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# The Needs Analysis and Design of Programmable Logic Controller Trainer Panel System In Vocational High Schools

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## Abstract

This research aims to develop learning tools in the form of trainer panel system of the subject Programmable Logic Controller (PLC). This paper will discuss the initial part of the study which is planned to be conducted in 3 years time. The early part of the research aims to determine the conditions of learning in vocational majors Electricity PLC, which takes the form of trainers as well as how the initial draft of the form generated by the analysis of needs.
The method used is the research and development, in accordance with the purpose of the initial phase of the study, ie, conduct research studies in vocational learning conditions PLC, needs assesment which form the trainer, as well as the preliminary draft Trainer Panel system.
Research shows that the conditions in vocational learning, especially in the subject matter PLC, is still very low. Conditions there is still a lack of PLC or vocational trainer. Therefore, subject teachers PLC requires a trainer with forms and models of effective and practical.

**Keywords:** Forms of Trainer, Trainer Panel System, PLC, Need assesment

## Introduction

### A. Background

To anticipate the direction of government policy in vocational development in Indonesia, Directorate of Secondary Education Vocational has issued vocational development policy until the year 2020. This policy is leading to the establishment of

educational institutions and vocational training which have both national and international standards. At the end of 2020, it is expected that the number of vocational high schools (SMK- Sekolah Menengah Kejuruan) that have national standard will be 500 schools, and the international standard of 100 SMK [1]. In initial step, some schools have already identified and are eligible to be developed into SMKs that have international and national standard

In fact, this policy is not accompanied by the provision of adequate resources, such as complete the lab equipment. One of the departments in the SMK is the electrical department. Although this course is one of the majors that have already existed in long time ago, but in reality it lags behind in term of technological advances. This happens as the policy to increase the number of vocational high school was not accompanied by increasing the number of vocational additional resources especially in school lab equipment, such as electrical and industrial automation equipment in the lab.

In the industrial automation laboratory, currently, one of the equipments that widely used in industry is Programmable Logic Controller (PLC). Most of complaints in the automation laboratory are the unavailability of PLC's practice equipment. Schools find difficulty to buy it directly as the market price is still very high, especially those come in the form PLC Trainer.

Based on researchers' observations in several vocational high schools, it was found that PLC learning in those schools were far behind if compared with the development of PLC in the industrialized world. The use practical equipments were still lacking and old compared with the existing equipment in the industry today especially the PLC trainer. Most of SMKs have compact PLC trainers , some of them even do not have any trainer. Meanwhile, in industries, they are now using modular (rack) type PLC which consists of modules PLC with very sophisticated used**.**

Based on these problems, researchers took the initiative to develop the Trainer Panel System which is easy to be used by students and teachers at SMK. In addition, the price of the design can be minimized so that all vocational schools can develop and build similar trainers.

In this study, there are several problems that need to be solved which are by first looking at the conditions that exist in vocational learning, analyzing what is needed (shapes, and specifications) that allow practical use in vocational, as well as designing the PLC trainer in the form Trainer Panel system. The design can be developed in accordance with the inputs from teachers that obtained through the analysis of needs, both in terms of shape, position placement, the required specifications to the efficiency of the price and cost development.

The goals to be achieved in this research are to know the condition of PLC learning in vocational schools especially those that majors in electricity, to determine the required shape and specifications of the trainers in electrical department, as well as to design PLC trainers to be used in laboratorium practicum. The benefits are to known the condition of learning in vocational high schools, especially in the matter of PLC that will be beneficial to the development of the vocational school, such as knowing the shape and specifications of corresponding trainer, produce designs that

can be implemented in the form of trainers that can be used by students majoring in electricity.

**b. Literature Review**

According to Iwan Setiawan [2] Programmable Logic Controller (PLC) is basically a computer that is specifically designed to control a process or machine. The controlled process is in the form of rules of continuous variables as in the servo systems or control involves only two states (On / Off) but it is done repeatedly as we commonly encountered in drilling machines, conveyor systems, and so on. A digital computer is used as a programmable controller is also still in its scope, in addition to the type of mechanical sequential controller [3]. PLC is a type of control system that has the input device (input device), the controller (controller) as well as the output device (output device). Equipment connected to the PLC that has function to send a signal to the PLC are called input device. Then the PLC will send a signal output to the output device [4].

