Development of Integrated Control System Learning Module

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Abstract. Development of automatic technology in industry must be balanced with human resources and competence as an experts in their job. One of the competencies that electrical engineering graduates must have is control systems engineering. The aim of this research is to develop a basic learning module for an integrated control system trainer. It contains control system concepts, control system simulation and programming, case studies and project building tasks. This research adjusts the ADDIE model which is consisted of five stages namely Analysis, Design, Development, Implementation, and Evaluation. The results of this research indicate that the basic integrated control system learning module is in the feasible category based on validation carried out by four material experts and four media experts. Based on the results from students trial, this learning module really helps students understand the basic material of control systems.

Keywords: Integrated, Control, System, Learning, Module.

1 Introduction

Nowadays, various applications in the sophisticated industrial sector use a lot of artificial intelligence[1]. In relation to the field of control, knowledge of the system or plant model to be controlled is one of the determining factors in selecting the control system to be designed [2]. The development of control innovation has become progressively broad in all modern areas today. Based on this condition, the requirements of the modern work market in industrial revolution 4.0 era, one of which is dominating modern control innovation that is connected by internet connection. Indeed, this control innovation is not just applied in the production process industry, including smart home systems, traffic monitoring, electrical energy management, and safety constraint systems[3].

The development of science and technology today has experienced a lot of progress in various fields, for that causes, it is needed to require many qualified specialists in their fields. On the other side, this is a challenge for human resources ability have to always improve, so that they

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can become competitive and strong resources. The development of technology increase rapidly so that industries compete to improve the quality of their products[4]

The modern industrial technology which is usually called the 4.0 industrial revolution era, encourages industry to use effective and efficient machines or automatic tools. Many industries utilize advanced technology to meet company needs such as worker safety, security, control system and product quality. For industry, innovative technology can make process more easier and increase the amount of products. It can make the machines or production equipments used by industry are able to work effectively and efficiently[5].

A control system is a system that has at least 2 parts: (1) The Control or Controlled Part (or Subsystem) (Plant), which can be equipment, devices, or processes that produce output (output, results, products, output signals) because they are controlled by the control part; (2) The Controller Part (or Subsystem), which can also be equipment, devices, or processes that produce control signals to control the controlled parts[6].

Control systems are a technology related to the application of mechanical systems, electrical and electronic systems, and computer-based systems (computers, PLCs or microcontrollers). In the Meriam-Webster Dictionary (digital version), the definition of automation is the autonomous control of equipment, processes, or systems by means of mechanical or electronic devices that can replace human labor. In an automatic constraint system, humans will only be involved in the design or design of the system, monitoring system operations, and maintaining the system. The industrial world really needs automation systems because they are able to produce large quantities of products in a short time, with a very small error rate[7].

A control system is a set of apparatuses designed to manage, direct, and regulate the components work within a system. It is crucial in the advancement of Science and Technology (IPTEK). It is extensively utilized in the industrial sector and also being an essential part of the education sector. Therefore, alternate instructional materials are required to enhance students' knowledge, enabling them to compete in the industrial sector[8].

To yield graduates as anticipated, learning facilities must not only be aesthetically pleasing but also sufficient for the educational process. The cost of industrial-scale control system equipment is prohibitively high, resulting in a significant inadequacy ratio between available equipment and the number of students. It requires more practical, low-cost, and efficient learning support resources. Designing a review program requires that students possess practical skills developed through educational growth opportunities. Therefore, the occurrence of events and the utilization of educational media are particularly necessary[9].

Media is a part that conveys messages or news among communicators and communicants. This implies that media is a connection between the two gatherings who need to pass on data. So that gaining is a connection from conveying messages between speakers to students[10]. Learning media about control systems can provide convenience for students to learn the development of control technology in industry. With the existence of learning media, students can conduct experiments, so that understanding the concept of theory and practice can be understood completely[11].

2 Method

The examination technique adjusts the Research and Development (RnD) model, which is a review that produces or fosters an item plan which is then approved by specialists and tried on understudies after the item is reexamined to get the end result. There are a few innovative work methods set forward by a few specialists. One of them is the innovative work technique set forward by Sugiyono[12]. Based on Sugiyono's theory, the process that must be followed to produce a media product include the potential and problem analysis, data collection, product design, validation, product revision, product trial, revision, user trial, product revision, and mass production as shown in Figure 1[13].

