P-ISSN: 2776-7329, E-ISSN: 2776-7310
Proceedings
5th Vocational Education International Conference
Semarang, 13 July 2023

Development of Outseal PLC-Based HMI as Learning Training Kits for Programmed Control Systems Subject in Vocational Schools

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ABSTRACT
This research aims to produce a learning media product in the form of training kits used in programmed control system learning. This research is conducted due to the suboptimal implementation of practical learning in programmed control system for class XII at SMK Negeri 2 Payakumbuh, specifically in the Human Machine Interface (HMI) topic. One of the challenges lies in the absence of learning media that accommodates the outcomes of practical learning in the HMI subject. To address this issue, development research was conducted using the ADDIE development model (Analyse, Design, Develop, Implement, and Evaluate). The average validation score obtained from material experts is 0.91. The practicality results carried out at SMK Negeri 2 Payakumbuh showed a practicality value from teachers with a percentage of 97.56% in the highly practical category. Meanwhile, the practicality percentage by class XII students in programmed control system learning was 88.31% in the highly practical category. The effectiveness value obtained from the development product of training kits using the N-gain score was 0.65 with a moderate category, indicating its effectiveness.

Keywords: *HMI 1, Training kits 2, ADDIE 3, PLC 4.*

1. INTRODUCTION

The business and industrial world continues to experience technological advancements over time. This has an impact on the demand for a workforce that can keep up with the applied technologies. Vocational education is the process of implementing formal education to produce graduates who are competent in specific fields and ready to be employed as professional workers in the business and industrial sectors. The competencies acquired during vocational education are expected to serve as preparation for entering the business and industrial world [1]. In order for vocational education graduates to be absorbed as competent workers, there must be a link and match between the needs of the job market and the competencies of the learners [2]. Therefore, all the situations and standards applied in the industrial world become references in classroom teaching. On the other hand, introducing and delivering materials that are in line with industrial specifications will help prepare learners before entering the industrial world.

Practical learning is conducted through the application and verification of theories and laws directly by learners to observe and draw concrete conclusions from the practical materials being implemented [3]. Practical learning activities train learners' skills in carrying out structured tasks. According to the learning experience levels presented by Edgar Dale, it is known that learning activities dominated by reading result in the least amount of learning experience for learners. On the other hand, activities involving direct creation and simulation provide learners with the most memorable and impactful learning experiences [4]. Consequently, conducting practical learning directly related to the studied materials is the most ideal approach for learners to comprehend the learning materials.

The implementation of practical learning requires a combination of various teaching models and learning media as supporting facilities in practical activities. The practical materials will be transformed from initially abstract to concrete through the use of training kits as learning media [5]. Therefore, by using concrete delivery methods, educators can easily assess learners' understanding and skills effectively and accurately.

The implementation of programmed control system learning for class XII at SMK Negeri 2 Payakumbuh has been carried out according to the curriculum, including theoretical learning and practical activities. Based on field observation results, several constraints have been identified that hinder the optimal implementation of programmed control system learning in achieving its learning objectives. The practical learning activities related to SCADA equipment have not been able to be implemented optimally. Educators prefer delivering theoretical materials using visual learning media. The use of visual learning media is a suitable choice for theoretical learning, as it allows learners to become familiar with the general aspects of the presented materials [6]. However, it is less appropriate for achieving skill-based learning outcomes.

The implementation of the curriculum aims to ensure that learners have not only good competencies but also adequate skills [7]. The suboptimal implementation of practical activities related to SCADA equipment results in learners not acquiring sufficient skills to apply and test the theories they have learned. Consequently, learners have minimal learning experiences in SCADA-related topics. The availability of HMI equipment as learning media is insufficient compared to the number of learners. Additionally, educators find the current learning media less practical to use as it requires a long preparation time before starting the learning process. Given this condition, if educators choose to conduct practical activities alternately with each learner, it will take a relatively long time considering the complex steps involved in operating HMI, including program creation, addressing, sending, and conducting trials. One of the fundamental principles of using effective learning media is practicality and ease of use to support the learning process [8]. On the other hand, the preparation of the SMK Pusat Keunggulan program also involves the implementation of the Teaching Factory (TEFA) learning model, which makes practical activities more open and focused on conceptual thinking and product creation, following mechanisms suitable for the industrial environment [9].

