Experiential Learning Using Solar Tracker Prototype In Industrial Automation Course

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Abstract. Experiential Learnings is based on the understanding that the knowledge created as the result of an experience. Experiential Learning consisted of four stages, abstract conceptualization, active experimentation, concrete experience, and reflective observation. Experiential learning - Based learning is considered to have characteristics that are expected in the 21st Century Skills Learning. This study aims to develop experiential learning -based instructional design in Production Automation courses using a solar tracker system prototype. The effectiveness of the learning design is measured from the student learning outcomes and responses of the questionnaire provided. The control system subject in the production automation course is considered to have abstract and complex learning material so that it requires visualization to facilitate understanding. The development of the instructional designs is carried out using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The instructional design of the course was implemented in a class consisting of 40 students in the department of Mechanical Engineering Education in a state university in Central Java, Indonesia. From a series of lectures during the course of Production Automation, the instructional design developed based on experiential learning approach received a positive response from the students. The student learning outcomes were also considered good with the average scores of more than 80. This study shows that experiential learning approach could stimulated student learning in mechanical engineering subject.

1. Introduction

The in – class learning is expected to achieve the 21st Century Skill where students are encouraged to nurture the ability in communication, collaboration, critical thinking and problem solving, as well as creativity and innovation. The experiential Learnings which based on the understanding that the knowledge created is the result of an experience is considered appropriate in achieving the skills required in the 21st century. Experiential Learning consisted of four stages, abstract conceptualization, active experimentation, concrete experience, and reflective observation [1]. According to Ayoub [2], experiential learning could lead learners to use their experience in improving their creativity to solve the problem on learning. Experiential learning could improve conceptual understanding since, students build their knowledge and skills through direct experience. This method emphasizes the role of active experience and student involvement [3].

Experiential learning has applied in several subject across several regions. Experiential learning was intensively performed at Ryerson University to have students understand the concepts of electrical engineering in mechatronics subjects [4]. In a Malaysian higher education institution, experiential learning is applied to create creativity and innovation among students that supports generic skill requirements among students. Widiastuti et. Al [5], using the concept of experiential learning by implementing four cycles of Kolb approach in the subject of heat transfer in mechanical engineering education.

This study is focused on the use of a prototype to support experiential learning. A solar tracker system prototype has been previously used for the subjects of (1) Virtual Instrumentation, (2) Control Systems, (3) Computer Aided Design [6]. The use of prototypes, could benefit in learning since it is easily accessible and requires low cost [7]. In the course of automated production system, control system
subject is considered to have abstract and complex material. Therefore, the prototype in this subject is expected to help students visualize the matters in improving their understanding.

This research was conducted so that in the learning process leads to the 21st Century Skill Learning program and hopefully students will also have the necessary knowledge and skills in accordance with the learning objectives that will be achieved. If this research is not carried out immediately, it is feared that the learning process is not in accordance with the 21st Century Skill Learning program and the purpose of production automation learning cannot achieve the expected goals.

2. Research Method

This study uses a qualitative method with a development research approach using the ADDIE development model in learning instruments. The ADDIE approach was used in this study for designing the instructional materials. The purpose of ADDIE is to explain learning science and learning modules as a complement to teaching materials [8]. The ADDIE development model is used to improve the quality of teaching material instruments [9].

Aldobie’s research [10] states that the ADDIE development model is divided into five main stages: (1) Analysis, this stage is the first stage that is carried out when using the ADDIE development model. Analysis There are some aspects that do, such as analysis of students, analysis of learning objectives, and developing learning analysis. (2) Design, this stage contains the planning of learning concepts that will be implemented in this development. (3) Development, the development stage contains activities to develop and design instruction, learning materials, and carry out learning. (4) Implementation, this stage changes what was originally a planning into a direct practice. (5) Evaluation, the stage where development is determined whether it is acceptable or should be redeveloped.

