The Development of Integrated Control System Learning Module

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Abstract. Human resources with expertise and competencies in their respective fields must support the advancement of automation technology in industry. One essential competency for electrical engineering graduates is control systems engineering. The study's goal is to create an initial learning module for an integrated control system trainer that includes simulations, programming, case studies, and project-based work to teach control system concepts. The research adopts the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. Four experts in the field and four experts in the media all agreed with the results that the basic integrated control system learning module is possible. Furthermore, results from student trials indicate that this learning module significantly assists in understanding fundamental control system concepts.

Keywords: Development, Integrated, Control system, Learning module.

1 Introduction

Nowadays, various applications in the sophisticated 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 advancement of control technology has increasingly expanded across various modern sectors today. Based on this condition, the requirements of the modern work market in the industrial revolution 4.0 era, one of which is dominating modern control innovation that is connected by internet connection. Indeed, this innovative control method is not limited to application within the production process industry, including smart home systems, traffic monitoring, electrical energy management, and safety constraint systems [3].

The rapid development of science and technology in today's era has led to substantial progress in various sectors, creating a demand for highly skilled professionals in their respective fields. On the other hand, the rapid advancement of technology drives industries to continuously strive for higher product quality, posing a challenge for human resources to always improve and become more robust.

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Modern industrial technology, often referred to as the 4.0 industrial revolution era, motivates industries to utilize effective and efficient machines or automatic tools. Various industries employ advanced technology to fulfill company requirements, including worker safety, security, control systems, and product quality. In the industrial sector, innovative technology simplifies processes and boosts production capacity. It can make the machines or production equipment used by industry able to work effectively and efficiently [5].

A control system is one that has at least two parts: The controlled part (or subsystem) (Plant) can be made up of machines, tools, or processes that make output (output, results, products, or output signals) because they are controlled by the controlled part. The controller part (or subsystem) can also be made up of machines, tools, or processes that make 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 Merriam-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 of the system, monitoring its operations, and maintaining it. The industrial world really needs automation systems because they are able to produce large quantities of products in a short time, with a minimal 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). Both the industrial sector and the education sector extensively utilize it. 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 functions as a medium for transmitting messages or information between communicators and recipients. In other words, media acts as a connection between two parties looking to share information. During the learning process, it serves as a conduit for transferring messages from teachers to students [10]. Learning media on control systems offers students an easier way to understand the advancements in industrial control technology. By utilizing such media, students can engage in experiments, enabling them to thoroughly comprehend both theoretical and practical concepts [11].

2 Research Methodology

The way the tests are done changes the Research and Development (R&D) model. R&D is the process of coming up with an idea for a product, getting it approved by experts, and then testing it on students. The product is then tested again to get the final result. There are a few innovative work methods set forward by a few specialists. Sugiyono [12] introduced an innovative work technique. According to Sugiyono's theory, the process for producing a media product involves the analysis of potential and problems. The process includes gathering data, designing the product, validating it, refining the product, conducting product tests, making revisions, performing user testing, making additional adjustments, and proceeding with mass production, as shown in Fig. 1 [13].

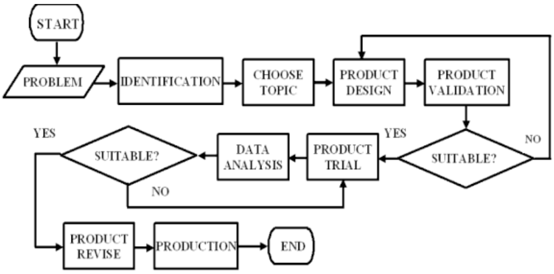

Fig. 1 Research Flowchart

Dick and Carey's ADDIE model served as the foundation for this study's approach to developing learning modules. The ADDIE framework for development comprises five phases: Analysis, Design, Development, Implementation, and Evaluation [14]. The efficient development and instructional design theory of this model led to its selection. Fig. 2 illustrates the phases of the ADDIE model.

