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Development of Instructional Media DCS using LabVIEW and Arduino Platform for Instructional of Processing Control System

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ABSTRACT

One of many duties of teachers is as a facilitators of students learning activities, as facilitator a teacher has to be capable in serving various kinds of instructional media. This research aims to develop instructional media by applying the computer assisted as simulation trainer of DCS in order to run processing control system, and analyzing characteristics on processing control systems, interactively, intuitive, effectively, and efficiently. This DCS/SCADA trainer is developed using LabVIEW application as the Human Machine Interface (HMI) which usually present on Distributed Control System (DCS). Arduino microcontroller as replacement for Programmable Logic Control (PLC) device. Applied controlling systems are Proportional Integral and Derivative (PID) control on single loop level and cascade loop level. From the research result by using mixed methods acquired qualitative and quantitative data's. Data then analyzed through triangulation process by using the support of NVivo application until its validity and credibility can be approved as assessment on the instructional media which had been developed. To know the effectiveness thus testing of the student comprehension regarding of the media that is being used before has to be done by providing pretest and posttest. The results of the analysis of qualitative data obtained the information that stakeholders in the development of instructional media have confirmed agreement on the suitability of media that is developed with the curriculum in instrumentation processing control program. And the results of testing the effectiveness of this medium can be proven by the average value of the results of more than pretest posttest, the effectiveness is then expressed in Cohen-d where the results indicate a positive

1. Introduction

In the process of learning, especially Vocational High School, educators can provide direct experience, real and concrete to students is ideal. If not possible, it can be given through the experience of imitation, dramatizations, demonstrations, field experience, modeling or simulation in a computer program. Advantages of the device physically from a good design an interactive media has incredible potential not only to help people easy to learn, but it can also cause a form real love of learning. (Liu, Chen, Chen, & Chen, 2006).

Studying the effect of technology provides students the opportunity to apply their knowledge in an interactive, increase learning motivation and self-development. Identifying the motivation, finding suitable methods which will be effective to increase the ability of students. In the process of learning, the technology also facilitates interaction between the learning process by teaching materials, students with students, students with an instructor or teacher as well where students with media. (Sagirani, Ferdiana, & Kumara, 2013).

DCS is a broad term in a wide variety of industries, to monitor and control a distribution equipment. DCS system has had a satisfactory development and has made a very strong influence in the manufacturing industry, the chemical industry to meet result the automatic processing control arrangement of the many I/O in real time. The fundamental advantage is that it can put the program code can even do the wiring for the new configure other applications. DCS offers high reliability, and requires little maintenance. (Asst, Ph, & Nadu, 2014).

A number of solutions in the form of a software simulation of the control, and scientific visualization are widely available for sale include LabVIEW, which in this application is found in which there are several advantages, including: (1) The interface with the user graphically or GUI (Graphical User Interface); (2) Built with only a draw and put into a function; (3) The design is modular and hierarchical; (4) Working in a multi-platform; (5) Hardware development multiple high level. (Asst et al., 2014)

Using LabVIEW, making animation software is easier if altogether consists of programming in graphically. There is no iota of additional required form of writing code. Furthermore, all the functions available in LabVIEW and can be easily understood and can be fitted by the user. For the new LabVIEW users can learn just have a firm understanding of the prerequisites Visual Basic program. LabVIEW offers a comprehensive set of functions and is more than adequate as software that can be developed in accordance with the expected. (V, Madhuridevi, & Sindhuja, n.d.).

LabVIEW provides the facility of communication with hardware such as data acquisition, device controlled movement and supervision. One of the hardware that is simple and inexpensive that can be connected to LabVIEW that Arduino board.

The implementation of graphics-based interface using LabVIEW and Arduino in the curriculum Instrumentation computer aided design laboratory in physics, produce result algorithms that accurately and protocol syntax along with imagination, communication, scientific applications and innovations experimentally. Curriculum effectiveness is evaluated through statistical analysis of questionnaires, interviewing respondents, improved learning achievement and competence. These results provide support in terms of quantity that the curriculum can eliminate the obstacles are great in making programs that are common in the text programming based, helps students to improve their knowledge in programming and instrumentation, and improve self-confidence and motivation to study physics and programming languages computer. (Kuan, Tseng, Chen, Wong, 2016).

