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Implementation of Project Based Learning in Mechatronic Lab Course at Bandung State Polytechnic

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ABSTRACT

Mechatronics is a multidisciplinary that includes a combination of mechanics, electronics, control systems, and computer science. The main objective of mechatronics learning is to establish a comprehensive mindset in the development of mechatronic systems. Project Based Learning (PBL) is an appropriate method for use in the learning process of mechatronic. The use of PBL by following the V model in system development process is expected to encourage the achievement of the main goal of learning in mechatronics lab. Demonstration of knowledge during the practical work done by drafting product development procedures documents, presentations, and project demo. The test result of mechatronics lab course based on PBL in Electronics Engineering Bandung State Polytechnic led to the conclusion that the model is acceptable and desirable to be passed with a few improvements. In addition, learners also feel there is a new challenge in following the PBL-based practicum.

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1. INTRODUCTION

Definition of mechatronics has evolved since the term mechatronics found by Tetsuro Mori, who works at Yaskawa Electric Corp. in 1969. At the trademark application documents, Yaskawa provides definition mechatronics as a leading-edge technology and products that incorporate more electronics into the mechanics so as to form a coherent whole [1]. These definitions were subsequently developed by the researcher and one of them posted by Harashima, Tomizuka, and Fukada in 1996. In their paper they put a mechatronics definitionas synergistic integration of mechanical engineering with electronics and intelligent computer control in the design and manufacture of products.

According to the French standard NF E 01-010, mechatronics is an approach that aims to integrate synergistically between mechanics, electronics, control systems, and computer science in the design and manufacture of products for the purpose of optimize functions[2].Based on the definition under French standards, in addition to meaningful as a system, mechatronics is also meant to be a multidisciplinary. The learning process of multidisciplinary courses require special methods that can be delivered comprehensive framework and not simply pass on some knowledge at the same time.

In curriculum at Electronics Engineering Bandung State Polytechnic, the mechatronics subject is placed in semester V for D3 and D4 program. In first four semesters, mechatronic components generally have been taught. Therefore, the main objective is to give an insight into the learning mechatronic design by combining all four components of mechatronics.

Development of mechatronic systems requires systematic development procedure and use a variety of software aids. The specificity of the development of mechatronic system is an integration of engineering that crosses traditional boundaries [3]. Mechatronic system development procedures, among others,

following the V model. Development of mechatronic systems can also be done through the flow of standard practiced by industry [4].

Mechatronic development not only on products that are directly used by consumers but also on all means of production in the industry. Industry requires mechatronics for the demands of a rapidly changing market. These demands include the diversity of products, product quality and consistency, as well as the number of requests fast-changing [5].

Mechatronics is now developing into a design philosophy that encourages the experts to integrate the conventional core industries and industrial development of modern processes. As a design philosophy, taught more precise mechatronic approach learning by doing. The concept of learning by doing, introduced by John Deweywill ensure that learners are able to construct knowledge through action research and build knowledge on what they already know[6]. Learning methods consistent with the thinking of John Dewey, among others, Project Based Learning (PBL).Project Based Learning is a learning approach that deep and comprehensive learning and teaching in the classroom that invites students to investigate real issues[7].

PBL fuller description given by [8] as follows: PBL integrate knowing and doing. Students learn knowledge and elements of the core curriculum, but also apply what they know to solve authentic problems and produce result that matter. Students in PBL using excess digital devices to produce high quality products and collaborative. PBL refocus education on students and not on the curriculum-a shift that is mandated by a global world that values of intangible assets such as motivation, passion, creativity, empathy, and durability. It can not be taught from a textbook, but must be activated through the experience.

PBL is a learning model that emphasizes on improving the ability (skill) analytical and critical thinking of students [9]. Expolaration, teamwork and communication skills are the foundation for the development of both these capabilities. Analytical ability and critical thinking are also the cornerstone of the students as live long learners. In this model, a group of students were asked to work on a project. Students are involved in designing, problem solving, decision making, and investigative activities. It allows students to work in groups or independently. They are also expected to generate ideas and realistic solutions and be able to deliver it in the form of presentation. In this model the lecturer acting as a supervisor/facilitator, providing feedback gradually, assessing the grating process with ratings related to the skill growth[10].

