Project-Based Mechatronics Training Scheme and Media: Case Study in a Mechatronics Laboratory

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Abstract. Actions to achieve R.I. competency 4.0, namely through mechatronics training as a learning transformation. To obtain research data through (1) analysis of basic needs, (2) creation of project-based training program schemes, and (3) evaluation of mechatronics training schemes and training media. The results of the basic needs analysis were carried out to see the dominant material, namely (1) mechanics 43%, (2) electricity 30%, (3) informatics 27% as well as training media needs and time allocation for the training process including; (1) preparation 10%, (2) analysis and design 45%, (3) process management 30%, (4) evaluation 15%, while for assessing the feasibility of training schemes and training media all indicators received a 'valid' interpretation. Based on these results, the training scheme and training media are suitable for use for mechatronics training in the Mechatronics Laboratory as a form of learning transformation in the R.I. 4.0. era.

Keywords: Training Scheme, Training Media, Mechatronics.

1 Introduction

The field of mechatronics integrates the subfields of mechanics, electronics, and informatics, so it requires skill competencies that come from various engineering fields [1]. The user configuration facing the challenges of the Industrial Revolution (R.I) 4.0 towards multi-competence in the field of mechatronics is determined based on the direction of mechatronics development based on different concepts, models, and tools according to stakeholder needs [2]. To face the challenges of R.I. 4.0, the direction of mechatronics development is currently configured with cloud systems and the Internet of Things because this is the direction of continued development in the mechatronics field [3].

Internet of Things (IoT) is an R.I. technology. 4.0, which processes data. IoT is currently a new technology in the industrial world that can control equipment operation independently via the internet network [4][5]. Lecturers and instructors can feel the presence of IoT, so it requires creativity in implementing it in the world of education, especially in the curriculum, especially in control system material [6].

This potential impacts the implementation of the curriculum, which must refer to the target of achieving 21st-century competencies. one of the demands of the 21st-century curriculum is that achieving skills competencies can be proven through output results at the end of learning [7]. The resulting learning outcomes if a project-based learning approach is implemented [8].

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The integration of mechatronics with IoT devices as a tool for identifying the performance of mechanical systems that can be controlled remotely is the implementation of R.I 4.0 [9]. This implementation is through a project-based learning approach, which is applied to mechatronics training to produce outputs in the form of products that require a laboratory to implement them [10].

In the laboratory, IoT devices are used to obtain monitoring data from measurement results obtained from several sensors that function as decision-makers for a working system shown in digital numeric data [11][12]. This monitoring tool is process management on a working system or machine called data acquisition. However, due to the need for new technology in the industry, mechatronics laboratories must respond by practicing IoT [13][14]. In their practice, they must integrate with a project-based approach so that Media is needed to make it easier to obtain information that can be controlled remotely [15].

The aims of this research include (1) analyze the need for a project-based mechatronics training scheme at the Mechatronics Laboratory, (2) design a project-based mechatronics training scheme at the Mechatronics Laboratory, and (3) evaluate the mechatronics training scheme and training media.

2 Literature Review

2.1 Mechatronics

Efforts to control production progress and quality, the efficiency of production operational costs but the value of product quantity and quality are maintained, through the integration of electromechanical systems is an effort to accelerate the complexity of production processes in the industry which focuses on the characteristics of intelligent control systems [1][16]. The intelligent control system in question is the application of mechatronics through Internet of Things (IoT) devices [3].

The Internet of Things is an instrument device embedded with electronics connected directly to machines via the Internet network. Implies that IoT can identify data objects in virtual representation, thus dealing with everything in exchanging data and processing data according to a specified schema [10].

The presence of IoT technology has become the main choice for engineers in modern industry. It is highly desirable for this technology to be brought into undergraduate education, especially in the engineering field, if applied in laboratories [9].

2.2 Data Acquisition

Data acquisition is the process of reading and storing various types of data obtained from various sensors installed on equipment to monitor initial conditions and for subsequent processes when the equipment is operating [11]. The development of a data acquisition system includes applications for automotive telemetry, such as driving style analysis data and detecting driving errors [13]. However, this method is only for processing data analysis through process data, so reading the data only displays the process data results if we want to meet Industry 4.0 requirements. Data reading must be continuous during the process and in advanced conditions, which can be monitored remotely [12].

2.3 Application of Internet of Things Technology for Data Acquisition Systems

In the era of R.I. 4.0, IoT technology is becoming a favorite, so it has a special role in the industry to help prevent equipment damage and extend equipment service life.

Several cases of application of IoT technology in the industry include the working process of a machine which can be controlled according to needs to more effectively control the working process of the machine being integrated with the internet, which is connected to all machine equipment so that it becomes one network system [8]. Complex systems require real-time data collected from machine work processes to support data acquisition resulting from equipment communication, which is the final result of data decision-making [11].