2. Research Method

This study use a mixed methods design, the research activity begins with developing a product of DCS instructional media using LabVIEW and Arduino, on the subjects Processing Control Systems, after the development of instructional media, furthermore the testing of the effectiveness the results of the application of instructional media, by testing through statistical t-test.

Overall a mixed methods research, following the pattern of using the approach phase models ADDIE (Analysis, Design, Development, Implement, and Evaluate). Development of instructional media refers to the ADDIE model of instructional design and experimentation followed by field trials. Learning software development procedures using ADDIE models, a model of instructional design system for designing a unified teaching materials, a course or program in which the process is as shown in Figure 1.

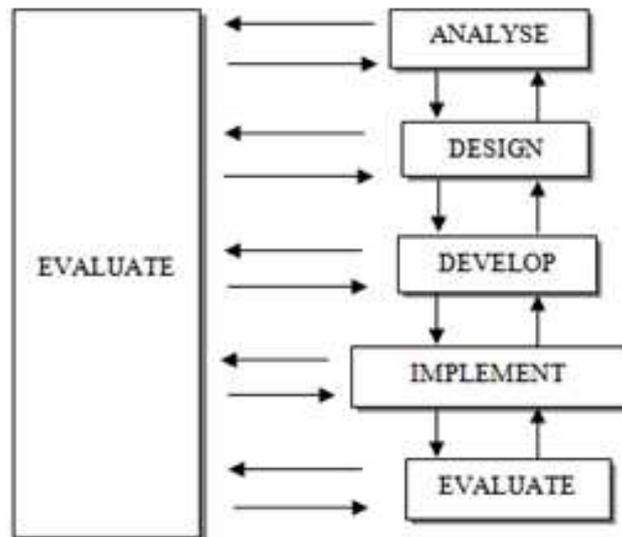


Figure 1. Diagram ADDIE Model Development

Learning software development procedures ADDIE model consists of five stages:

- Analyse stage, to review the subject matter developed and Overview of subjects, content and competencies are written.
- Stage design, designing or designing instructional media, research instruments, and determine the steps and timetable development of instructional media.
- Phase develop, improvement of instructional media, preparing learning modules, manufacture jobsheet practicum.
- Phase implement, application of instructional media learning DCS Processing Control Systems.
- Evaluate this phase, the assessment results and the efficiency of learning, student satisfaction, and improvements recommended.

3. Result and Discussion

3.1 Subjects Curriculum Analysis Process Control Systems

The analysis of the linkages basic competence with the object of media that was developed in the syllabus above, gives consideration as a reason for the basic needs to meet the equipment in the form of trainer DCS, remember more clearly the emphasis mastery of the competencies of knowledge and skills in the learning control system DCS/SCADA using PLC, controller, or microcontroller. Although written in the couples using only basic competence PLC or controller, then the possibility of use of LabVIEW and Arduino microcontroller on the amount of process control systems, and considering that the component controller either on a PLC or controller is actually equal to the microcontroller.

Therefore, the selection of a successor Arduino is a solution in which the microcontroller can be programmed using LabVIEW applications which can be used as well as DCS HMI system. Here are some of the components necessary to build a LabVIEW-based learning media DCS and Arduino:

- Arduino UNO R3
- Temperature sensor LM35
- Transducer E/P
- Relay 5 V dan 25 V
- Solid State Relay (SSR)
- Ultrasonic sensor FC-SR04
- Pressure gauge
- Pump
- 1 set the table along with the panel frame and tank simulator
- Control Valve
- Water Hose
- 1 set PC (Personal Computer)
- Heater
- T-Connect
- 1 Unit Kompresor

- Box Panel
- Terminal strip
- Jumper
- Power Supply 25V
- Air Regulator

3.2 Preliminary Design Learning Media DCS

In the initial draft, instructional media DCS based on LabVIEW and the Arduino is only targeted at the control system PID for the single loop on controlling the water level, but implementation is targeted to be able to run the system control mode storey, ie controlling temperature and water levels on a single loop controllers, following in the figure 2 below the initial design based on LabVIEW DCS loop controller and Arduino.

