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Shorting Machine Trainer Based on Programmable Logic Controller OMRON as Learning Media for Controller and Robotics Subjects

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ABSTRACT

The purpose of making a Programmable Logic Controller-based shorting machine trainer is as a development of learning media in schools related to control and robotics subjects. The method used in the development of this media is the Research and Development Method. The stages carried out are (1) potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) product trial, (7) product revision . This trainer consists of 14 components namely Programmable Logic Controller, Power Supply, Push Button, Pilot Lamp, emergency button, infrared sensor, 24V DC motor, inductive proximity sensor, capacitive proximity sensor, Mini Circuit Breaker, relay, solenoid valve, pneumatic cylinder, and water filters. The results of the trainer content validity test as a whole get an assessment of 0.13 included in the very valid category. Meanwhile, for construct validation testing, a rating of 0.38 was included in the very valid category. The results of the trainer practicality test as a whole which were assessed by students obtained a practicality percentage rating of 90.83 included in the very practical category.

Keywords: *Trainer, Shorting machine, Programmable Logic Contoller, Controller, Robotics.*

1. INTRODUCTION

especially in the era of the industrial revolution 4.0, are experiencing very rapid progress, especially the technology used in industry. Vocational High School or SMK is an educational forum to produce ready-to-use secondary workers needed in industry. In line with the development of this technology, SMKs whose subject matter is mainly Productive material that has been designed in the curriculum must be able to be taught to students according to the demands of the industrial world. For this reason, we need a learning media in the form of a trainer whose shape has been designed and made as well as possible so that the components installed on the trainer are functioning according to the desired goals, so that students more quickly understand how the components used in the control system work and robotics. The real influence that is easy to see in the world of education, especially in the Technology and Industry group of Vocational Schools, is that schools tend to compile and apply and provide learning materials that are in line with industry needs, namely link and match that students not only have the opportunity to get quality education, but after graduation can job opportunities in Industry. Programmable Logic Controller (PLC) is an important component in the implementation of industrial automation systems, namely as a control device in the industry. Because the PLC is an easy tool to use and program, namely using a ladder diagram, it can help companies carry out complex tasks and increase production flexibility, reduce production costs and simplify control system components such as counters and timers [4]. In addition, an HMI (Human Machine Interface) system is also available so that it can monitor PLC performance.

In the subject of Controller and Robotics students learn and prepare themselves to be able to recognize and master the concept of pneumatic systems, understand the components used to make electropneumatic circuits, understand the concept and workings of solenoid valves, understand the concept of robotic control systems, namely understanding the main component data of

robots/ Modular Production System (MPS) uses PLC, understands the order of operation of MPS robots, and makes MPS robots manually or automatically. Most of this material can be learned through a media trainer.

Learning media is a means that can support the achievement of learning objectives. Based on the results of observations of the implementation of learning activities and the use of tools to support practical activities in schools, it shows that the use of practical tools in learning is not optimal in helping to achieve lesson objectives. The trainer used as a medium in practice is still simple. Like a pneumatic trainer, students only practice connecting the air hose from the compressor to the pneumatic valve, controlling the flow and direction of air in the solenoid valve manually without combining it with other sensors such as metal detection sensors and distance detectors as well has not used an integrated control system using PLC, so it has not directed students to critical, creative and independent thinking processes. Based on this, to support the implementation of good practice in schools, it is better if the learning media used is a trainer that resembles an industrial automation control system, so that students can understand concretely the control system in the industry and more quickly understand the subject matter taught by the teacher about control and robotic system components and how they work.

The trainer is a set of equipment in the laboratory that is used as a practicum facility. Trainers are intended to support the learning process of students in applying the knowledge/concepts they acquire to real objects. Real objects or model objects that are very similar to real objects will provide a very important stimulus for students in learning tasks involving psychomotor skills [1].

Learning media is anything that can be used to convey messages (learning materials), so that it can stimulate the attention, interest, thoughts and feelings of students in learning activities to achieve certain learning goals. Learning media includes all the resources needed to communicate in learning. This can be in the form of hardware and software used [5].

