Enhancing learning experience of turbine engineering using finite element method software

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Abstract. The call for providing practical learning opportunities to students is prominent in engineering education. To address this requirement, an experiential learning approach was applied in a turbine engineering course emphasizing on practice-based learning. It is expected that after completing this course, the students will capable to undertake design calculation of specified turbine for assessing and predicting its performance. In this research, the Finite Element Method (FEM), a numeric procedure for analysing a wide variety of engineering problems was incorporated within the Kolb’s experiential learning cycle to give visualization of physical behaviour of a turbine. The ADDIE method consists of a series of activities (analysis, design, develop, and evaluation) was employed in this study to develop a lesson plan of turbine engineering. This research is to supposed to establish a new learning options for turbine engineering courses which increases student understanding of basic turbine engineering concept as well as provides opportunities for students to have experience in designing a wind turbine with FEM. After completing the development stage, it was found that the instructor responses positively to implement the learning module for turbine engineering.

1. Introduction
Engineering education will always face challenges along with the development of science and technology. The real challenge of an engineer is to be required to have expertise gained from experience and conceptual knowledge of problems in the field of engineering [1]. If we see it in a wider scope, Republic of Indonesia Law No. 20 of 2003, states that education is a conscious and planned effort that has the goal of realizing a learning atmosphere and learning process so that students can actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and skills needed by himself, society, nation and state [2].

The definition of education listed above confirms that one of the main goals of education is to create an active learning environment and enable students to develop all their potential to the fullest. Considering the demands of engineers in the industry, it is important to prepare engineers facilitating students to build strong basic concepts and have experience in applying those concepts in practical. the Experiential Learning based learning model could be an alternative model for improving student’s understanding.

The application of the experiential learning (EL) is to change the role of the lecturer, where lecturers position themselves as guides and advisors no longer act as controllers in the lecture process in class[3]. The use of this learning model can improve student learning outcomes, so they suggest improving student learning outcomes by applying this learning model[4]. The use of EL went very
well and was very helpful in designing the learning process in the classroom [5]. The use of this learning model may also be developed in other subjects related to mechanical engineering and use different forms of simulation with the simulations used in the civil engineering department. Numerical solution techniques in finite element methods can be applied to broad physics problems, related to variables from algebra, differential, or integration equations [6]. Today, the use of finite element methods in mechanical engineering lectures has been carried out because the numerical code of MEH can provide something interesting to calculate, analyze, and visualize on a solid object[7].

The experiential learning model initiated by David A. Kolb with an adjustment to the finite element method by using the Ansys simulation application is expected to be an alternative in the process of internalizing turbine learning material because in applying this model, later learning activities can function as a process of constructing knowledge through transformation of experience that the author will develop. The author will develop this learning design on turbine courses because turbine courses are closely related to abstract things and cannot be seen directly, such as fluid flow and how the turbine design influences the rotation and power produced by the turbine. Where abstract things can be visualized in detail using MEH that will be able to construct students understanding.

The development carried out by researchers based on the ADDIE development model that has been commonly used in the development of learning. Looking at some of the problems raised above, this study directed at developing Experiential Learning methods using the Finite Element Method in Turbine Courses which are expected to provide learning innovations that can accommodate students to find deep and meaningful understanding.

2. Methods

The method in this study is a qualitative method with a development research approach. The development in this study is based on an ADDIE development model which is a model that has been widely used in various studies related to the development of learning. The ADDIE model itself is an acronym for each stage in development. The stages of this model include Analysis, Design, Development, Implementation, and Evaluation. But this research is planned to reach the stage of development and go directly to the lecturer evaluation steps that are related due to various considerations of the author.

In this study, the analysis phase began by interview with turbine lecturers’ team as research subjects because they were understood about lack of turbine courses very well, interview was conducted structured with grids of questions validated by content validation from expert judgment so that the questions asked to subject of this study was in accordance with the context of this study. Then from the discussion, several things were formulated that could be developed in the turbine courses. Analysis phase done after we can find some needs in learning process of turbine courses so we can step on next phase.

At the design phase we design an option of learning process based on need that appear on analysis phase. Here we applied experiential learning cycle by Kolb to provide an active learning process. Design phase done when we get a learning activity plan. We develop this learning activities by using FEM software for give solution of need on turbine courses. This phase done when we get a visual simulation and some data of air-foils from ansys software.

3. Results and Discussion

The resultof this study is a new learning option that can be applied to turbine courses or those related to wind turbines. The results of this study elaborated according to the steps in the ADDIE development method. This learning option is presented in the form of a learning plan that is include to the model and visualization of the turbine and several other learning instruments.

From the learning analysis process with the lecturer of turbine courses we find some needs in learning that we can develop using this method, these needs include: (1) The need for a visualization approach that has been used in turbine learning has become a visualization of images using MEH software; (2) The need for media is in the form of interactive software where users can change parameters in the
simulation; (3) The need for steps in the process of applying experiential learning as a guideline for lecturers to implement this method.