Adam [3] revealed that the PLC is one of programmable electronic systems that can be enabled to control and optimize a wide range of equipment that requires a high level of security such as traffic control, patient monitoring, and controlling the production line. PLC has been widely use in the field of process control applications (process control), but the software can turn to be extremely complex. By using the formal specification (formal specifications) to build a block function (function blocks), it can help to improve security of the PLC software and make it easier to be repaired or verified.

As the name implies, the PLC concept can be explained as follows: Programmable refers to its ability that can easily be modified according to the design program and also its ability in terms of program memory that has been made. Logic demonstrates its ability to process input arithmetically (Arithmetic and Logic Unit), which perform several operations such as to compare, add, multiply, divide, subtract, and negation. Finally, controller demonstrates the ability to control and regulate the process to produce the desired output. PLC function according to Ackermann [4] are described as follows:

PLC process the binary signal inputs into outputs that are used for the processing techniques sequentially. Here, PLC maintain all the steps in a sequential process to be in a proper order. For example: a conveyor in a series of automated production. PLC task here is to control all the motors (eg conveyor belt speed), controls the hydraulic or pneumatic components.

PLC continuously monitors the status of a system such as: temperature, pressure, altitude level, flow and take the necessary action in connection with the controlled process (eg, the value has exceeded the limit) or display the message to the operator.

PLC also can be used as an Interface Control in CNC mesin. Recently, most machine tools have already equipped with CNC (Computer Numerically Controller) control, where between machines and CNC controls PLC is needed as an interface. Meanwhile, the advantages of using PLC [4] are: a) it is flexible, meaning that it can control multiple machines only with one PLC; b) can be detected / monitored during operation (running); c) can be documented, which means the program in the PLC

memory may be downloaded for printing; d) can operate very fastly; and e) easily modified without changing the wiring cables. In line with these opinions, Bolton [5] explains that the advantages of PLC compared to other control systems is concise so that the wiring becomes more tidy, pathways of control circuit wiring is replaced with the program contained in the PLC, minimizing the use of relays and it becomes easy to perform scanning and repair error.

The previous research that has done is research on the design of the PLC using Microcontroller, [6] and the development of computer assisted learning in subjects operate machinery production with electromagnetic control, electronic control and PLC control, in the form of an interactive software, which packaged in a Compact Disk (CD) [7]. The results that have been achieved in both study were prototype that built from Microcontroller PLC and PLC learning through computer assistance in the form of a CD.

Development models that used in this study is the Borg and Gall [8], Dick and Carey [9], and Romizsosky [10]. All of these three models were used to strengthen the development of learning tools that have dimensions of learning, information technology and electro technology (controller).

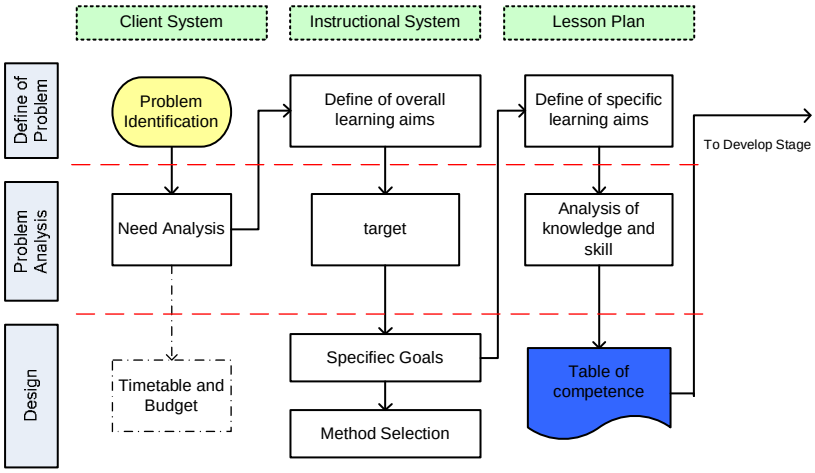


**Figure 1:** The Development Model (adapted from Abdul Muis Mappalotteng [11])

## Methods

The method used in this research is research and development. It refers to Educational Research and Development method which was initiated by the Borg and Gall [8]. Futhermore, the model development used the model based on the reference of Dick and Carey [9] and the development of computer technology use by Romizswoski [10]. For the initial stage of this research, a study carried out on the stages of research (Research), until the preliminary draft PLC Trainer.