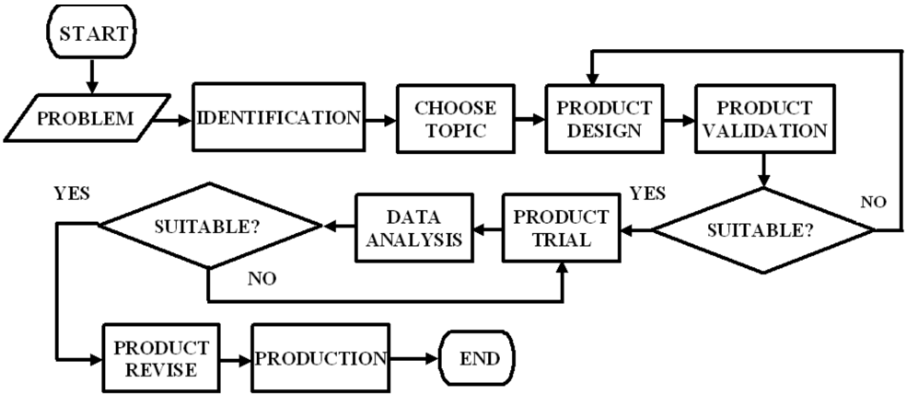

Fig. 1. Research Flowchart

The methodology for creating learning modules employed in this study was adjusted from the ADDIE model created by Dick and Carry. The ADDIE development methodology comprises five stages: Analysis, Design, Development, Implementation, and Evaluation[14]. The choice of this model depends on the thought that this model is grown efficiently and depends on the hypothetical premise of learning plan. The phases of the ADDIE model should be illustrated in Figure 2.

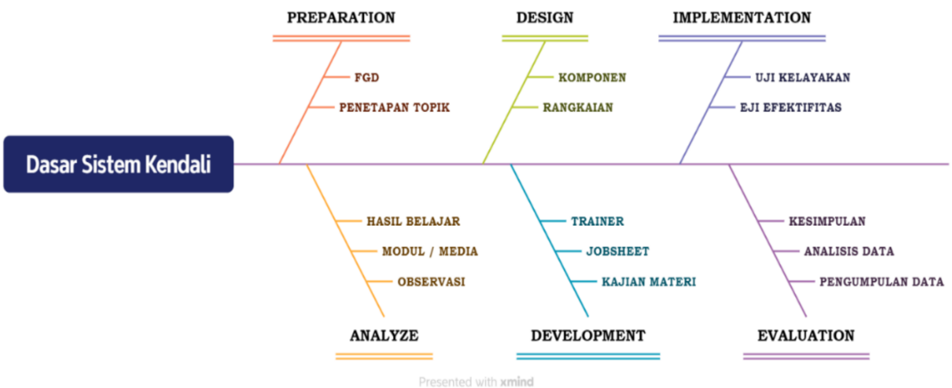

Fig. 2. Researh steps using ADDIE model

The next stage of the research is the collection of research data to gather information related to the module feasibility as a learning media, learning materials and also the benefits for users. Data collection was carried out using research instruments. After the product has been designed and developed, the product will be tested for feasibility by 4 material experts and 4 experts in the field of control systems.The product will be tested on students to see how students respond and also assess when using the product in the learning process. The instrument used is the learning media feasibility test assessment sheet. There are three instruments that will be used in this study for data collection, including media feasibility instruments from material experts, media feasibility instruments from learning design experts and feasibility instruments from users[15], [16].

The collected data will be analyzed using statistical calculations. The first step is to change the scale from the instrument to a value. Then the value will be calculated as the average value and standard deviation. Furthermore, changing the calculated value into a qualitative scale. The last step of data analysis is to determine the feasibility of the developed module based on the calculated value.

3 Results

This research develops a fundamental control system learning module for students in the Electrical Engineering study program at the State University of Medan. According to the ADDIE model, the initial stage of this research is analysis, where the analysis is conducted following the requirements of the Basic Control System course learning process. Activities conducted encompass identifying student requirements, reviewing the curriculum, assessing competencies, and determining concepts for designing the module. The outcomes of the analysis stage then will be used in the design stage. The design phase include the development of the learning module structure and the formulation of a comprehensive program that incorporates all elements of the learning module and instructional materials.

The next stage is the product development stage. The results of the product design will be developed by the requirements of teachers and students in basic control system course. The materials developed for the basic control system course include Basic Concepts of Control Systems, Types of Control Systems, Mathematical Models of Systems, PID Control, Control System Stability, Implementation and Application and Development of Control System Technology.

The following stage is the implementation of technology, media, and materials. The deployment of the produced media targets professors and students as practitioners. Before the modules are used in the practicum, the generated product must undergo validation by material and learning design experts. Upon product validation, a media feasibility assessment is conducted by users, specifically lecturers of the Basic Control System course and students. The results of the module feasibility test are presented in Tables 1, 2, and 3.