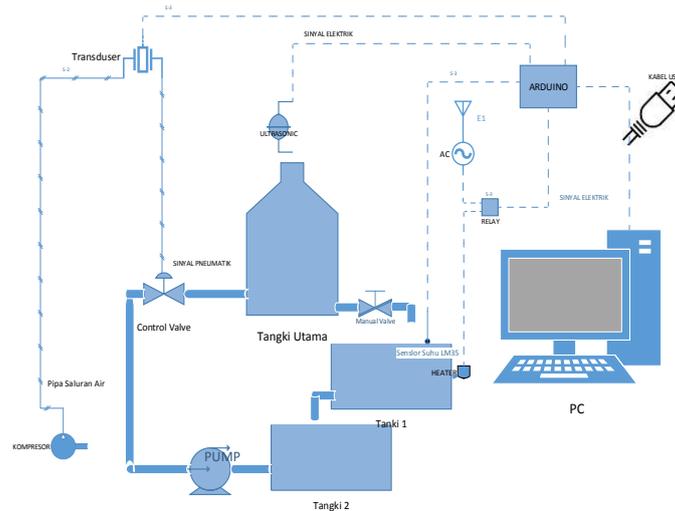


Figure 2. Preliminary Design Designing Learning Media DCS / SCADA

The program has been created to be functioning and run on Arduino, run the process must be done in advance. At the time the program starts if there is a problem with the program, then it will not be able to function so that the display will show the message and an error code corresponding to the cause of the problem. With the code and the error message can facilitate the process of trouble and shooting, both in hardware and software. The program fragment of the overall program, which have been tested in the form of program-based Function Block Diagram (FBD), shown in the figure 3 below.

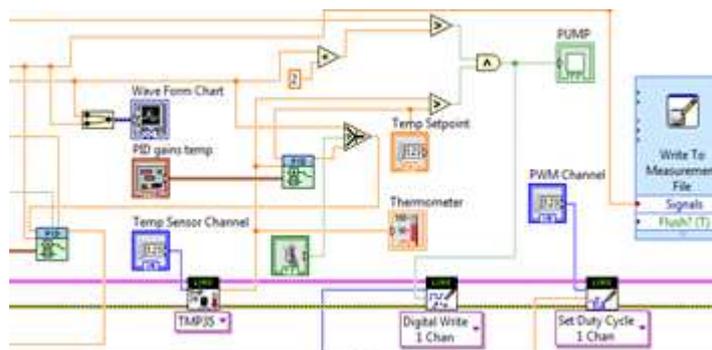


Figure 3. Function Block Diagram (FBD)

In figure 3 looks fragment program in the form of block diagram FBD in the area, so will produce a display on the front panel HMI on LabVIEW application, the display can be seen in Figure 4 as follows.

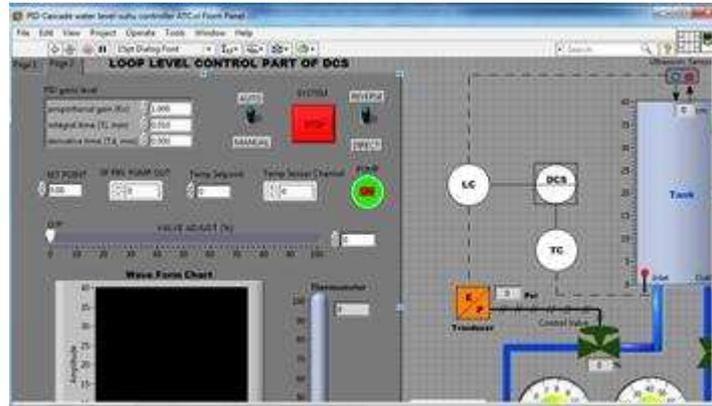


Figure 4. Display the Trainer DCS HMI / SCADA

3.3 Development of instructional media DCS

On the program LabVIEW block diagram PID should be added that in accordance with the groove P & ID at the cascade PID controller, analog input channel activation program, as well as digital program outputs. On the Arduino microcontroller devices also need to be added to the input channels of the LM35 temperature sensor and actuator in the form of relay output channels, which will be used to manage changes in condition ON or OFF the load, in the form of a heater used to heat the water in the auxiliary tank. So the program also need to be added, the selection mode to perform control functions, whether for single-loop PID controller mode or cascade loop.