Project Based Learning is a learning approach that has the following characteristics:students to make a decision on a framework,any problems or challenges posed to the students,students to design a process to determine a solution to the problems or challenges posed,students collaboratively responsible for accessing and managing information to solve problems,the evaluation process is run continuously,students regularly to reflect on the activities already carried out,the end product of learning activities will be evaluated qualitatively, and learning situation is very tolerant to errors and changes.The development of PBL in general through five stages[11]: Begin With the End in Mind, Craft the Driving Question, the Assessment Plan, the Project Map, and Manage the Process.Research in PBL has been done by [12]-[16] and research in mechatronics learning has been done by[17],[18]. While researchsare to develop mechatronic learning using PBL among others carried out by[19]-[24].

2. RESEARCH METHOD

In this study developed a V model of the research that has been done by [3] and [4] in order to comply with the definition mechatronic used in learning. V model development is very important considering the mechatronic system development process adheres taught following the V model.

As a starting point of teaching mechatronics the curriculum studies are also needed in the perspective of the course in mechatronics. These studies provide elements of a mechatronic system that has been, is being, or has not been taught in other subjects. This study also aims to avoid duplication in teaching materials considering the mechatronics is a combination of several disciplines.

In PBL characteristics of the project is the most important thing that must be determined. Therefore, this study also examines criteria appropriate projects for mechatronics lab course. The process of practical implementation in accordance with the flow of product development must be controlled in order to achieve the learning objectives. Control of mechatronic learning lab work is performed by applying the design procedure document preparation liability product which is used in industry as well as present the results of the project's progress in the classroom.The scoring system as part of the learning process needs to be developed considering the learning process using PBL make different demands with other learning methods. The assessment process was developed with reference to the research that has been conducted by [25].

2.1. V Model in The Development of Mechatronic Systems

Mechatronic system development should be done with a structured and well planned considering the mechatronic system is an integration of four components, each of which has a quirk in the design process.

Research has developed a model V in the process of developing mechatronic systems, among others, performed by [3] and[4]. The definition used in the development of V model in [3] and [4] is the mechatronics is the integration synergies of mechanical systems, electronics, and information technology. In these definition the control system has not been included as a component of mechatronics.In this research, a V model is better suited to mechatronic definition given by the French standard NF E 01-010. The result of the development of V model used in the mechatronics lab work can be seen in Figure 1.

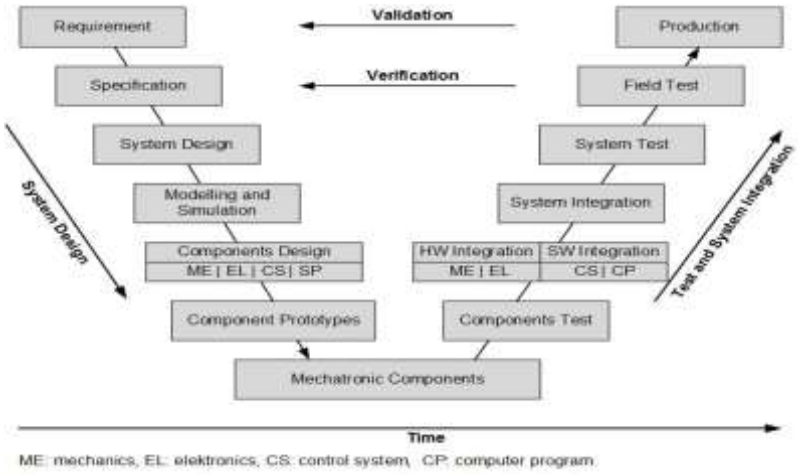

Figure 1. V Model for the development of mechatronic systems

In addition to adjustments to the definition of mechatronics which used in the mechatronics lab, modification V model also performed in the process of phasing the development so that the verification process can be done at each stage. Each component has a development procedure which is commonly used in the industry as can be seen in Figure 2. The development procedures of three mechatronic components have been provided by [4]. This study added a development procedure of control system in mechatronic system development.