The subjects of this research are teachers and students in four vocational high schools located in Tana Toraja, Palopo city, the city of Makassar and Gowa district. Analyses of the data were performed using descriptive analysis.

## Results and Discussion

### A. Needs Analysis

Needs analysis phase is done to obtain a variety of information about what subjects in Vocational High School that require the development in their model of learning, especially in Electrical Program. Some data collection activities have been conducted that related to the analysis of these needs such as the study of literature and field studies.

Based on procedural modeling, requirements analysis described at the beginning of development, which was located on the first level (client system), the first stage (define the problem). This position means needs analysis performed on the user side, both at the level of students, teachers or schools that aims to find the existing problems related to this research, and the need to resolve the issue.

In literature review activitis, it was obtained that subject required the development of TPS-PLC is the subject of PLC control. This is a new subject and new technology which is taught in vocational, as well as being used in the industry. This activity also found the lack of special books that discuss these subjects such as common text books, especially books written specifically for electrical program.

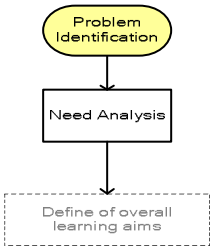


**Figure 2:** The Need analysis (First Step) in Development Process [11]

In the field study activity, data were found more or less the same as those in the activities carried out through literature. Based on the instrument needs circulated to schools sampled in Makassar, Palopo and Gowa, it showed that subject industrial control a new subject that requires a PLC stations so that students have the skills and can understand and operate PLC.

Activities in the field study were conducted with a needs analysis involving 13 vocational school teachers, 2 vocational teachers in Tana Tana Toraja, 6 vocational teachers in Palopo, 3 teachers in Makassar, and 2 teachers in Gowa. Analysis of the contents of the instrument showed that 13 teachers mentioned that their schools need the PLC trainer, training and coaching PLC, and requires both interactive media, and other media in the learning process PLC. They think that PLC is important because it is the brain in industry especially in control process field. Analysis of the 13 respondents teacher revealed that approximately 76.9% of them said the most difficult subjects for their students is to operate industry based equipments such as PLC, SCADA, and electro-pneumatic control system, According to them, this field of study is difficult due to incomplete practice equipment, the inavailability of adequate media,

as well as the less number of teachers who teach the subject areas and most of handout were written in foreign language. Other findings showed that 61.6% of respondents felt that PLC learning was poorly absorbed by the student because of the low level of knowledge of the teacher, not the full practice equipment, unavailability of adequate media, as well as the lack of source material, and a shortage of teachers. Media are considered to be most helpful for them in the learning process are video and multimedia.

Moreover, other results of the need analysis showed a more in-depth observations and interviews conducted by researchers at SMK Negeri 1 Makale, Tana Toraja in Industrial Automation Engineering Competency. Based on field observations and interviews with curriculum vice principal and subject teachers of SMK Negeri 1 PLC in Makale, the obtained data were described as in Table 1.

In Table 1, it is seen that: it term of learning resources, it was found that there was a lack of lab equipments, teaching materials do not match with the development of PLC in the industry today, Books PLC all expressed in English. In term of the teacher: Lack of PLC learning resources, shortage of teachers of subjects PLC, two teachers of subjects have less industrial work experiences and teachers still dominate in the classroom. In the student side: motivation to learn less, lack of understanding on the matter PLC, students are passive because of teacher-centered learning is still used, still takes time to copy the lessons taught by educators. These findings have to be solved in further research to be conducted.

The results of the identification are the problems encountered in implementing the PLC learning in vocational schools. Based on observations and field studies, it became the foundation for researchers to develop PLC Trainer Panel System (TPS-PLC) equipped with teaching materials in vocational high schools. The TPS-PLC that will be developed will be adapted to the existing SK-KD with reference to the analysis of the needs of industry in the form of competencies required in the industrial world for the technician level of vocational graduates.

Based on the above analysis of requirements, then the subject taken in the development of this model is the PLC.