2. METHOD

The method used for the development of instructional media is Research and Development (R and D), which is a strategy or research method that is powerful enough to improve practice. This research and development is a process or steps to develop a new product or improve existing products and can be accounted for. The model used in this development is a procedural model, namely a model that is descriptive in nature and outlines the development steps that are tailored to the needs of the researcher. The steps that must be followed to produce a product include the stages: potentials and problems, data collection, product design, design validation, product design revisions, product trials, product revisions, usage trials, product revisions, and mass production [6]. In the form of blocks can be seen as shown in Figure 1 below.

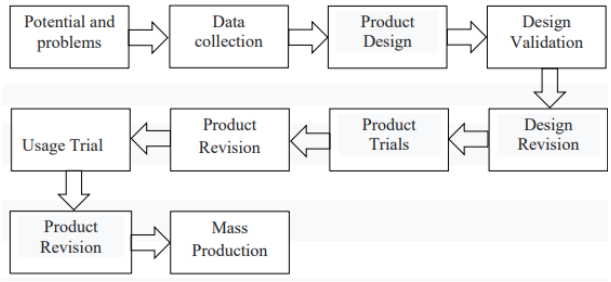

Figure 1. Research and Development Procedures

In this study, the researchers limited the 7 steps of developing the OMRON Programmable Logic Controller (PLC)-based Shorting Machine Trainer learning media to be developed, namely (1) potential and problems, (2) data collection, (3) product design, (4) validation design, (5) design revision, (6) product trial, (7) product revision.

Data was collected using a questionnaire filled out by the material expert validator, media expert validator, and practicality validator. Validity testing is a test of content validity and construct validity. Content validation was tested by material expert lecturers in the field of PLC and control systems and robotics subject teachers which included two aspects of assessment namely content quality, objectives and learning quality. Construct validation was tested by learning media expert validators which contained two aspects of assessment, namely technical quality and usefulness. The practicality of a media is used to measure how practical the learning media that has been made is. The practicality of learning media includes 5 aspects namely: ease of use of media, time effectiveness, media interpretation, product attractiveness and equivalence [3].

Lawshe's Content Validity Ratio (CVR) data analysis was used to identify the validity of each validity questionnaire item, assessing the developed OMRON Programmable Logic Controller-Based Shorting Machine Trainer learning media. The CVR method has been widely used to measure content validity by measuring agreement between learning media experts in assessing the importance of an assessment item, these media experts are referred to as subject matter experts (SME) [2]. The formula proposed by Lawshe to calculate the Content Validity Ratio (CVR) is as follows:

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

CVR = *Content Validity Ratio*
n_e = The number of validators who answered is important

N = Total number of validators

This formula will produce values ranging from -1 to +1. A positive value indicates that the opinion of experts about an assessment item is considered important and a minus value indicates that an assessment item is considered unimportant [2]. After obtaining the CVR values of all assessment items, Content Validity Index (CVI) analysis is used to calculate the average value of all items assessed by the validator using the formula:

$$CVI = \frac{\sum CVR}{\sum Rating\ items} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Furthermore, the values obtained are interpreted into practicality categories [7] as shown in table 1.

Table 1. Product Practicality Interpretation Category

No	Achievement Rate (%)	Category
1	81 - 100	Very Practical
2	61 – 80	Practical
3	41 – 60	Pretty Practical
4	21 – 40	Less Practical
5	0 - 20	Impractical

3. RESULT AND DISCUSSION

The following is an explanation of the stages that have been carried out in the development research of the OMRON Programmable Logic Controller-Based Shorting Machine Trainer as a learning medium in the subject of control and robotics

3.1. Potential and Problems

3.1.1 Problems Experienced

The range of CVI calculation results is -1 < 0 < 1, thus the CVI numbers obtained from the calculation will be categorized as follows [8]:

-1 < x < 0 = Invalid
0 = Valid
0 < x <1 = Very valid

After the data was obtained from the results of the trainer's practicality assessment by practitioners, namely teachers of control systems and robotics subjects. This value is analyzed for its practicality using the formula:

$$\text{Practical value} = \frac{Score\ obtained}{Maximum\ score} x\ 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Based on the results of observations and interviews with control and robotics subject teachers in schools, it was found that trainers in schools were still simple and did not use an integrated control system using PLC.