From the experiments and observations, the system controller PID cascade that is applied to the trainer DCS based on LabVIEW and Arduino, giving a behavior control, wherein the water is heated using a heater in the auxiliary tank, when reached set point then the control system will react, with opening control valve is linearly dependent on the size of the response is given, as a result of changes in the value of the first and second PID parameter.

3.4 Implementation of Instructional Media DCS

To implement an Instructional media DCS LabVIEW-based, requires an understanding of how to read and functioning of the program in function block diagram (FBD). FBD is a program in the form of symbols or icons that resemble the symbol electronics and P & ID (Piping and Instrumentation Diagram). The program library has been determined from the LabVIEW itself and not easily understood immediately, if not by a programmer who has been accustomed to understand text-based programming languages.

Overall trainer control system DCS/SCADA, can be developed almost in line with that planned from the beginning, but there are some feature untried standard owned DCS system as a whole. Among these untried ie network communication system via standard Ethernet communication, with this system it is possible in the future to be able to be connected to a local network via a PC that serves as an operator station on a loop other controllers, used as a server or main station, usually located in control room. The figure of implementation trainer DCS/SCADA as shown in the figure 5 below.



Figure 5. Implementation Trainer DCS HMI/SCADA

With the implementation of trainer DCS/SCADA is in students' learning, it is known that the tendency of the response answers the interviews that have a positive perception, the assessment of the development trainer DCS/SCADA has done. Analysis performed by nodes in NVivo application, also shows the shape of the approval levels of stakeholders on the effectiveness of the use of instructional media that have been developed, it can be seen by the taxonomy by nodes as shown in the figure 6 below.

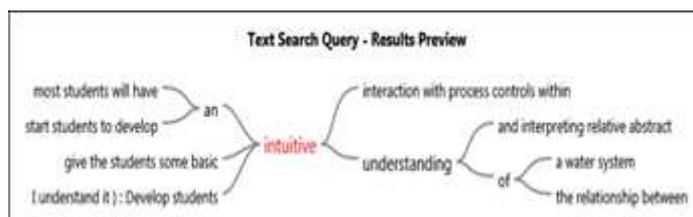


Figure 6. Words Based Taxonomy Nodes in NVivo

By analyzing data from questionnaires obtained from each respondent, from a number of experts from the teachers, experts from the industry, and a number of students were given a questionnaire, it can be obtained information as shown in table 1 below.

Table 1. Percentage of Expert Assessment Questionnaire Results against Trainer DCS/SCADA

	Percentage (%)		
	Teachers	Industry Experts	Students
Strongly agree	64.54	27.06	16.32
Agree	32.27	61.18	70.18
Disagree	0.00	3.53	3.68
Strongly disagree	3.19	8.24	9.65
No Answer	0.00	0.00	0.18

From the data in Table 1 are shown the level of approval of stakeholders, the trainers use DCS/SCADA based on LabVIEW and the Arduino has been developed. Approval is evident from the data that provide answers to the criteria agreed and strongly agreed, for the answer from the teacher obtained amounted to 96.81 %, and for answers from industry experts obtained by 88.24 %. The survey data through questionnaires given to students, obtained information that, 86.5 %, this value describes the approval levels of students, that with the use of instructional media based on LabVIEW and the Arduino 's, rated as good or effective to enhance students' understanding in learning systems control DCS/SCADA. Based on these data we can conclude the majority of stakeholders agreed that the development of instructional media DCS based Lab-VIEW and Arduino has a good criteria.

3.5 Evaluation of Learning DCS Observations

At table 2 shown the value obtained by the students in the experimental class of pretest and post-test results. The data is the result of the measurement of the mastery of the material control system DCS / SCADA, to give a test in the form of preliminary tests before using instructional media DCS based LabVIEW and Arduino (pretest), and a final test (posttest) in the experimental class students. Tests were conducted using research instruments that have previously been tested against all other classes to be tested on the validation and reliability. After posttest then the results will be compared with the results of the pretest so that it can be seen the value of its gain on each student, from the data obtained from each student.

