

# Learning Model of Industrial Control Engineering Based on Augmented Reality

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**ABSTRACT----** *This study aimed to determine the Learning Model of Industrial Control Engineering based on Augmented Reality developed to improve student learning outcomes. This type of research is Research & Development (R&D), with the development stages modified from various existing development models. Data collection techniques were observation and questionnaires. The data analysis technique uses validity analysis and effectiveness analysis. The results obtained from this research were Learning Model of Industrial Control Engineering based on Augmented Reality can improve learning outcomes. The value of the n-gain score in the experimental class is 0.54, which means that there has been an increase in learning outcomes in the medium category. There are two implications of this research. (1) the Learning Model of Industrial Control Engineering based on Augmented Reality is expected to be used as input for other researchers to conduct similar research on other subjects or even in other methods for further research. (2) Implementation of Learning Model of Industrial Control Engineering based on Augmented Reality is expected to be continuously applied as an alternative learning model in Industrial Control Engineering Courses and other subjects.*

**Keywords---** Learning Model, Industrial Control Engineering, and Augmented Reality

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## 1. INTRODUCTION

Digital transformation and digitization have taken place intensely and have provided incentives to various levels of society. On the other hand, the Digital Transformation currently taking place is also destroying the system that has been built so far. Digital Transformation brings massive changes due to the process of digitizing electronic designs. Today, digital transformation has penetrated various sectors, including the public service sector such as telecommunications, banking, tourism, health, transportation, and production, to the world of education and services. Digital Transformation is the main trigger for the Industrial Revolution 4.0 movement, where massive changes occurred in design strategies, production processes, automation, order acceptance, product marketing and delivery caused by digital technology.

The current conditions indicate that the Business and Industrial World (DUDI) development is also undergoing rapid changes. Trends that occur in society today have entered a new phase known as the era of the Industrial Revolution 4.0. Digitalization in various sectors marked this era, so digital technology has recently begun to replace what was initially human as the centre of the economy. (Merkel, 2014) stated that the Industrial Revolution 4.0 is a comprehensive transformation of all aspects of production through digital technology and the internet with conventional industry. These changes inevitably make DUDI compete to adapt to the demands, thus not being left behind and eroded by the wheels of time that continue to spin. In addition (Yahya, 2018) also stated that Industry 4.0 was used on three interrelated factors, namely; 1) digitalization and economic interaction with simple techniques to economic networks with complex techniques; 2) digitization of products and services, and 3) new market models.

The conditions described above indicate the importance of mastering digital technology. The development of digital technology cannot be dammed and will continue to grow. The digital technology order can have both good and bad impacts depending on its designation and management. To compete and win today's global competition, the world of education,

especially vocational education, must produce more competitive human resources according to needs. According to (Aoun, 2017), in the Industrial Revolution 4.0 era, there were three new types of literacy, including data literacy, digital literacy, and human literacy.

Vocational education providers should take a role and place themselves in the current era of Digital Transformation and Industrial Revolution 4.0. This needs to be realized considering that vocational education requires learning designs that are adaptive to changes in DUDI. Thus, vocational education is expected to make a real contribution to

Print superior human resources and are ready to compete. The existence of Digital Transformation will certainly bring new opportunities for vocational learning innovation. Digitization in education can be seen through digital learning, online courses, e-books, and integrated academic information systems. At the higher education level, digital learning is a form of educational disruption that can fundamentally change the learning process. Therefore, so that graduates can be more competitive, the curriculum in vocational education needs a new orientation that leads to digital learning.

Digital competence is built so that human resources, especially teachers and students, can master digital technology. This is done to improve the quality and quality of education. The importance of digital competence for educators is also emphasized by (Blyznyuk, 2018), who explains that in 21st-century learning, educators are required to be able to create digital learning content such as learning application programs, interactive presentations, and learning animations, and others.

Internalizing the context of digitization, digital transformation, and the industrial revolution 4.0 in a learning process can be done in the learning design. Learning design with this context can be implemented into a learning model because the learning model leads to a particular approach and specific learning. As stated at the beginning of the discussion, the digital-based learning approach is internalized into the learning model. The learning model is a systematic procedure or pattern used to achieve learning objectives in which there are strategies, techniques, methods, materials, media, and learning assessment tools (Afandi, 2013). The learning model also has an essential role in achieving instructional learning objectives. Learning models have four unique characteristics that are not owned by learning strategies or methods: (1) logical theoretical rationales compiled by educators; (2) learning objectives to be achieved; (3) the teaching steps needed so that the learning model can be implemented optimally; and (4) the learning environment needed so that the learning objectives can be achieved (Purnamawati & Jaya, 2016).

One of the digital technologies that can be used in learning is Augmented Reality (AR) technology. This technology provides an interesting learning atmosphere because it provides a more interactive, 3D, and real display. In addition, Augmented Reality (AR) technology is widely developed in the manufacture of multimedia learning presentations as a teaching tool in the learning process in the classroom. It does not replace the teacher as a whole. This is following the opinion (Munir, 2017) that digital learning is a system that can facilitate learners to learn more broadly, more, and varied. Through the facilities provided by the system, learners can learn anytime and anywhere without being limited by distance, space, and time.