The data validity test technique in this study is through expert judgment on the validity of the context. In this case the expert judgment in question is a lecturer in the automation production course of PTM FKIP UNS. The data analysis technique used is a Likert scale. The percentage calculation can be used a Likert Scale to find out the feasibility of the assessed module [11].

3. Result and Discussion

This research was conducted following the stages of the ADDIE development model. In the analysis stage, interviews were conducted with 2 lecturers in the production automation course. The results of the interview obtained several important points that would support this development research, namely: (1) The production automation course aims to improve students’ understanding of the automation production system. (2) Experiential learning based on learning should be compatible with the control system learning material because students will experiment a lot (3) The use of prototypes will help in experiential learning.

At the design stage, learning objectives planning are carried out at each stage of experiential learning. The planning is divided into 2 meetings, namely:

| Table 1. Purpose of Each Stage of Experiential Learning Meeting 1 |
|---------------------------------------------------------------|
| **Experiential Learning Stages** | **Purpose of Each Stage at the Meeting 1** |
| Concrete Experience | Students understand the definition of a control system |
| Reflective Observation | Students understand the components of the control system. |
Abstract

Conceptualization

Students can get to know the functions of the control system components, namely sensors, controllers, and actuators.

Active

Experimentation

Students make block diagrams on the solar tracker system.

Table 2. Purpose of Each Stage of Experiential Learning Meeting 2

| Experiential Learning Stages     | Purpose of Each Stage at the Meeting 2                                      |
|----------------------------------|--------------------------------------------------------------------------|
| Concrete Experience              | Students understand the types of sensors, controllers and actuators in the prototype solar tracker system. |
| Reflective Observation          | Students expected to identify other control system in different applications beside the solar tracker system. |
| Abstract Conceptualization      | Students understand the types of sensors, controllers, and actuators.    |
| Active Experimentation           | Students can design a system and understand the components that must be used in the system. |

The development stage is the learning design is developed. The learning instruments developed include a lesson plan, Learning Modules, and Prototype Solar Tracker System. The lesson plans are developed in accordance with the experiential learning stages in which there is a solar tracker system prototype to support learning.

![Solar tracker system prototype](image)

**Figure 1.** Solar tracker system prototype

In the lesson plan, there is a learning steps that has been developed. The learning development carried out is based on experiential learning using a prototype solar tracker system. The learning sequence that has been developed can be seen in the following table:
### Table 3. Learning Steps at the Meeting 1

| Experiential Learning Steps | Concrete Experience | Reflective Observation | Abstract Conceptualization | Active Experimentation |
|-----------------------------|---------------------|------------------------|---------------------------|------------------------|
|                             | 1) The lecturer delivers the basic material of the automation system. | 1) Students implement the control system elements in the water filling system. | 1) Lecturers use a prototype so that students explore information and data which is then used to answer these questions to increase understanding. | 1) Students observe the simulation results of the solar tracker system prototype based on the knowledge concepts that have been obtained. |
|                             | 2) The lecturer presents a picture of the working mechanism of the water tank. | 2) Students re-analyze the input, process, and output stages using an analogy. | 2) Students are asked to explain the meaning of sensors, controllers, and actuators. | 2) Students are asked to identify the control system components in the solar tracker system prototype. |
|                             | 3) Students are asked to answer questions according to the picture of the water tank mechanism that has been presented. | 3) The lecturer provides an example of a system application and introduces a block diagram. | 3) Students are asked to make a block diagram in the solar tracker system prototype application and explain the contents of the block diagram. | 3) Students are required to be able to use control system components according to their function in the control system design they make. |