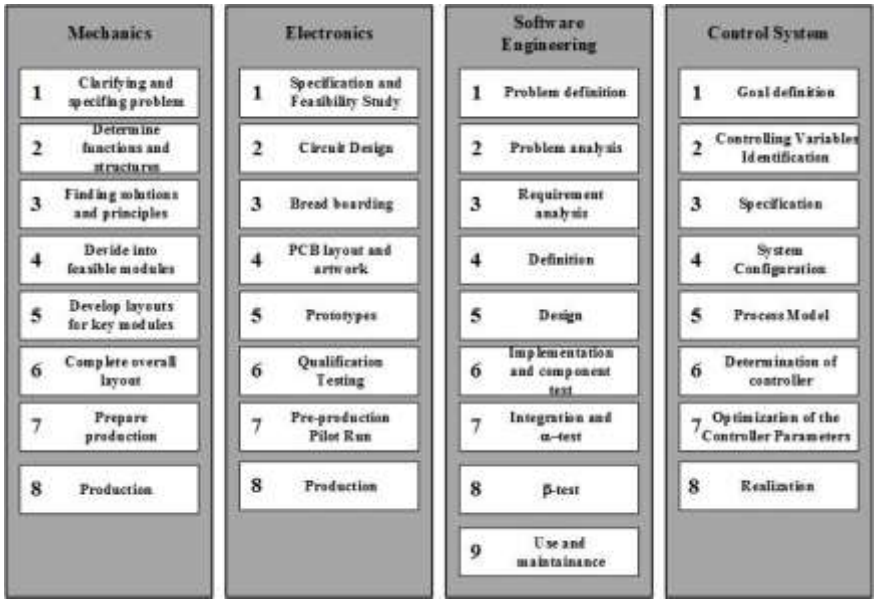

Figure 2. Plot the development of mechatronic components

2.2. Curriculum Studies

Curriculum studies is run with the aim to map the position of the mechatronics courses among other subjects. The curriculum used in these studies is the curriculum of Electronics Engineering Study Program BandungState Polytechnic. In Table 1 it can be seen that most of the subjects supporters Mechatronics course has been taught before teaching courses Mechatronics Engineering.Based on the map of the teaching material course, mechatronics lab is designed to harness the knowledge of students who have owned. Moreover map obtained subjects are also used to avoid duplication of teaching materials on mechatronics lab.

Table 1. Map of subjects supporting Mechatronics lab course

Teaching Time	Mechanics	Electronics	Computer	Control System
Before	a.Basic Mechanics b.Technical drawing	a.Electronics System Design and Fabrication 1 & 2 b.Digital System Design c.Industrial Electronics 1 & 2	a.Computer and Programming b.Microprocessor System	a.Sensor and Transducer b.Continuous Control System 1
Simultaneously			Microprocessor and Interfacing	a.Continuous Control System 2 b.Industrial Otomation System
After				Digital Control System

2.3. PBL Planning

The planning process of mechatronics lab using PBL method is implemented in the following order [11]:

2.3.1. Start thinking of the end / results

In the mechatronics lab, the expected end result is that students are able to develop (design and realize) mechatronic system with the correct procedure.

2.3.2. Leading questions

Some of the questions that lead to the achievement of the desired results is as follows:

1. How mechatronic system development procedures that correct ?
2. What skills are needed to develop a mechatronic system ?
3. How to support other subjects in achieving the desired results ?
4. Is the laboratory facilities to support the achievement of results ?
5. Is sufficient time available ?
6. Is the cost of the project implementation ?
7. Are teachers who will implement the learning has been available ?

Design practicum can be carried out by answering these questions. The most decisive thing is the selection of project topics. Here are the criteria for projects in accordance with mechatronics lab using PBL.Project criteria:

1. Qualify as a mechatronic system that has mechanical, electronics, control system, and computer systems;
2. Can be done by students with the support of knowledge of the subjects that have been taught;
3. Meeting Outlines Learning Programme;
4. Meeting the criteria set out in PBL;
5. Can be done by using the tools and components provided;
6. Can be done at reasonable cost and within 1 semester

2.3.3. Planning for assessment

The main target of the mechatronics lab was formed in the right mindset in the process of developing mechatronic systems. Therefore the assessment is not only based on the final outcome alone but also on the stage of the design process and project realization. The bases used in the assessment process is the Creative Design Process (CDP) and Creative Thinking Scale (CTS) [25]. CTS evaluating students in two dimensions:

a. The first relates to the design, construction, and evaluation of products or sistem.Therein are originality, usability, and unique design. In addition, functionality, reliability, accuracy, geometrical structure, and application of scientific principles.

b. The second relates to a process of learning and thinking, problem solving, and teamwork.