The results of research conducted by (Setiawan & Dani, 2021) reveal that Augmented Reality technology can increase understanding of the object being studied. In addition, the use of Augmented Reality technology is more effective than other learning media such as books, videos, or the use of ordinary computers. The results of research conducted by (Ihsan et al., 2017) explain that Augmented Reality technology has begun to be widely developed in education as a learning aid. By using Augmented Reality, a student can learn visually and interactively and more effectively with virtual simulation teaching materials. The working principle of this technology, according to (Usada, 2018), is tracking and reconstruction. First, the marker is detected through the image from the webcam. The detection mechanism (tracking) can involve various algorithms such as edge detection or other image processing algorithms. The data obtained from the tracking step is used to reconstruct the coordinate system in the real world. (Joefrie & Anshori, 2012) explains that AR is a technology that uses computer vision techniques in determining the suitability between the image and the real world, calculating poses, projection matrix, and homographs of these adjustments. To run an AR system consists of at least a camera, a monitoring device, and in some instances, requires a particular device to interact with virtual objects.

Based on this, this research will examine a learning model with a digital-based learning approach by integrating industrial control learning materials into a digital technology system.

## **2. RESEARCH METHODS**

This type of research is Research & Development research which aims to design Augmented Reality-based Learning Models at Polytechnics which aims to improve digital literacy skills and learning quality. The final product produced is the Learning Model of Industrial Control Engineering based on Augmented Reality and its learning tools that meet the valid, practical, and effective criteria for use. The development model has been modified from the five development models, namely the Borg & Gall, 4-D, ADDIE, ASSURE, and Gerlach & Ely in (Rusman, n.d) development models. The modified conceptual framework from various development models produces a relevant and appropriate syntax for designing and

developing learning model products based on augmented reality. The syntax consists of, among others: (1) analysis of model requirements; (2) Model design; (3) Model development; (4) Model Trial; (5) Evaluation; and (6) Final product dissemination & Feedback analysis.

The pilot subjects involved in this study were vocational college students in the Electrical Engineering Study Program, Industrial Control Course, semester 3. The universities included: (1) Ujung Pandang State Polytechnic in small group trials; (2) the Bosowa Polytechnic Makassar in a limited group trial; and (3) the Bosowa Makassar Polytechnic and the Ujung Pandang State Polytechnic in field trials which were then disseminated.

The data analysis technique used in this research is descriptive analysis. Descriptive statistical analysis techniques, namely statistics used to analyze data by describing or describing the data that has been collected. The presentation of the data used in this study is in the form of tables and figures, each of which is accompanied by an explanation. The results of the descriptive analysis in this study were used to determine the level of validity, reliability, practicality, and effectiveness of the product or the results of the development of an Augmented Reality-based Learning Model at the Polytechnic.

### **3. RESULTS AND DISCUSSION**

The initial step taken in this stage is a needs analysis following the results of the modification of the development model that has been carried out. The modification of the development model results consists of 7 syntaxes: model requirements analysis, model design, model development, model testing, model evaluation, product revision, and dissemination & feedback.

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#### ***3.1. Needs Analysis***

Needs analysis is the first step in this research. At this stage, the needs analysis is carried out by means of initial observation and documentation. The scope of the initial observation includes an analysis of the implementation of the learning process and an analysis of student characteristics. Based on the results of the observation on the implementation of the learning process above, it concluded that: (1) The orientation of learning is still centred on the lecturer; (2) The implementation of learning has not implemented a typical learning model; (3) The learning process is considered less interactive and innovative so that it tends to make students easily bored and unfocused; and (4) the implementation of the learning process has not maximized the use of digital features or technology. Observations on the use of teaching materials used in the learning process are carried out by reviewing the documents that have been used so far. Some of the materials taught are not yet relevant to the Industrial Revolution 4.0 trend, which focuses on digitalized industrial automation systems. Currently, the material being taught tends to lead to the field of instrumentation or measurement.

The observations obtained information that students who are currently in lectures are dominated by Generation Z or also called iGeneration, which since childhood have been familiar with technology and are familiar with sophisticated gadgets that indirectly affect their personality. Currently, most students from the Electrical Engineering Study Program at the State Polytechnic of Ujung Pandang and students from the Electrical Engineering Study Program at the Bosowa Polytechnic have used gadgets as communication support devices and various activities and access to information. The availability of multiple features offered by these smart devices certainly makes it an opportunity to be used in learning so that learning is more exciting and interactive.

#### ***3.2. Design of Learning Model***

Learning Model of Industrial Control Engineering based on Augmented Reality is designed to be used in the learning process in Industrial Control Engineering Courses so that students know automation and digitization. In developing this learning model, the scope of the researchers includes: (1) determining CPMK; (2) determining learning achievement indicators; (3) compiling learning modules; (4) preparing a semester learning plan; (5) drawing up a student assignment plan; (6) compiling an assessment rubric; and (7) applying digital-based learning.