### Table 4. Learning Steps at the Meeting 2

| Experiential Learning Steps | Concrete Experience | Reflective Observation | Abstract Conceptualization | Active Experimentation |
|-----------------------------|---------------------|------------------------|---------------------------|------------------------|
|                             | 1) The lecturer displays a prototype to show the various types of sensors, controllers, and actuators used in each example of an automation system application. | 1) Lecturers begin to direct students' minds to see examples of system applications widely so that students can mention control system applications other than the solar tracker system prototype. | 1) Lecturers use a prototype in order for students to dig up information and data which are then used to answer these questions. | 1) Students observe the prototype simulation results based on the knowledge concepts that have been obtained. |
|                             | 2) The lecturer opens questions by asking what sensor, controller, and actuator components are used in the Prototype Solar Tracker System. | 2) Students are asked to show one example of a control system in several applications: agriculture, traffic, smart city, building, health, etc., then identify and explain the types of sensors, controllers, and actuators used. | 2) The lecturer introduces the many types of sensors, controllers, and actuators. | 2) The student proposes a control system with an Arduino controller, then is asked to draw a diagram block and determine the sensor used and the actuator working mechanism in the system. |
|                             | 3) Students are asked to identify the control system components in the solar tracker system prototype. | | 3) Students are asked to explain the types of sensors, controllers, and actuators. | 3) Students are required to be able to use control system components according to their function in the control system design they make. |
As for the learning module, the lecturers are assessed so that it can be concluded whether the module is suitable for use or not. There are 4 aspects that are assessed in the module, namely: Self Instructional, Self-Contained, Adaptive, User Friendly. The assessment of the lecturer on the learning module will be interpreted so that conclusions can be drawn. According to Risma Novita [11], the percentage calculation can be used a Likert Scale to find out the feasibility of the assessed module using the formula:

\[
Percentage (\%) = \frac{\text{The number of scores obtained} \times 100}{\text{maximal scores} \times \text{responden}}
\]

Then from the calculation results, each element of the question will be interpreted to be able to draw conclusions. The indicators used to draw conclusions are:

a. If the calculation result is 0% - 20% = very weak
b. If the calculation result is 21% - 40% = weak
c. If the calculation result is 41% - 60% = enough
d. If the calculation result is 61% - 80% = strong
e. If the calculation result is 81% - 100% = very strong

The results of the module assessment are as follows:

| Question element     | Percentage | Information |
|----------------------|------------|-------------|
| Self-Instructional   | 84%        | Very strong |
| Self-Contained       | 70%        | Strong      |
| Adaptive             | 80%        | Strong      |
| User Friendly        | 90%        | Very strong |
| **Overall Average**  | **81%**    | **Very strong** |

Based on the table above, the results of the overall module assessment are 81%, so the module has a very strong interpretation for use in experiential learning-based learning.

The implementation stage is carried out to test the learning designs that have been developed. The trial was carried out for 40 students in the department of Mechanical Engineering Education who took an automated production system. Learning is carried out online and in accordance with the lesson plan in the course, where learning takes place in 2 credits (2x50 minutes). The learning technique carried out is to provide learning videos related to the learning material to be delivered and a demonstration of the solar tracker system prototype.

In the evaluation stage, the results of using the learning design that have been developed can be seen. Student learning outcomes can be used as indicators to measure the level of understanding of students when experiential learning designs are tested. Student learning outcomes can be seen in the following table:
Table 6. Student Learning Outcomes

| Value Interval | Value Predicate | Frequency | Module 1 | Module 2 |
|----------------|-----------------|-----------|----------|----------|
| <55            | E               | 0         | 0        | 0        |
| 55 - 59        | D               | 0         | 0        | 0        |
| 60 - 64        | C               | 0         | 0        | 0        |
| 65 - 69        | C +             | 1         | 2        |          |
| 70 - 74        | B               | 3         | 1        |          |
| 75 - 79        | B +             | 16        | 4        |          |
| 80 - 84        | A -             | 1         | 15       |          |
| 85 - 100       | A               | 19        | 18       |          |
| **Total Frequency** | **40**   | **40**    | **81,725** | **83,325** |

Based on the student learning outcomes in the table above, the students mean scores were 81.725 and 83.325. If this value is interpreted, it will get category A- values, which have good information.