3.1.2 Overcoming Potential

Based on these problems, it becomes the background for developing an OMRON Programmable Logic Controller-Based Shorting Machine Trainer as a learning medium in control and robotics subjects. This trainer is superior to the previous trainer because it represents more real forms in the industry. This trainer is a metal and non-metal separator (shorting machine) integrated with sensors as an input system, a Programmable Logic Controller (PLC) as a control system, and a pneumatic system as an output system in one complex system.

3.2. Data Collection

Data was collected through direct observation and interviews with control and robotics subject teachers related to the learning media used and analyzed and identified them.

3.3 Product Design

After finishing collecting the necessary data, then do the initial design of the trainer as shown in Figure 2 below:

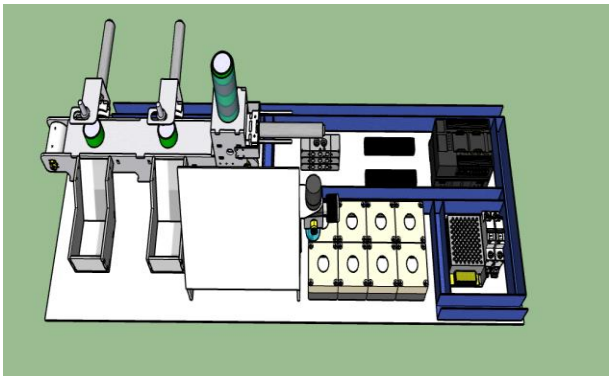

Figure 2. Initial Trainer Design Drawing

3.4 Design Validation

Based on the results of this product design, the initial trainer design must be validated, whether it is in accordance with the objectives and content of the controller and robotics subject matter, then an assessment is carried out. The validation results of the OMRON Programmable Logic Controller-Based Shorting Machine Trainer design developed include:

1. The trainer must have a clear and detailed indication of the name of the component
2. Adding a relay to the output on the PLC in order to control the on and off of a 24VDC DC motor.

3.5 Design Revision

Then the design revision is carried out and proceed to product manufacture. The results of the revised design can be seen in Figure 3 below.

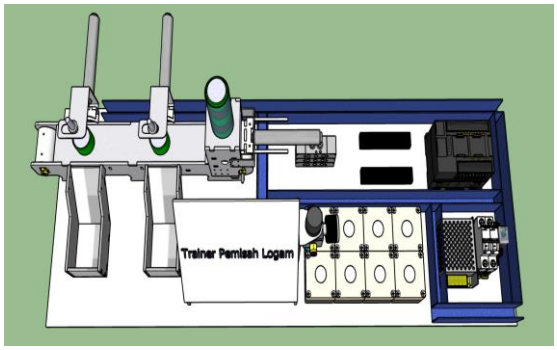

Figure 3. Results of Design Revision

The trainer consists of 14 main control system components namely PLC, power supply unit, push button, pilot lamp, emergency button, infrared sensor, 24VDC DC motor, inductive proximity sensor, capacitive proximity sensor, miniature circuit breaker (MCB), relay, solenoid valves, pneumatic cylinders and air filters. The integration of all these components resulted in a learning media trainer that was developed, namely the Modular Production System (MPS) separating metals and non-metals.

The seat of the OMRON Programmable Logic Controller-Based Shorting Machine Trainer is made of boards 2 cm thick, 120 cm long and 50 cm wide. The form of learning media trainers created can be seen in Figure 4 below.

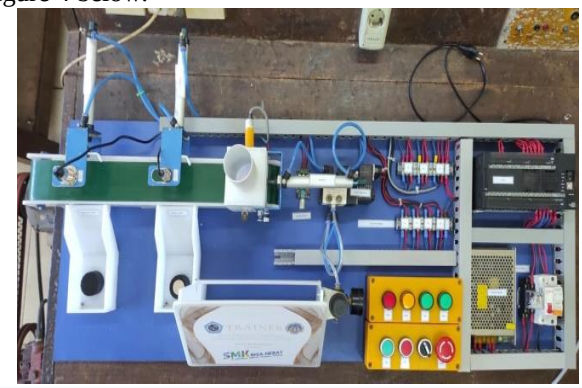

Figure 4. The results of making the OMRON PLC Based Shorting Machine Trainer

The module is a learning material that is used to convey learning material, in this case material related to control systems and robotics (figure 5).