**Table 1:** Observations and Interviews Through Needs Analysis In SMK

| No. | Finding | Needs |
|---|---|---|
| I. | Learning resources: | |
| 1 | Lack of practical equipment | To add more practical equipments |
| 2 | The learning materials are not *match* with the PLC development in industry recently. | The PLC learning material is made based on the needs of industrial world |
| 3 | Most of PLC books are written in English | To add more books and references that has been translated into Indonesia language |
| II. | Teachers: | |
| 1 | Lack of learning resources | Learning materials |

| | | |
|---|---|---|
| | about PLC | |
| 2 | Shortage of teachers who teach in subject PLC | More teachers who can teach in subject PLC |
| 3 | Two teachers in PLC subject are lack in industrial experiences | Learning material that relevant to the needs of industrial world |
| 4 | Teacher still dominated in learning process in classroom | Learning material that can stimulate students to become more active during learning process |
| III. | students: | |
| 1 | Less learning motivation. | Learning model that can improve students motivation |
| 2 | Lack of understanding in PLC materials | PLC materials |
| 3 | Students are passive as the process is still teacher-centered learning | Learning media that can make students to become more active and make students becoming independent and mastery in skills |
| 4 | Still time consuming to copy learning material that have been taught by teachers | Learning model that is efficient in time |

**B. Design Stage**

Activity in the initial design includes materials development and manufacture of media tutorials. Step-by-step preparation of teaching materials is carried out as follows:

**1) Analysis of Resource Requirements**

To obtain teaching materials in accordance with the demands that must be mastered by students required: a) analysis of SK-KD, b) analysis of learning resources, and c) the determination of the type and title of teaching materials. Analysis of learning resources is done by means of an inventory of the availability of learning resources that are associated with the need, while the selection and appointment of teaching materials is done by selecting the shape and type of varied teaching materials that meet the criteria interesting and helps learners to achieve competency.

**2) Preparation of Teaching Material Mapping**

The map of needs in the form of teaching materials required to determine the amount of instructional materials that must be written and the order of materials to be taught. Sequence of instructional materials is very necessary to determine the priority of teaching materials.

**3). Creating The Structure of Teaching Materials**

Create a structure of teaching material is designing instructional materials that outline the complete contents of the teaching materials. The structure of the teaching

materials created consisting of: a) title, b) introduction, c) learning objectives, d) learning materials, e) evaluation, and f) bibliography.

The title is taken according to the basic competence. Introduction contains a brief description of the material that will be discussed. The purpose of learning determines what to expect after students learn the learning content. Learning materials contain materials in this case teaching materials that will be studied by the participants students. The function of the evaluation is to train students to the extent to how much of the material that can be absorbed. Bibliography is a reference of the material that has been prepared.

**4) Develop Material**

Through the syllabus, materials were arranged in accordance with the purpose of learning. The materials are arranged in PLC enriched with various references obtained through: a) literature books, b) research journals, c) leaflets, d) the Internet, e) experience / knowledge of researchers, and f) data- field data in the industry.

To further deepen the understanding of students or readers of the material then the text is accompanied by pictures and video. Preparation of teaching materials produces teaching materials and lesson plans achievement test.

**5) Design Panel System of PLC Trainer**

After the analysis of the needs in vocational and preparation of teaching materials, the next is the physical design the TPS-PLC. Here are pictures of the Draft TPS-PLC.

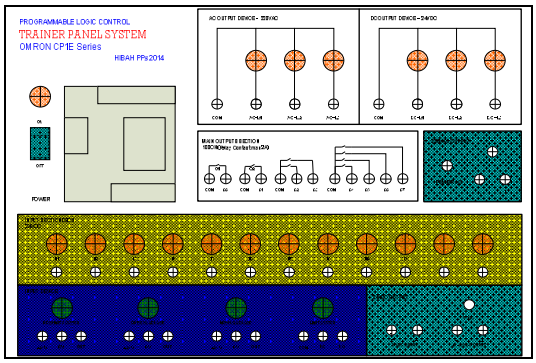


**Figure 3:** The design of the Main Panel

Figure 3 shows the design of the main panel of the TPS-PLC that will be developed. It is made by considering that the main panel can be placed on the table, in the panel stand and placed in a bag (box). With such a design, then the TPS-PLC will be easy to be taken everywhere, just by placing it in the box.

The design of next panel of the TPS-PLC outputs is shown in the figure below. This panel consists of two parts. The first is the panel Traffic Light, and the second panel 16 220V lamps. This panel can only be placed in the box, and on the table. The design for the output panel is shown in Figure 4.