In addition to learning outcomes, another indicator used to assess the implementation of experiential learning is the student response questionnaire. This study used a closed questionnaire which contained 15 positive questions to be distributed to 40 respondents.

Table 7. List of Questionnaire Questions

| No.  | QUESTION                                                                 |
|------|--------------------------------------------------------------------------|
| 1.   | I'm happy to participate based learning Experiential Learning this       |
| 2.   | Learning Experiential Learning arouse my curiosity towards learning material |
| 3.   | The learning model used is very satisfying                               |
| 4.   | The learning is very interesting and not boring                          |
| 5.   | Simple learning concept                                                  |
| 6.   | The learning process takes place sequentially and systematically         |
| 7.   | The learning is informative, so that you can understand the basic knowledge of the material being taught |
| 8.   | Learning is realistic (according to actual conditions) and related to everyday life |
| 9.   | Every activity in learning helps improve my understanding               |
| 10.  | I feel actively involved in learning                                     |
| 11.  | I feel challenged to use this learning model.                            |
| 12.  | Experiential Learning based learning helps me to connect and receive subject matter |
| 13.  | In this learning model I learned things I didn't know before             |
| 14.  | There was a change in the level of my belief and knowledge of the material |
| 15.  | The learning process can develop my personal knowledge and skills       |

The calculation can be done using a Likert Scale [11]. The results of the assessment of the response to the use of experiential learning are:
Table 8. Questionnaire Assessment of Using Experiential Learning

| Statement | Score | Maximum Score | Likert Scale (%) | Information |
|-----------|-------|---------------|------------------|-------------|
| 1         | 162   | 200           | 81               | Very strong |
| 2         | 161   | 200           | 80.5             | Very strong |
| 3         | 139   | 200           | 69.5             | Strong      |
| 4         | 145   | 200           | 72.5             | Strong      |
| 5         | 160   | 200           | 80               | Strong      |
| 6         | 166   | 200           | 83               | Very strong |
| 7         | 154   | 200           | 77               | Strong      |
| 8         | 154   | 200           | 77               | Strong      |
| 9         | 161   | 200           | 80.5             | Very strong |
| 10        | 155   | 200           | 77.5             | Strong      |
| 11        | 147   | 200           | 73.5             | Strong      |
| 12        | 150   | 200           | 75               | Strong      |
| 13        | 170   | 200           | 85               | Very strong |
| 14        | 157   | 200           | 78               | Strong      |
| 15        | 162   | 200           | 81               | Very strong |

Based on the above results, each question given has strong and very strong information so that the respondent gives a positive response to the use of experiential learning with a prototype. This is in accordance with the opinion of Falloon [12], which states that experiential learning can be used to develop students' thoughts and concepts, and find motivation and things that make students interested. Therefore, the use of experiential learning in learning can indeed attract students and students will give positive responses in learning. This is also in accordance with the results of research by Pamungkas [3], which states that the application of experiential learning is very suitable for use in mechanical engineering education because the learning model will increase student knowledge and learning outcomes.

4. Conclusion

In this research, a learning design based on experiential learning was developed which contained 4 main stages, namely concrete experience, reflective observation, abstract conceptualization, and active experimentation. In experiential learning, a prototype solar tracker system is also used as a tool to provide an overview or visualization of the learning material presented to students. This learning design is structured in a lesson plan which is also equipped with a learning module.

When the experiential learning-based learning design trial was conducted, students gave positive responses or responses to the learning. This can be seen from the questionnaire given to students to assess or respond to the learning they have taken. Even within these classes, the class average score is relatively high. In 2 meetings, the average grade for assignments in the class was 81.725 and 83.325. If interpreted, the two class averages get an A-grade category, which has good information. This study shows that experiential learning can be an option in control system learning or even developed on other basic learning materials or competencies.
5. References

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