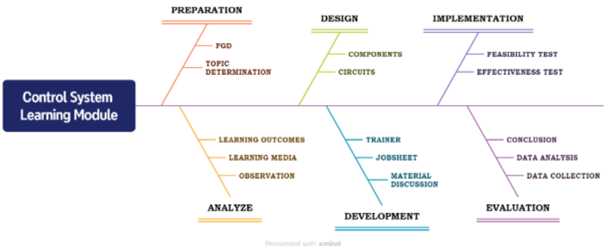

Fig. 2 Illustrates the phases of the ADDIE model

The next stage of the research is the collection of research data to gather information related to the module's feasibility as a learning media, learning materials, and also the benefits for users. We conducted the data collection process using research tools. After the product has been designed and developed, it will be tested for feasibility by four materials experts and four experts in the field of control systems. Students will evaluate the product by observing their responses and assessing its usage during the learning process. The tool utilized for this evaluation is a learning media feasibility 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].

We will analyze the collected data using statistical calculations. The first step is to change the scale from the instrument to a value. We then compute the value using the average and standard deviation. We then convert the calculated value into a qualitative scale. The last stage of the data analysis process is evaluating the viability of the developed module based on the calculated value [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. The value is then computed as the average and standard deviation. Subsequently, the calculated value is converted into a qualitative scale. The last stage of the data analysis process is evaluating the viability of the developed module based on the calculated value

3 Results and Discussion

The goal of this research is to develop a basic control system learning module for students in the State University of Medan's Electrical Engineering program. Following the ADDIE model, the study starts with the analysis phase, which is conducted based on the particular needs of the learning process in the Basic Control System course. Activities conducted encompass identifying student requirements, reviewing the curriculum, assessing competencies, and determining concepts for designing the module. The design stage will then incorporate the outcomes from the analysis stage. The design phase includes 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 step is the product development phase, during which the product design will be improved and tailored to suit the needs of both teachers and students in the basic control systems course. Basic Ideas 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 are some of the materials made for the basic control system course.

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.

Users, specifically the lecturers of the Basic Control System course and students, conduct a media feasibility assessment after the product validation process. Table 1, Table 2, and Table 3 present the results of the module feasibility test.

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%	Fully Accepted
2	Easy understanding	5	5	4	4	4,5	90%	Fully Accepted
3	Competency targets	5	4	5	5	4,75	95%	Fully Accepted
4	Pedagogy	5	5	5	5	5	100%	Fully Accepted
5	Relative advantages	4	5	5	4	4,5	90%	Fully Accepted

Table 2. Material Expert Validation Results

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

Table 3. User trials results

No	Instrument	Instructional Experts				Average	Percentage	Category
		I	II	III	IV			
1	Easy use	5	5	5	4	4,75	95%	Fully Accepted
2	Motivate learner	4	5	4	5	4,5	90%	Fully Accepted
3	Self-learning	5	5	5	4	4,75	95%	Fully Accepted
4	Problem solving	5	4	5	5	4,75	95%	Fully Accepted
5	Contextual	4	5	5	5	4,75	95%	Fully Accepted
6	Informative	5	4	4	5	4,5	90%	Fully Accepted

7	Affective	5	5	5	5	5	100%	Fully Accepted

The final phase of product development in the ADDIE model is evaluation. We conduct this evaluation based on the feasibility test results from the implementation phase. The evaluation focuses on identifying weaknesses and areas that require improvement to enhance the Basic Control System learning process. The evaluation results are presented 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

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. The validation results yielded an average score of 4.75, which is equivalent to 95%. We highly recommend using the content in the Basic Control System module in educational activities. Several aspects that received high ratings include contextual, up-to-date coverage and references.

Furthermore, a feasibility assessment was carried out by the lecturer in charge of the Basic Control System course within the Electrical Engineering program at the State University of Medan. According to the data from the test results, the lecturer provided an average score of 4.71, corresponding to a feasibility rate of 94%. These results indicate that the Basic Control System module is well-suited for implementation in the learning process. Several aspects that received the highest scores include being easy to use and understand; being able to be used for independent learning; contextual material; problem-solving; and emphasizing attitude values.

Based on the results of the student trials, the developed media shows that the Basic Control System Module has helped students understand basic control system concepts better. 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.

In line with previous results, this module successfully connects theory with practical applications, which is one of its strengths. Students not only acquire knowledge about theory but also understand its practical application in real-world scenarios like control system design. This makes learning more captivating and meaningful for students.

4. Conclusion

This research has developed a highly viable module for use 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 demonstrate the practicality of using the modules 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, we can equip this module in the future with additional materials or exercises that delve deeper into specific topics.

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