The suboptimal implementation of practical programmed control system learning requires attention to overcome the constraints in delivering materials related to SCADA equipment. This will enable the achievement of learning objectives and the development of learners' skills. One solution to address these constraints is the need to develop a learning media for programmed control systems in the form of training kits, taking into account the requirements of practical programmed control system activities.

2. METHODS

This study is a Research & Development (R&D) study. The development research conducted aims to produce a development product in the form of Human Machine Interface (HMI) training kits based on Outseal PLC Nano V.5 for the subject of programmed control systems. The steps used in the research refer to the ADDIE development model. This development model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation [10]. The selection of the ADDIE development model is based on the fact that the ADDIE model follows a logical and systematic sequence. The subsequent stages cannot be implemented if the previous stages have not been fully completed [11]. However, it should be noted that using the ADDIE development model requires a relatively longer time because each stage involves validation and improvements if they do not align with the objectives.

The Analysis stage involves gathering information, identifying problems, analyzing needs, and analyzing the basic specifications required for the training kits. Information is collected through school observations and interviews conducted as initial data sources in the research. The Design stage involves the initial design of the product to be developed based on the analysis results. The information gathered from the actual learning conditions is translated into a design. In this stage, the design is validated by experts. The Development stage applies the results of the analysis and design to develop the HMI training kits.

The development process is carried out gradually according to the previously prepared layout in the design stage. The development process takes longer compared to the previous stage because it requires consideration of the technical steps for manufacturing and adjusting several components of the training kits. The Implementation stage involves the application of the developed product. After the implementation, limited testing is conducted on the developed product to assess its performance when used in real conditions. The Evaluation stage involves measuring the developed product to obtain values such as validity, practicality, and effectiveness.

Data collection techniques involve filling in instruments that use Likert rating scales, as shown in Table 1. The instruments used in the development research consist of validity and practicality instruments. Before the validators and assessors fill in the respective instruments, the instrument's feasibility is reviewed by an expert. If the instrument is deemed feasible, it can be used as a data collection tool in this study. If the expert suggests improvements, the instrument cannot be used until the necessary adjustments are made according to the expert's notes.

The validity value of the training kits was obtained by filling in the instrument by the validator. The instrument has been filled in and then processed using the Aiken's V equation as in equation 1.

Table 1. Linkert scale[12]

Statement	Score
Strongly agree	5
Agree	4
Less Agree	3
Moderately Agree	2
Not Agree	1

$$V = \frac{\Sigma S}{[n(C-1)]} \quad (1)$$

Equation description [13],
V = Validity level
S = r – Io
Io = The lowest validity assessment number
r = The number given by the validator
C = The highest validity assessment number
n = Number of validators

The category used to declare HMI training kits can be declared valid if the value of Aiken's V analysis > 0.6. As stated in table 2.

Table 2. Validity Category Table[14]

Score Range	Category
> 0.61	Valid
< 0.6	Invalid

Practicality value is the level of ease, speed and practicality of using a tool [14]. The practicality value of the training kits is reviewed from the aspects of the programmed control system subject teacher and the aspects of XII grade students of industrial automation engineering. Each assessor will be asked to fill out a practicality instrument. Following the filling of the instrument is the processing of the practicality data using equation 2 [15].

$$\text{Practicality} = \frac{Total\ Score\ obtained}{Maximum\ score} x\ 100\% \quad (2)$$

After the practical data is processed using equation 2, the results obtained are averaged which are then adjusted to table 3 to get the appropriate category according to the calculation results.

Table 3. Practicality Interpretation Categories [15]

No	Percentage	Category
1	0% − 20%	Not Practical
2	21% − 40%	Less Practical
3	41% − 60%	Moderately Practical
4	61% − 80%	Practical
5	81% − 100%	Very Practical

Table 4. Score Acquisition Criteria [17]

Limitation	Criteria
0.7≤ n ≤ 1	High
0.3≤ n < 0.7	Medium
0≤ n< 0.3	Low

The product results in the development research are then tested for effectiveness. The effectiveness value is used to determine one of the success rates of learning media in meeting learning objectives. The effectiveness in the study was obtained by using a one group pre-test post-test design. After the data for each test is obtained, then processing is carried out using the N-gain score in equation 3 [16].

$$\text{N Gain} = \frac{\text{Sposttest} - \text{Spretest}}{\text{Smaximum} - \text{Spretest}} \quad (3)$$

The n-gain score results are at $0 \leqslant n \leqslant 1$ which is obtained from the average score in one group [16]. The criteria obtained on the effectiveness of the n gain score value are adjusted to the score criteria in table 4.