In this discussion a core activity in learning designed that applies Experiential Learning by utilizing the finite element method to provide visualization in explaining abstract principles found in turbine courses. Learning using experiential learning is designed based on 4 cycles on experiential learning, namely; Concrete Experience, Reflective Observation, Abstract Conceptualization, Active Experimentation. Effective learning will be seen when someone experiences the 4 components above: (1) has concrete experience, followed by (2) reflection and observing that experience which leads to (3) forming abstract concept analysis and generalizing conclusions which then (4) are used to test hypotheses in subsequent simulations, resulting in new experiences [8]. The four components are outlined in the Figure 1.

![Figure 1. CE cycle](image)

The first step in the learning process using experiential learning begins with the CE cycle (concrete experience) that can be done through early discussion at the beginning of class and understanding student learning capital and connecting the basic knowledge that students have with the material on the turbine course. CE phase is planned as follows: The lecturer gives time for students to discuss their knowledge and experience regarding calculation and energy equation at horizontal wind turbines. We assume that student know the equation well because this learning process was planned to happen at the end of semester. Discussions conducted at this stage were guided by lecturers in positioned as guides and advisors no longer served as control holders in the lecture process in class, so active learning was centre on students. In this cycle we can allocate around 15-20 minutes to be able to explore concrete experiences from students sufficiently and not too long.

\[ P = \dot{E} = \frac{1}{2} \rho A v V^3 \]

In CE we will discuss this equation because in this case we assume student meet this equation at the beginning of semester. We concern at the “A” variable on the equation because we will focus at the rotor design.

The second step is to begin the reflection observation stage where students begin to reflect and observe new experiences that displayed by lecturers who utilize the finite element method. The important thing about this component is combining experience and understanding that students will get through visualization displayed by the lecturer. At this stage the lecturer gives an overview of the types of air foils to explain the differences in each air foil and its specifications. In this stage student expected to know that “A” variable on the equation is have dependence on rotor design. Student can find out the effect of blade design by refer to Figure 2 and Table 1.
Table 1. Air foil specification

| Specification        | Value  | Description           |
|----------------------|--------|-----------------------|
| Thickness            | 9.9%   | Max Cl                | 1.65 |
| Camber               | 6.7%   | Max Cl angle          | 11.5 |
| Trailing edge angle  | 11.5%  | Max L/D               | 79.29 |
| Lower flatness       | 12.2%  | Max L/D angle         | 4.0  |
| Leading edge radius  | 2.2%   | Max L/D Cl            | 1.435 |
| Efficiency           | 43.8%  | Stall angle           | 5.5  |
|                      |        | Zero lift angle       | -8.5 |

Figure 2. Airfoil NACA AH 79-100C

This figure and table are the media that shown to students for reflective and observe the calculations that can be done with existing data. At the end of this phase student expected to know some parameters based on fundamental aerodynamic theories are needed in order to get more energy from the wind so it can produce more power from the rotor design. The parameters can be expressed as follow: Radius of rotor \( R \), tip speed ratio of the rotor at design-point \( \lambda_D \), number of blades \( B \), design lift coefficient of the air foil \( C_{lD} \), and angle of attack \( \alpha \).

The next step is the application of the third cycle of experiential learning, abstract conceptualization which is a continuation of the reflection of observations that have provided additional ideas, at this stage students are encouraged to be able to modify abstract concepts that have been understood from the first two cycles. At this stage it is assumed that students have understood the basic concepts of turbine calculations and know how to get more power by optimize the rotor design. The activity that carried out at this stage is that students are asked to modify the parameters that show in the RO phase to make hypothesis how the output of modified turbine. Then, active experimentation will begin using FEM software, student expected to make a simulation to establish the hypothesis from the manual calculation and can visualize the wind on this case. At the end of learning activities student can show their project simulation as refer to Figure 3 and Figure 4.

Figure 3 shows visualisation approach of abstract concept on turbine course. Table 2 shows the learning stage and learning activities of each ELT stage.
Table 2. Learning stage and learning activities of each ELT stage

| Stage                   | Section                                                                 |
|-------------------------|-------------------------------------------------------------------------|
| Concrete experience     | Discuss energy equation on wind turbines                               |
| Reflective observation  | Discuss how to gain more power from wind turbine through optimize rotor design. |
| Abstract conceptualization | Do teamwork to build a modified turbine blade and build a hypothesis   |
| Active experimentation   | Develop and analyse blade with FEM software and establish the hypothesis |

From this learning activities that build from experiential learning by Kolb’s and combined with finite element software we can provides a new way of studies abstract things.

4. Conclusion
This article provides a new option of learning in turbine course in an education program of vocational teacher of mechanical engineering, which combines Kolb’s experiential learning cycle and finite element method. It developed with learning activities in four-part representation the process of grasping and transforming the information. There is no formal assessment of this module has been made; although initial faculty reaction has been positive. For future works we will include an evaluation and assessment of implementing the Kolb’s cycle within the course at the end of year’s use in the classroom. It is expected that the long-term effects of the experiential learning cycle implementation will result in enhancing student learning and later strengthening pedagogical skills of the student teacher.

5. References
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