Table 2. List of Values pretest and posttest results

Data	Pretest	Posttest	N-Gain	Cohen-d
Mean	44.79	67.50		
Standard Deviation (SD)	14.22	16.69		
Total SD Pretest and Posttest	30.91			
N	30		0.38	0.73
Dk	29			
t-table	2.462			
t-count	4.26			

Value Cohen-d is a measure of the value of an effect, which is used to indicate standardization of the difference between the two averages. The value can be calculated as the difference between the two averages in the pretest and posttest test results divided by the standard deviation which has been put together. When compared to the value of Cohen-d based on the results of research in the journal, the value of Cohen-d to the results of this study, which only analyze one-dimensional understanding that the control system DCS/SCADA, obtained a value of 0.73. These values can be interpreted that there is a difference or a positive effect.

Based on the formulation of the problem which has been expressed in the form of the null hypothesis (H₀) before, that does not differ student understanding before using instructional media DCS using LabVIEW and Arduino, and after using the instructional media learning Processing Control Systems.

From the data processing according to table 3 was obtained t-count of 4,426. After compared with t-table value at the significance level (α) = 1 % df = 29, ie amounted to 2,462. Then through the comparison shows that the value t-count larger than t-table value, meaning that H₀ is rejected, in other words there are significant differences between the two data value pretest and posttest. With the difference in the value can be inferred that there has been a significant increase in the understanding of students in the learning processing control system before and after using instructional media DCS based LabVIEW and Arduino.

4. Conclusion

Based on the data obtained in the field during the study, obtained some important notes as a conclusion as follows:

- Trainer DCS / SCADA have developed could be used in accordance with the competence of knowledge and skills on the syllabus subjects Control Systems Process interactively, effective, and efficient, which has been evidenced by the survey data through a questionnaire given to the expert of teachers, experts from industry, as well as the students.
- The survey results assessment tool trainer DCS / SCADA has been developed, the data obtained ratings of teachers by 96.81 %, to answer experts from industry amounted to 88.24 % , as well as a 86.5 % students assess both to increase understanding of the students in learning control system DCS / SCADA. Based on these data we can conclude the majority of stakeholders agreed that the development of instructional media DCS based LabVIEW and Arduino has a good criteria.
- From the interview on expert teachers and industry data obtained through analysis using the application NVivo, provide that information to some questions that serve as nodes for any answers from the respondents, may show a high percentage of statements Yes and Match are respectively 2:05 % and 1.93 % of all the words (statement) given all respondents, where word often appears as a whole regarding DCS at 6:37 %.
- Of the various ways in data collection both from the results of surveys, interviews, and field notes (memo), then do the process of data validation test (the credibility and reliability) of a number of

respondents through triangulation techniques. Retrieved perception positively charged (either) of each respondent's answer to the questions through interview, questionnaires, and the process of consultation or discussion.

- e. Of all students in the experimental class after the test at the time before treatment (pretest) with tests carried out afterwards (posttest). Providing value gains normalized average middle category that is equal to 12:38. Therefore it is proven that it is not merely the result of the poll are giving good ratings , but also evidenced from the results of student learning in the form of an increase in the average value of the test, where the average value is greater posttest results are 67.50 and 44.79 of the pretest results.
- f. Value Cohen's-d based on the results of research on one dimension of understanding, which is the students' understanding of the control system DCS / SCADA, obtained a value of 0.73. These values can be interpreted that there is a difference or a positive effect.
- g. From the analysis results obtained statistically t-count of 4426, when compared with the value of the t-table with a significance level (α) = 1 %, df = 29, ie amounted to 2.462. Then the comparison shows that the value t-count larger than t-table value. This means that there are significant differences between the two data value pretest and posttest. With the difference in the value can be inferred that there has been a significant increase in the understanding of students in the learning process control system before and after using instructional media DCS based LabVIEW and Arduino.

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