3. RESULTS AND DISCUSSION

The results of the development research conducted are learning media products in the form of training kits used in learning class XII programmable control systems at SMK Negeri 2 Payakumbuh. The implementation of development research is carried out in accordance with the sequence of stages of the ADDIE development model. The implementation of the analysis stage will carry out problem identification in the learning system.

The design stage is carried out by designing three constituent parts of the training kits to be developed, namely the main part (Outseal PLC), the HMI section and the mini plan silo section. Each part of the training kits is first prepared layout design to determine the position of the component layout and size adjustment. After the layout design is in accordance with the results of the analysis, it can be continued with the creation of a three-dimensional image to determine the appearance of the training kits more realistically. When the layout design and the results of the three-dimensional image of the training kits are ready, then further validation is carried out by material experts. So that the design that will be continued at the development stage has been declared valid. Validation was carried out using an instrument with a total of 16 statement items regarding the design of training kits assessed by material experts. The average value obtained from design validation using equation 1 is 0.83. The validation value can be stated where 0.83> 0.60 then it can be classified as valid criteria. So it is concluded that the design prepared is declared valid and can be continued at the development stage.

The development stage is a follow-up to the analysis and design stages. The development stage implements the application of the design made by carrying out technical activities for making training kits. All equipment to be used will be installed in accordance with the component layout design. In addition to preparing the technical of the three parts of the training kits at this stage also making instruments that will be used as validity and practicality data collection tools which are then used in the next stage.

The implementation stage of the training kits learning media products that have been developed directly in the programmed control system learning situation in class XII at SMK Negeri 2 Payakumbuh. At this stage, students will be taught and given the opportunity to try directly various circuits on HMI material. Learning in this stage is carried out by giving projects to students, where students can flexibly explore their abilities. Based on observations made at the implementation stage, the response of students is very good and generally has a high curiosity about the training kits developed.

The product evaluation stage is carried out to determine the performance of the development product from the assessment results. Before using the training kits at the implementation stage, a pre-test was first carried out to determine the level of knowledge of students. After carrying out learning by using learning media training kits, a post test is carried out to determine the ability of students after carrying out learning. The data is used as data that will be processed to determine the level of effectiveness of the training kits. On the other hand, after delivering learning, students and subject teachers are asked to fill out a practicality instrument which is used to assess the level of convenience of the developed product. The validity assessment carried out by material experts and learning media experts using validation instruments that have previously been declared suitable for use. The results of the validation carried out by media experts and material experts will then be processed using equation 1 to obtain the validity value of the training kits learning media. Based on the results of the validation carried out by material experts, the average validation value for 30 statement items on the validation instrument is 0.91. Based on the validation criteria in table 2 where 0.91> 0.6, it can be stated that the training kits learning media are valid from the material expert's review. More clearly the validation value obtained on each instrument item is contained in Figure 1.

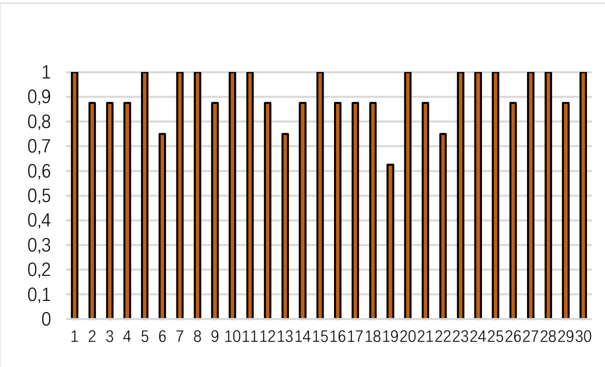

Figure 1 Graph of Validity by Material Experts

The validation process of training kits in the aspect of learning media is carried out by collecting data using validation instruments addressed to learning media experts. Based on the results of data processing using equation 1, the average validity results in the aspect of learning media were obtained with a value of 0.96. Based on the validity criteria in table 2 where 0.96> 0.61, the learning media training kits are declared valid from the aspect of learning media. The validity value of each statement is more clearly presented in Figure 2.