2.4 Project Based Learning (PBL)

Project-based learning is a contextual approach based on constructivism, constructionism, and cooperative learning theories, which promises to acquire knowledge and problem-solving skills [8]. Teaching is promised to increase students' ability to play an active role in real-world practice, characterized by investigating problems, setting goals, collaborating, and communicating [14] [15].

Studying in higher education focuses on the outcomes students achieve by learning objectives. These results are evaluated through rubrics by observing the involvement of students' behavior in producing products [14]. In implementing PBL, students can carry it out without pressure and are free to ask questions according to the problem being investigated to the lecturer to reveal solutions to the problem until they complete the task, while the lecturer will provide the necessary materials and tools as well as learning services during the process [8].

3 Methods

3.1 Basic Needs Analysis

The information obtained has become necessary to determine the flow of the training program process from internal and external sources as relevant information related to the objectives to be achieved. This process includes two steps:

a Analysis of information from the Indonesian National Job Qualification Standards (SKKNI) document related to the Mechatronics Sector. As well as mechatronics laboratory infrastructure.

b Analyzing information from 8 industry practitioners and two professional learning instructional design experts, data was obtained from observation questionnaires to obtain data on training materials and process stages of project-based training program schemes.

3.2 Creation of Project Based Training Program Schemes

The process of creating training program schemes and media in accordance with normative curriculum references integrated with the study program graduates' profile. This process consists of 3 processes.

a Analyze the National Job Qualification Standards document in the field of Mechatronics according to the graduate profile to meet industry needs in the Study Program: (1) Mechanical Engineering Education and (2) Automotive Engineering Education. As well as the media needed for training

b Creation of training schemes according to R.I.'s needs. 4.0 with integrating project-based learning models and determining training media consisting of pneumatic trainer media, hydraulic trainer media, and IoT trainer media, as seen in Figures 1, 2, and 3.

Fig. 1. Pneumatic Media Trainer

Fig. 2. Hydraulic Media Trainer

Fig. 3. IoT Media Trainer

3.3 Evaluation of Mechatronics Training Schemes and Training Media

Data collection techniques were obtained from an assessment process by eight industry practitioners and two professional learning instructional design experts. Data was obtained through observation questionnaires to evaluate training schemes and media before being implemented for users. Training material assessment items in aspects: 1) Learning design, 2) Information design, 3) Interaction, and 4) Simulation

quality. Meanwhile, the training media assessment items include 1) Content feasibility and 2) Simulation.

4 Result and Discussion

The results of this research include 1) basic analysis results, 2) results of creating project-based training schemes and learning media, and 3) evaluation results of project-based training schemes and learning media.

4.1 Basic Needs Analysis

a Results of Basic Needs Analysis
To meet the profile needs of graduates of the Automotive Engineering Education study program and the Mechanical Engineering Education Study Program, Medan State University as education and training instructors. Graduates must be given training to equip graduates with skills in the industrial competencies of the Republic of Indonesia era. 4.0 therefore, a training scheme is needed to increase student potential.

b The results of information analysis based on the Indonesian National Job Qualification Standards (SKKNI) document regarding the field of mechatronics engineering are determined as a normative reference that competency units in mechatronics engineering are divided into mechanical, electrical, and informatics. The results of the analysis of the need for adequate mechatronics laboratory infrastructure for mechatronics training, the training media available are oscilloscopes, pneumatic trainers, hydraulic trainers, and Internet of Things trainers.

c An information needs analysis survey on the distribution of time allocation for the training process was obtained by distributing questionnaires to 8 industry practitioners and two professional learning instructional design experts. The results of the analysis of training material needs covering mechanics, electricity, and informatics are shown in Figure 5. Meanwhile, the stages of the project-based training process include preparation, analysis and design, process management, and evaluation. As shown in Figure 6.

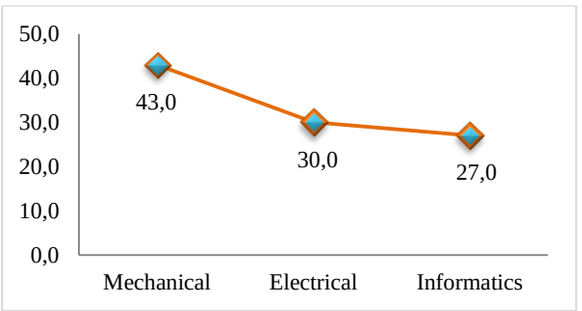

Fig. 5. Mechatronics Training Materials

The average results obtained from observation questionnaire assessments obtained from industry practitioners and learning instructional design experts to determine training material needs were obtained in the following materials: mechanical (43%), electrical (30%), and informatics (27%). These results become a normative reference for the weight of training materials.