3.6 Product Trials

After the trainers and modules have been made, the next step is to test the product. Product testing is carried out in two stages, namely: product performance testing and product usage testing. The product performance trial aims to test each component used in the trainer whether it is running as expected or not. Meanwhile, product usage tests include validity tests by experts and practicality tests by users, namely students.

Figure 5. OMRON PLC Based Shorting Machine Trainer Module Cover

3.6.1 Product Performance Trials

Product performance trials were carried out by the researchers themselves, namely by testing each component used in the developed PLC trainer. The components tested are: OMRON PLC, power supply, pilot lamp, push button, emergency button, conveyor motor, infrared sensor, inductive proximity sensor, capacitive proximity sensor, solenoid valve and pneumatic cylinder.

3.6.2 Product Usage Test

The product usage test is a stage of testing the validity and practicality of the OMRON PLC Based Shorting Machine Trainer learning media. Validity testing consists of two tests, namely: 1) content validity testing assessed by control and robotic subject teachers, 2) construct validity testing, namely testing the appearance of the developed media assessed by learning media expert lecturers. While practicality testing on trainers is carried out by students who are studying control and robotics subjects.

Validity Results

This stage aims to obtain validation results by conducting demonstrations or testing the use of trainers in front of the validator, as well as providing an assessment questionnaire for learning media trainers.

Content Validity Results

Content validity is in the form of the validator's response to the learning media developed in accordance with the questionnaire provided. There are two aspects of the assessment carried out by the validator, the first is the

quality of the content and objectives and the second is the quality of learning.

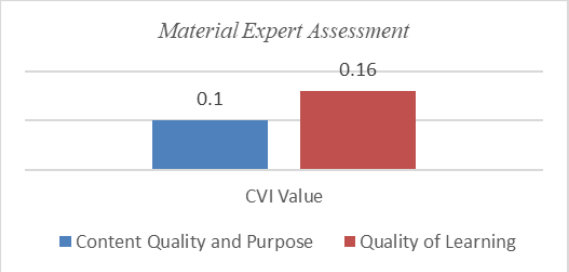

Figure 6. Results of Material Expert Assessment

Construct Validation Results

Construct validity is in the form of the validator's response to the learning media developed in accordance with the questionnaire provided. There are two aspects of the assessment carried out by the validator, namely technical quality and usefulness.

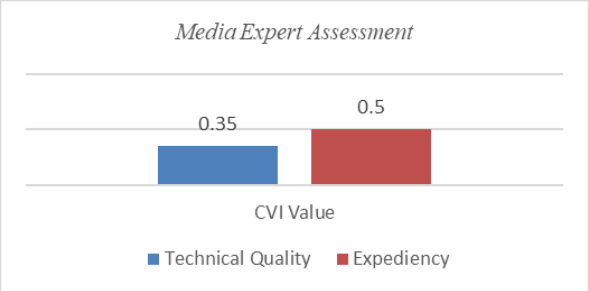

Figure 7. Results of Learning Media Expert Assessment

Practical results

This stage aims to get the results of the developed trainer practicality assessment. The way to carry out an assessment is to do a trainer test that was developed during the learning process, then give a trainer practicality assessment questionnaire to students. Learning materials prepared to support trainer testing during the learning process are learning modules.

The results of the practicality test by 10 students can be seen in Figure 8 below.

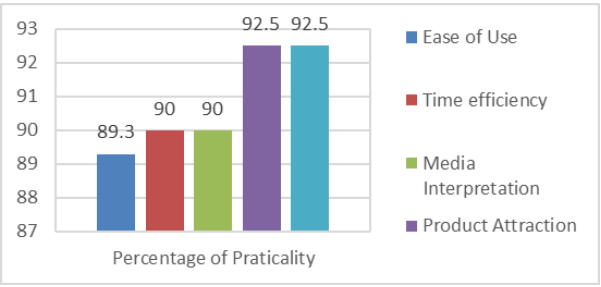

Figure 8. Percentage of practicality tests by students

Product Revision

Based on the results of content validation by learning material expert teachers and construct validation by learning media expert lecturers, the trainers developed did not experience revision. Based on the results of trials using trainers in schools during the learning process to find out the level of practicality assessed by students also did not experience revision. Learning modules get input from control and robotics subject teachers, namely adding job sheets to the module.