Table 1. . Instructional Design Expert Validation Results

No	Instrument	Instructional Experts				Average	Percentage	Category
		I	II	III	IV			
1	Content accuracy	4	5	4	5	4,5	90%	Very Eligible
2	Easy understanding	5	5	4	4	4,5	90%	Very Eligible
3	Competency targets	5	4	5	5	4,75	95%	Very Eligible
4	Pedagogy	5	5	5	5	5	100%	Very Eligible
5	Relative advantages	4	5	5	4	4,5	90%	Very Eligible

Tabel 2. Material Expert Validation Results

No	Instrument	Material Experts				Average	Percentage	Category
		I	II	III	IV			
1	Contextual	5	5	5	4	4,75	95%	Very Eligible
2	Conceptual	4	5	4	5	4,5	90%	Very Eligible
3	Up to date	5	5	5	4	4,75	95%	Very Eligible
4	Coverage and depth	5	4	5	5	4,75	95%	Very Eligible
5	Resources / References	5	5	5	5	5	100%	Very Eligible

Table 3. User trials results

No	Instrument	Lecturer				Average	Percentage	Category
		I	II	III	IV			
1	Easy use	5	5	5	4	4,75	95%	Very Eligible
2	Motivate learner	4	5	4	5	4,5	90%	Very Eligible
3	Self learning	5	5	5	4	4,75	95%	Very Eligible
4	Problem solving	5	4	5	5	4,75	95%	Very Eligible
5	Contextual	4	5	5	5	4,75	95%	Very Eligible
6	Informative	5	4	4	5	4,5	90%	Very Eligible
7	Affective	5	5	5	5	5	100%	Very Eligible

The final stage of ADDIE model product development is evaluation. It is conducted based on according to the feasibility test results from the implementation stage. Evaluation is carried out by looking at the shortcomings and also things that need to be improved to support the Basic Control System learning process. The results of the evaluation can be seen in table 4.

Table 4. Media Evaluation Results

No	Concept Undrstanding	Analytical Skills	Practice	Participation	Project	Problem Solving	Affective
1	86	87	89	89	92	92	87
2	91	85	86	89	85	85	92
3	91	91	85	90	85	92	87
4	87	91	92	92	86	87	92
5	91	90	89	85	91	85	89
6	89	86	86	87	89	85	88
7	91	92	87	91	89	88	87
8	89	92	88	92	92	87	87
9	89	86	85	87	85	92	86
10	87	91	89	91	88	86	90
AVR	89	89	88	89	88	88	89

4 Discussion

The basic module of the control system has been validated by four experts in instructional design. Based on the validation results from material experts, this module obtained an average score of 4.65, which is 90% of the maximal value. This indicates that this module is highly appropriate for use in learning activities. Several aspects that received high ratings include competency achievement targets and pedagogy.

Then four subject matter experts in the field of control systems were asked to validate the material compiled in the Basic Control System module. According to the validation results, an average score of 4.75 was obtained with a percentage of 95%. These results indicate that the material in the Basic Control System module is also highly recommended to use in learning activities. Several aspects that received high ratings include contextual, up-to-date, coverage, and references.

Furthermore, a feasibility test was carried out by the lecturer in charge of the Basic Control System course at the Electrical Engineering study program, State University of Medan. Based on the data from the feasibility test results from the lecturer, an average score of 4.71 was obtained with a percentage of 94%. These results indicate that the Basic Control System module is very feasible to be used in the learning process. Several aspects that received the highest scores include easy to use and understand, can be used for independent learning, contextual material, problem solving and emphasizing attitude values..

Based on the results of the trial to students, the developed Basic Control System Module has proven effective in improving the understanding of basic concepts of control systems among students. This can be seen in the well-organized module structure, as well as the material presented contextually and easily understood. In addition, one of the main objectives of developing this module is to improve students' analytical skills. The results showed that students who used this module experienced a significant increase in mathematical analysis and problem-solving skills. This module can help students to better understand how control systems work, both theoretically and practically.

According to the trial results of students, the developed Basic Control System Module has proven effective in improving the understanding of basic concepts of control systems among students. This can be seen in the well-organized module structure as well as the material presented contextually and easily understood. In addition, one of the main objectives of developing this module is to improve students' analytical skills. The results showed that students who used this module experienced a significant increase in mathematical analysis and problem-solving skills. This subject aids students in comprehending the theoretical and practical aspects of control systems.

Moreover, the evaluation results from instructional design experts and feedback from students, this module has a good level of readability and a layout that supports the learning process. The use of visualizations for diagrams and images is very helpful in explaining complex concepts, although some areas can still be improved, such as interactivity and visual aesthetics.

In line with previous results, this module successfully connects theory with practical applications, which is one of its strengths. Students not only learn about theory, but also how the theory is applied in the real world, such as in designing control systems. This makes learning more interesting and meaningful for students.

5 Conclusion

The module developed in this research is highly viable for application in the learning process. This is evident from the overall scores received from all experts. The instructional design experts and materials experts assigned an average score of 4.65 and 4.75, respectively. Both scores are considered in the valid category. Moreover, the lecturer responsible for the Basic Control System course conducted an assessment, yielding an average score of 4.71, categorizing it as valid. Overall, the results show that the modules are very feasible to be used in the learning process.

Although this module received a valid and very feasible predicate, there were several obstacles faced during its development and implementation. For example, some students need more time to understand more complicated concepts, such as frequency and stability analysis. Therefore, in the future, this module can be equipped with additional materials or additional exercises that are more in-depth for certain topics.

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