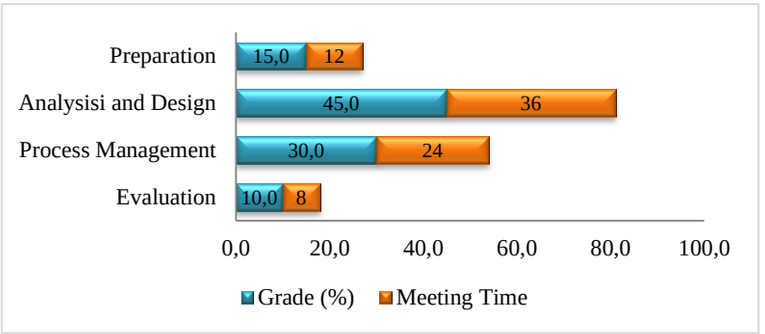

Fig. 6. Main Process of Project Based Training

The average results of the observation questionnaire assessment obtained from industry practitioners and learning instructional design experts to determine the time allocation for planned Meeting Hours (MH) is 80, The results obtained are (1) preparation 15% (12MH), (2) analysis and design obtained a percentage of 45% (36MH), process management 30% (24MH), and evaluation 10% (8MH). The survey data results become the basis for normative reference for training time allocation.

d Discussion

Based on the results of assessments by professional learning instructional design experts and industry practitioners, basic needs analysis data in the process of implementing mechatronics training in the field of mechanical engineering involves multidisciplinary knowledge, including mechanical (43%), electrical (30%), and informatics (27%) [17]. This slice of knowledge must provide more effective and efficient steps so that it is easy to understand in the analysis and design process, especially in the initial steps as a problem-solving study. It has an impact on problem solving, so that the syntax of project-based training for each material has a clear line of thinking that can be adjusted to the accuracy of time allocation [18]. The evaluation process becomes a reflection stage to provide feedback.

4.2 Creating a Project-Based Training Scheme

a Results of Creating a Project-Based Training Scheme

1 Analysis of the Indonesian National Job Qualification Standards (SKKNI) documents in the mechatronics field revealed competency units that will be used as a reference for compiling training schemes, including:

Mechanical: making installations of pneumatic equipment, installations of hydraulic equipment, installations of pump equipment, installations of motion transmission equipment.

Electrical: Make analog circuits and digital logic gate circuits and assemble multivibrator systems.

Informatics: Create a logic controller (PLC) program and a human interface (HMI) program for IoT device integration.

2 To meet students' competency needs regarding technology use in the Republic of Indonesia era. 4.0, to fulfill this through a 4-step process to regulate learning rhythms adapted to project-based training syntax and training media to make things easier for participants, encouraging accelerated problem solving, especially in teams, shown in Figure 7.