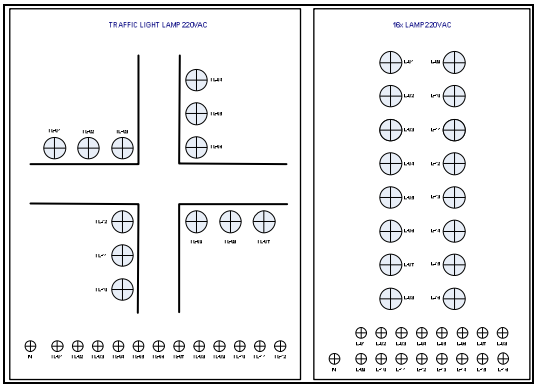


**Figure 4:** The Design of Panel Lights

Furthermore, Figure 5 shows the design for light output that can be placed in a stand. This panel consists of 8 pieces 220 Volt indicator lights. This panel can not be placed in the box (bag) but can be placed on the stand alone table.

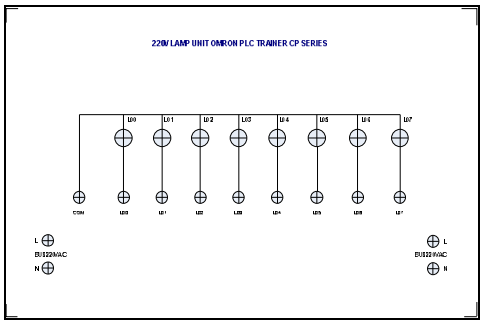


**Figure 5:** Design Separated Lamps Panel

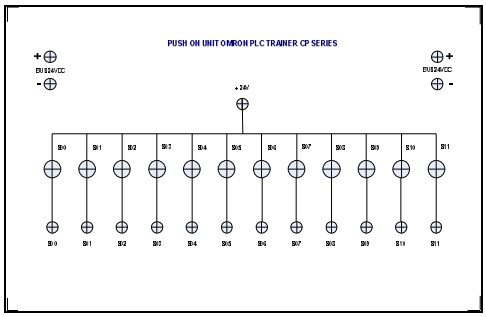


**Figure 6:** The Separated switch panel design

For input, switch is used. The design of the switch panel is shown in Figure 6. This switch consists of 12 pieces of multipurpose switch. The switch placed in this panels can serve as Push On, and can also function as a toggle switch. If the switch is pressed softly, then it serves as a Push Switch On. If pressed a little inside, then this switch will function as a toggle switch. In this switch, it also added with leds as an indicator

that the contact switch has been connected. The switch panel can only be placed on the order trainer (standing) and on the table, while in form of box, the panel has been equipped with a similar switch, as much input as those in PLC.

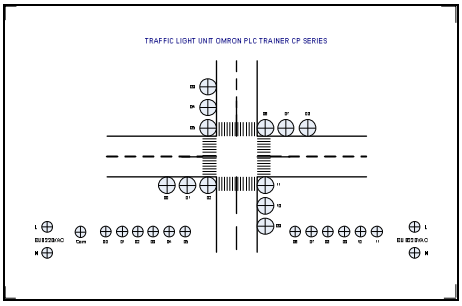


**Figure 7:** The Design of Separated Traffic Light

Figure 7 shows the traffic light panels, which can only be placed on the frame and table. As for placement in the box, it has no separate panels for light traffic light simulation. The panel consists of a four-lane road, with four pairs of traffic control devices. These panels are connected to the PLC using jumper cables. The lights are placed panel consists of 12 pieces lights 220 Volt, with three kinds of colors, namely red, yellow, and green.

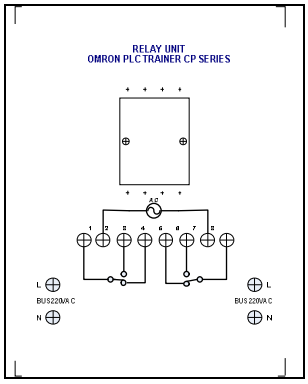


**Figure 8:** The Design of Separated Relay Panel

Figure 8 shows the relay panel design for placement on the table and in the framework of a trainer. For loads that are rather large, the additional relays are needed. These relays have function to prevent the damaged in relay PLC due to excessive current.

Furthermore, for a greater load, such as 3-phase electric motor, it is necessary to connect with supply contactor. In the TPS-PLC, it is equipped with a contactor panels that can only be mounted on the frame, and at the top of the table, whereas for placement inside the box , it is not provided. The design of the contactor panel is shown in Figure 9 below.