Assessment framework using CDP and CTS adapted to practical implementation can be seen in Table 2. In the assessment form, the framework detailed in the assessment criteria. The final score of each week are all scoreobtained for all criteria. Scores are then collected every week and then summed to obtain the total score.

Table 2. Assessment in mechatronics lab learning

Assessment criteria	
Design, construction, and evaluation of products / systems	Learning, thinking, and problem-solving activity
Week 2 - Phase consciousness thinking	
a. The standard diagram of the system / product that can be taken from the literature	a. Solving simple problems in the planning and construction
b. The fundamental description of the model and its construction	b. The division of tasks to team members
c. Description of the model in the form of drawings or sketches	
Week3-Phase observations thinking	
a. Requirements and specifications	a. Selection of a number of alternatives
b. Authenticity schematic diagram of a system / product is designed.	b. To exchange information and help each other in teams
c. A detailed depiction of the top models.	
Week 4 -15–Phase strategy thinking	
a. Functional block diagram of the original system, structural trees or flow charts	a. Contributions by individuals and teams in solving complex problems.
b. Description of a number of iterations in the planning and construction of models	b. Thinking planned, openness of thought, decision making, setting priorities, objectives and criteria.
c. Benchmarking of a number of possible models and the selection of the model number	
Week 16 -Phase reflection thinking	
a. Testing of the features of the final product, compared with the target specified	a. The effect of collaborative teams on improvement projects
b. Conclusion on the success or difficulties during the development process.	b. The views of learners on the influence of team function on thinking and learning
c. Suggestions for improvement in the process of planning and construction.	c. Assessment of the selected solution compared with the target design.

Table 3and Table 4 show the prerequisites and activities as well as the objects and the assessment criteria at this stage of consciousness thinking.

Table 3. Prerequisites and Activities

Prerequisites	Activities
a. Understand PBL b. Understand the mechatronic system c. Understand the rules of the lab d. Understand the criteria for project e. Understand the function of the group in the project	a. Formation of groups and group names b. Selection of project topics c. Preparation of project description d. Presentation of project topic

2.3.4. Mapping the project

At this stage the development of mechatronic systems are mapped in the process of practical implementation and assessment processes. The result is a unit of Events Teaching and the assessment guidelines which refer to the PBL.

2.3.5. Regulate the process

The process of practical implementation using PBL method lasts very dynamic and requires a lot of time, therefore the process of implementation needs to be well prepared. Liabilities develop and present a product development procedure document is a way applied to regulate the running of mechatronics lab using PBL. Table 4 discribes the objects and assessment criteria. Figure 3 shows the document B100-B700 which gradually prepared by learners with reference V model. Special document production test was not carried out by the students during the practicum.

Practical application of PBL in mechatronics lab has been tested by involving students in grade 3 Electronic Engineering Program of Electrical Engineering Department Bandung State Polytechnic. Participants were divided into 13 groups with each group of 4-5 students. The group's name and the title of the project can be seen in Table 5.

Table 4. Objects and assessment criteria

Objects Assessment	Criteria
The composition and the name of the group	a. Distribution task group members b. The reason for choosing the name of the group
Topics project	a. Compliance with the criteria of mechatronic systems b. Authenticity c. Uses d. The possibility of realization (cost, time, science)
Description of project	a. Selection of titles b. Depictions block diagram c. Development of a tool description d. Preparation function tool
Presentation of project topic	a. Preparation of the presentation slides b. Presentation skills c. Ability to answer questions d. Compactness team in presentation