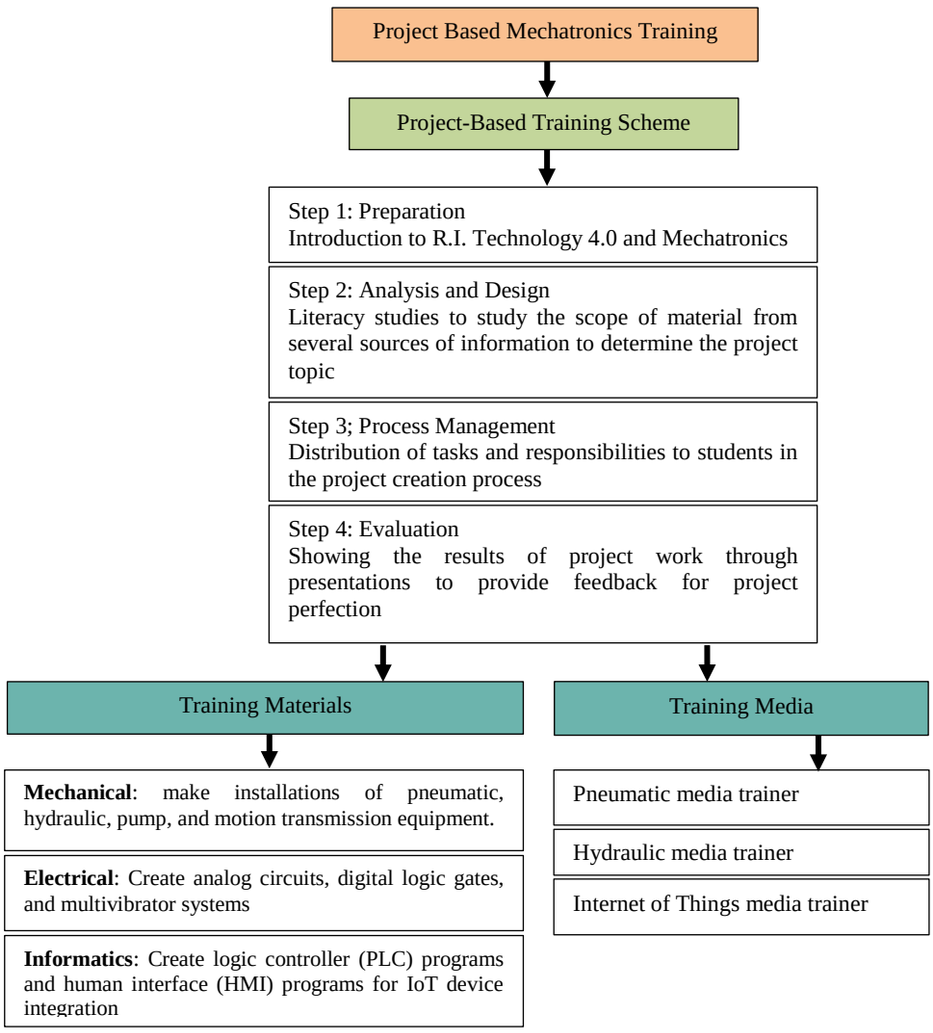

Fig. 7. Mechatronics Training Scheme Development Process in the Mechatronics Laboratory

b Discussion

The design of the training scheme adapts to the normative references of the Indonesian National Job Qualification Standards (SKKNI) in the field of mechatronics in mechanical engineering, which intersects with multi-disciplines including mechanics, electricity, and informatics. The design of the training scheme is integrated with project-based learning, so it has a four-step process to regulate the learning rhythm carried out by the team. Step 1 (preparation), step 2 (analysis and design), step 3 (process management), and step 4 (evaluation) [10].

4.3 Evaluation of Mechatronics Training Schemes and Training Media

a Evaluation Results of Mechatronics Training Schemes and Learning Media

The evaluation results of training materials for mechatronics training schemes and learning media were carried out through observation questionnaires, which were assessed directly by eight industry practitioners and two professional learning instructional design experts. The results are shown in Table 1 and Table 2.

Table 1. Training Scheme Feasibility Test Results

Indicator	Mean	S.D.	Interpretation
Learning Design	72,50	2,64	Valid
Information Design	84,00	1,41	Valid
Interaction	89,50	1,58	Valid
Simulation Quality	86,40	2,07	Valid

Table 2. Training Media Validation Test Results

Indicator	Mean	S.D.	Interpretation
Content Eligibility	80,33	2,92	Valid
Simulation	83,33	1,57	Valid

b Discussion

Evaluation of the material in the training scheme based on the opinions and ideas of professional learning instructional design experts and industry practitioners after testing was declared valid but there are several suggestions for minor revisions which can be summarized as follows; 1) feasibility test of training materials, especially on learning design indicators, must tell more specifically about project creation simulations from start to finish, and 2) feasibility test of learning media on content feasibility indicators, especially on materials that will be used to be given in quantity according to the project to be created and also attached a work instruction document for using the training media in the training module [10].

5 Conclusion

This research shows that the normative reference for project-based mechatronics training is to meet competency achievements in mechatronics. This study shows that the normative reference for the need for mechatronics training materials includes mechanical (43%), electrical (30%), and informatics (27%). In comparison, the process and time allocation for implementing project-based training schemes is based on the opinions and ideas of professional learning instructional design experts (2 people) and industrial instructors (8 people) in the 4-step process data was obtained to see the dominant steps in the implementation process including 1) preparation (10%), 2) analysis and design (45%), 3) process management (30%), 4) evaluation (15%) and the training media used are pneumatic trainers, hydraulic trainers, and IoT trainers.

The mechatronics training scheme is designed according to normative references with the distribution of training materials including (1) Mechanical, making pneumatic equipment installations, making hydraulic equipment installations, making pump equipment installations, making motion transmission equipment installations; (2) Electrical; making analog circuits and digital logic gate circuits and assembling multivibrator systems, and (3) Informatics; create a logic controller (PLC) program and create a human interface (HMI) program for IoT device integration.

Assessing the quality of the project-based training scheme, which was assessed directly by eight industry practitioners and two professional learning instructional design experts, test results obtained from all feasibility testing indicators obtained a 'valid' interpretation of the feasibility of the training material and the learning media. Based on these results, the training scheme and training media are suitable for Mechatronics training in the Mechatronics Laboratory.

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