Sensors, 5) Push Button, 6) Servo, 7) Motor Power Window, 8) PC and PLC connections. The testing results in each block was using the percentage error of 0%. After testing each block, the next test was overall testing by applying the sorting machine program for 20 times. The overall trial results obtained a percentage error of 5%.

Based on the results of the construct validation test from media experts towards the learning media in case of its appearance, technical aspects, and overall benefit aspects, it was obtained a value of 91.7%. Based on the acquisition of these values, the PLC learning media can be declared "very feasible" to be used as a learning media on PLC practicum courses in the Electronic Engineering Education study program, Faculty of Engineering, Universitas Negeri Yogyakarta.

Meanwhile, the results of the content validation from material experts towards the learning material showed that the feasibility of the PLC learning media in terms of the material quality was in the percentage of 85.9%. When viewed from the aspect of expediency it gets results of 86.1%. Based on the acquisition of these values, the PLC learning media is declared very feasible to be used as a learning media on PLC practicum courses in the Electronic Engineering Education study program at the Faculty of Engineering, Yogyakarta State University. Usage test results obtained an average value with a percentage of 84.1%. Based on these results, it can be concluded that PLC learning media can be categorized as "very feasible".

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