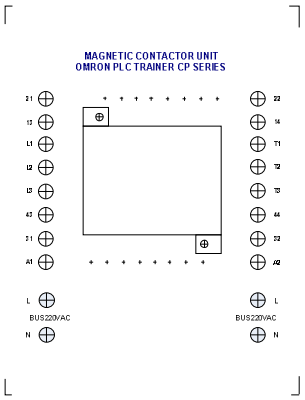


**Figure 9:** The Design of Separated Relay Panel

For the needs of the lighting load, practicum can be done by utilizing the fitting panel unit. The design of fitting the unit is shown in Figure 10. By using this panel, it can explain how to turn the lights on the control of the PLC. If the load is light, the large power can be connected to the panel prior to the relay or contactor panel. It is intended for prevented loadingin internal relay of PLC.

This panel can only be placed on the stand and placement on the table. It is not provided for placement in the box, as it requires a rather large place. Therefore, the lighting media is enough if represented by the lights of the existing Pilot in front of panel of trainers in the Box version.

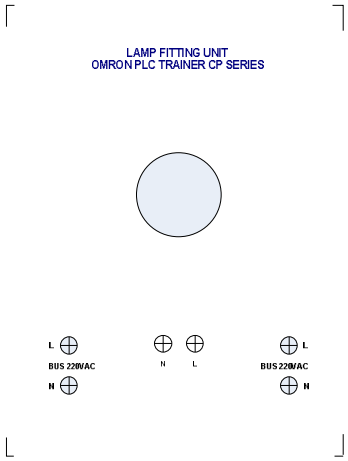


**Figure 10:** The Design of Separated Incandescent Lamp Panel

The next panel is the limit switch unit. The limit switch unit is one of the components of PLC input, widely used in industrial manufacturing, escalators, or general escalator. Panel limit switch unit has contact Normally Open (NO) and Normmally Close (NC). It is more flexible in its use. This panel can only be placed on the table and in standing trainer. It cannot be placed on the box, as in the main panel of the existing stations PLC, there have already been mini limit switch available.

The design of the limit switch panel unit can be seen in Figure 11 below. Other input panel is a proximity sensor. The design of Proximity sensor unit is shown in Figure 12 below. This panel can only be placed on the stand and placement on the table. On the other hand, it cannot be placed in the box, because the main panel TPS-PLC has been equipped with a proximity sensor, which can be used as a metal sensor. The type of proximity sensors mounted on the outside of this panel is NPN type, so the output is positive.

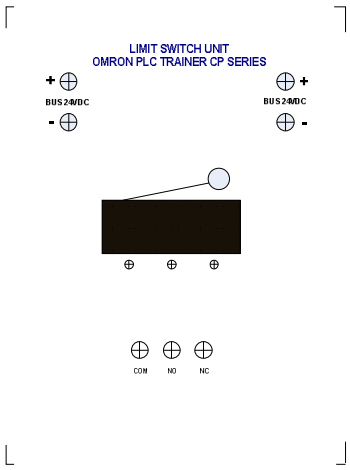


**Figure 11:** The Design of Separated Limit Switch Panel

The specifications of proximity sensors that placed outside this range is wider than that is placed inside the box.

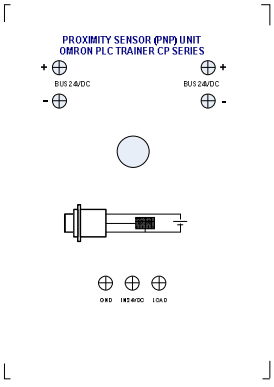


**Figure 12:** The Design of Separated Limit Switch Panel

For more flexibility, the proximity sensor is placed outside (in the panel frame and on the table) is easier to transport.

## Conclusion

Based on the results of research and development that has been done, it can be concluded as follows:

a) Learning conditions of Programmable Logic Control (PLC) in Power Engineering Program at SMK is still experiencing difficulties, due to lack of lab equipment in accordance with the expected competencies.
b) There is still a lack of the PLC media in vocational learning, in term of presentation media, animations, simulations even prototypes.
c) Students still feel difficulties in learning PLC and in the other hand, teachers still also find it difficult to teach the PLC without the proper equipment.
d) To develop TPS PLC device that has several separate modules can be done by using several models of learning development in order to form a model of the development of hardware (physical) and the appropriate software.

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