4. CONCLUSION

Research and development carried out to develop existing trainers into OMRON PLC-Based Shorting Machine Trainers can be summarized as follows: 1) This trainer consists of 14 main control system components namely PLC, power supply unit, push button, pilot lamp, emergency button, infrared sensor, 24VDC DC motor, inductive proximity sensor, capacitive proximity sensor, miniature circuit breaker (MCB), relay, solenoid valve, pneumatic cylinder, and air filter. The size of the trainer consists of a length of 120 cm and a width of 50 cm with the material being made of a board with a thickness of 2 cm. The conveyor material is made of acrylic which has strong resistance to impact, shock and vibration. Information in the form of component names is made with laminated stickers so that trainers have clear instructions and can add to the attractiveness of students to learn. In addition, the trainer is also equipped with modules to facilitate the learning process. 2) The results of the content validity test of the OMRON PLC-Based Shorting Machine Trainer as a whole obtained an assessment of 0.13 included in the very valid category. As for the construct validation test, it gets an assessment of 0.38 which is included in the very valid category. So it can be interpreted that this trainer is very valid to be used as a control and robotic learning media. 3) The results of the trainer practicality test as a whole assessed by students get a practicality percentage rating of 90.83 included in the very practical category. So it can be interpreted that the OMRON PLC-Based Shorting Machine Trainer is very practical to use as a learning media for controllers and robotics.

Based on the results of research, discussion and conclusions, the suggestions that can be given are: 1) To the next researcher to measure the level of trainer effectiveness on student learning outcomes. 2) In order to integrate more control and robotic components, such as by adding a human machines interface (HMI).

REFERENCES

[1] Anderson, A. 1994. Pemilihan dan Pengembangan Media Untuk Pembelajaran. Jakarta: PT Raja Grafindo Persada.

[2] Hendrayadi. 2017. Validasi Isi: Tahap Awal Pengembangan Kuesioner. Jurnal Riset Manajemen dan Bisnis (JRMB). Fakultas Ekonomi UNIAT. Vol. 2 No. 2, Juni 2017: 169-173. DOI: 10.36226/jrmb.v2i2.47

[3] Muhajir, dkk. 2019. Efektifitas Penggunaan E-Learning Berbasis Edmodo Terhadap Minat dan Hasil Belajar (Studi Kasus di SMK Negeri Al Mubarkeya). *Jurnal Pendidikan Teknologi Informasi*. Volume 3, Nomor 1, 1 Maret 2019, Hal 50-56. DOI: 10.22373/cj.v3i1.4725

[4] Risfendra, Sukardi, & Herlin Setyawan. 2020. Uji Kelayakan Penerapan Trainer Programmable Logic Controller Berbasis Outseal PLC Shield Pada Mata Pelajaran Instalasi Motor Listrik. JTEV (*Jurnal Teknik Elektro Dan Vokasional*), 6(2), 48. DOI: https://doi.org/10.24036/jtev.v6i2.108508

[5] Rudy Sumiharsono dan Hisbiyatul Hasanah. 2017. Media Pembelajaran: Buku Bacaan Wajib Dosen, Guru dan Calon Pendidik. Jawa Timur: CV Pustaka Abadi.

[6] Sugiyono. 2012. Metode Penelitian Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta.

[7] Umi Rochayati & Suprapto. 2014. Keefektifan Trainer Digital Berbasis Mikrokontroler dengan Model Briefcase dalam Pembelajaran Praktik di SMK. *Jurnal Kependidikan*, Volume 44, Nomor 2, November 2014. Hal 127-139. Universitas Negeri Yogyakarta. DOI: 10.21831/jk.v44i2.5223

[8] Vizensia Arsanty Nungki, Dkk. 2017. Pengembangan Perangkat Pembelajaran Fisika Berbasis Model Pembelajaran STS dalam Peningkatan Penguasaan Materi dan Pencapaian Kreativitas Peserta didik SMA. *Jurnal Pendidikan Fisika*. Volume 6, Nomor 1, Th. 2017 URL: journal.student.uny.ac.id/index.php/pfisika/article/view/6911/665