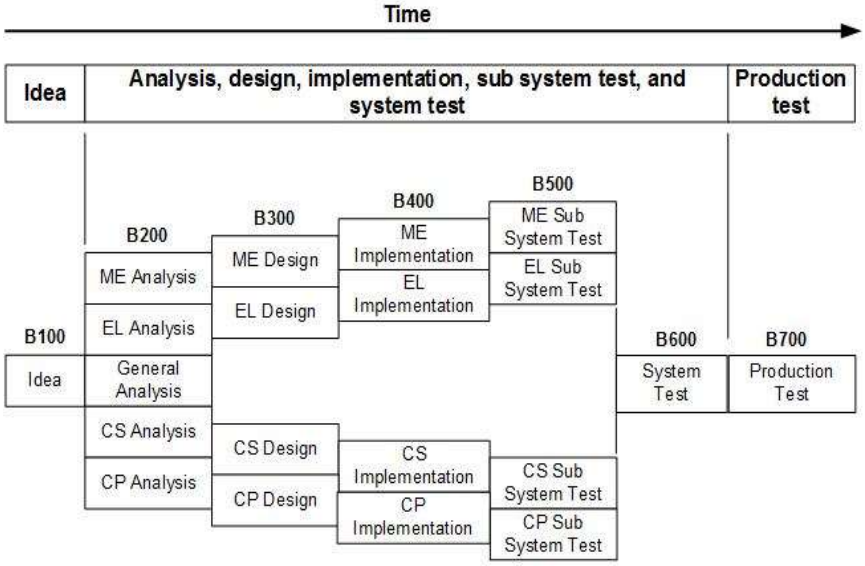

Figure 3. Document of mechatronics system development

Table 5. Student project data

Group Name	Project Title
Flying Dutchman	Robot arm (mobile)
Parity	Prototype of automatic car parking robot
AutoBot	3 floors elevator prototype based on PLC
Megatron	Goods movers line follower robot with gripper
De Phinisi	Robot floor scrubbers and sweepers
Five Boys Engineering	Automatic bottle filler simulation-based on microcontroller
Keep on Running	Line follower robot
Gorden	Automatic curtain opener based on microcontroller ATMega 8535
Vending Machine	Vending machine
Konveyor	Counter system design and products selection based on color on industrial conveyor track
Forklift	Forklift
Parkir	Two floors automatic parking system simulation based on microcontroller ATMega 16
Botol	Automatic bottle filling machines

3. RESULTS AND ANALYSIS

To determine student opinion questionnaires distributed. Results of the questionnaire showed that most students feel understood what that meant learning to use PBL (60%) and know the difference with the usual lab work (67%). Most students also feel happy (54%) and consider practical use of PBL as a challenge (80%). These results provide hope for the implementation of the methodthe Innovation and Entrepreneurship Integrated Project (IEIP) [26] and the results of this study are not much different from what was done in [27].

In general, the students stated that by using PBL in mechatronics lab need improvement (72%), while the rest wanted incorporation PBL with conventional learning.

The most preferred of practical implementation of PBL are the task of designing the tool (45%), presentation (18%), group work (13%), are more informed (11%), to share knowledge (8%), and to get feedback on its design (5%). While the constraints felt by students is hardly sufficient time (40%), other lecturers are less supportive (25%), practical way that minimal information (20%), and knowledge of lab-based PBL were minimal (15%). Availability of time is important in the implementation of PBL. Types of projects should be assessed how much longer time for completion [28].

Some experience in the application of PBL encourages additional criteria for project selection. The selected projects must also meet the specified topic in the semester. Some of the topics that was once used as a condition of the project is the mechatronic systems in the areas of health, military, agriculture, sports, the arts, and maritime. Determining a different topic in every semester/year will encourage creativity and motivation of students.

4. CONCLUSION

Mechatronics lab course using PBL method can be implemented in accordance with plans and got a positive response from students. Most students want a mechatronics lab with PBL method can be passed with some improvements such as the socialization of PBL, improvement guide lab, increased guidance by the lecturer, and the expansion of knowledge, especially in the field of mechanics.

Students feel a new challenge in the process of practical implementation of PBL. As part of the most favored in PBL is the task of designing the tool. The selection and project planning needs to be improved by taking into account the availability of time so that the target can be achieved with good lab.

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