The implementation of the practicality assessment of training kits is carried out to determine the level of ease and practicality of learning media obtained from programmed control system subject teachers and students. Based on the results of filling out the practicality instrument from 26 students, it is known that the percentage of the average value of practicality is 88.31% which is classified as very practical criteria. More clearly the results of practicality data processing from students can pay attention to the practicality graph in Figure 3.

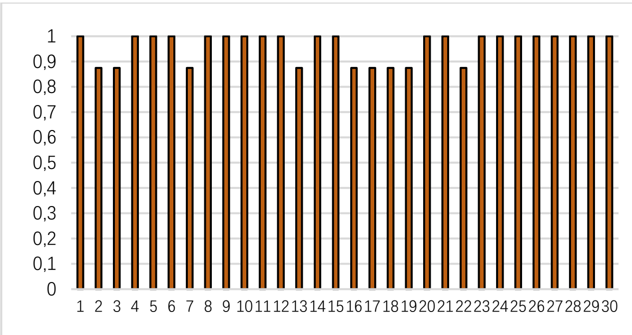

Figure 2 Validity Chart by Media Expert

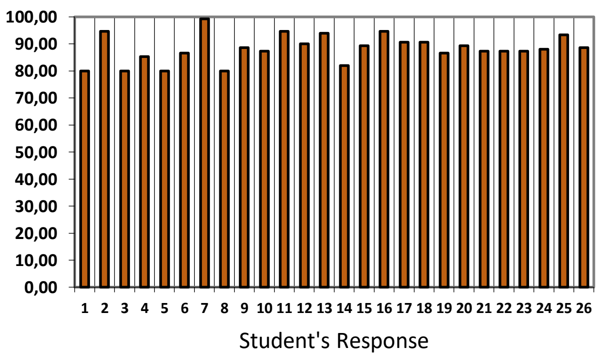

Figure 3 Practicality Graph of Student Response

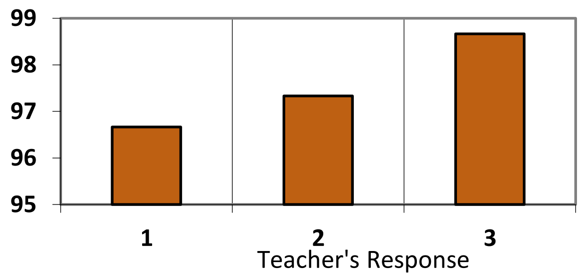

Figure 4 Practicality Graph of Teacher Response

The results of filling in the instrument of practicality of training kits by teachers were carried out by filling in 3 teachers of programmable control system subjects. The assessment is carried out alternately for each teacher. The results of filling in the practicality instrument with 30 statements obtained an average score of 97.56% which is classified as very practical. The graph of the practicality of each teacher's response is shown in Figure 4.

Based on the results of the effectiveness calculation using the N-gain score by carrying out the calculation of the difference between the pretest and post-test scores. So that from the average N-gain score value can be used to draw conclusions on the level of effectiveness of the use of learning media training kits. From the calculation using the N-gain score formula, the average value is 0.65 which can be classified as having moderate effectiveness.

4. CONCLUSION

The implementation of research on the development of HMI training kits based on Outseal PLC in programmable control system subjects was carried out using the ADDIE development model. Development using this model begins with collecting initial data and information related to the problems used to analyse the needs. The results of the next analysis stage will be translated into the design and layout of the product to be developed. After the design is complete, the research continues by carrying out the development stage by compiling and making all parts of the learning media training kits. After the product development is complete, it will enter the implementation stage which is carried out at school in a real situation of the learning process. In this stage also observed the response of students to the use of learning media training kits in delivering learning. After implementation, an evaluation is carried out which aims to determine the value of the development research carried out.

Based on the results of the training kits validation carried out, it was found that the training kits developed were declared valid by material experts and media experts. So that it can be used as learning media. Practicality assessment aimed at knowing the level of practicality and ease of use carried out by teachers who teach programmed control system subjects and students of class XII Industrial automation engineering obtained results that stated that the training kits developed were classified as very practical. Based on the assessment of the effectiveness of the use of learning media, it can be stated that it is effective with a moderate level because of the increase in learning outcomes in students after carrying out learning by using training kits as learning media.

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