The preparation of the learning model design is carried out based on the components of the learning model, which consist of: (1) compiling the learning syntax based on the relevance of the theory; (2) establishing a social system; (3) formulate the principle of reaction; (4) establish a support system consisting of learning tools and learning facilities, and (5) determine the impact of learning.

The drafting of the Learning Model of Industrial Control Engineering based on Augmented Reality is realized in the learning model book, which is described in Table 1 as follows.

**Table 1. Main Components of Learning Model Books**

<i>Component</i>	<i>Description</i>
<b>CHAPTER I</b>	<i>Rationalization of Model Development</i>
<b>CHAPTER II</b>	<i>Vocational Education and Relevant Learning Theories</i>
<b>CHAPTER III</b>	<i>A New Paradigm of Vocational Learning in Indonesia</i>
<b>CHAPTER IV</b>	<i>Learning Model of Industrial Control Engineering based on Augmented Reality</i>
<b>CHAPTER V</b>	<i>Implementation of AR-based Industrial Control Learning Model</i>

### 3.3. Learning Model Development

After preparing the learning model design, the next step is to develop a learning model. The Learning Model of Industrial Control Engineering based on Augmented Reality that has been designed is then developed through the validation stage. The learning model developed is Learning Model Books, Semester Learning Plans, Learning Modules, Learning Media, Student Task Plans, and Learning Outcomes Assessment Rubrics. The product development of the Learning Model of Industrial Control Engineering based on Augmented Reality and the research instruments used were validated by two experts, in the future referred to as validators.

**Table 2. Results of Expert Validation of Learning Model**

<i>No.</i>	<i>Component</i>	<i>Validation Score</i>			<i>Average</i>	<i>Category</i>
		<i>V1</i>	<i>V2</i>	<i>V3</i>		
1	<i>Learning Model Book</i>	3.15	3.18	3.25	3.19	<i>Valid</i>
2	<i>Learning Plan</i>	3.51	3.43	3.45	3.46	<i>Very Valid</i>
3	<i>Manual Book</i>	3.00	3.23	3.25	3.16	<i>Valid</i>
4	<i>Application AR</i>	3.35	3.43	3.54	3.44	<i>Very Valid</i>
5	<i>Evaluation Sheet</i>	3.34	3.43	3.32	3.36	<i>Very Valid</i>
<b><i>Average Validator Rating</i></b>					3.32	<i>Very Valid</i>

### 3.4. Learning Model Trial

The learning model test was obtained from the student's Industrial Control Engineering knowledge test results. Knowledge test data on Industrial Control Engineering in the Field Trial was obtained from the final test of learning mastery using the Learning Model of Industrial Control Engineering based on Augmented Reality. The results of the score data are the results that were tested on 35 students. The knowledge test results in the Field Trial can be seen in Table 3 as follows.

**Table 3. Knowledge Test Results of Industrial Control Techniques in Field Trials**

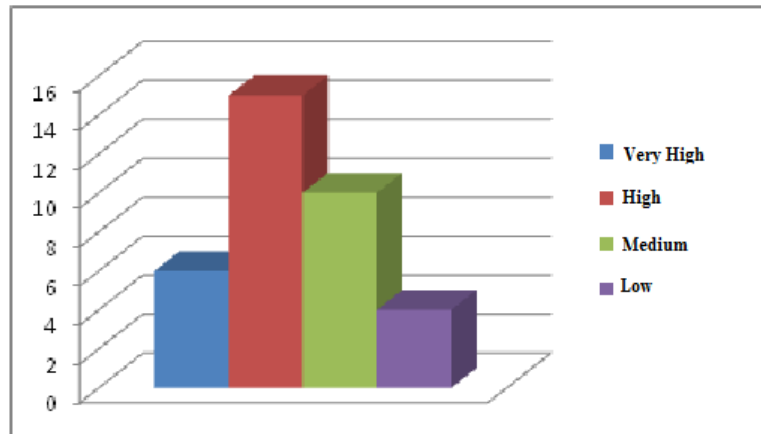
<i>Description</i>	<i>Statistic Value</i>
<i>Test Subject</i>	35
<i>Average</i>	83.21
<i>Median</i>	83.93
<i>Std. Deviation</i>	5.78
<i>Variance</i>	33.42
<i>Range</i>	25.00
<i>Minimum</i>	67.86
<i>Maximum</i>	92.86

Based on the descriptive analysis of the knowledge test data in the Field Trial, an average value of 83.21 was obtained. The minimum score obtained is 67.86, and the maximum score is 92.86. While the median value obtained is 83.93.

Furthermore, to determine the percentage of learning outcomes, the learning outcomes test data are grouped into four categories as follows.

**Table 4. Frequency Distribution of Student Knowledge Test Results in Field Trials**

Category	Interval		Frequency	Percentage
Very High	88.99	- Upper	6	17.14
High	83.21	- 88.99	15	42.86
Medium	77.43	- 83.20	10	28.57
Low	Lower	77.42	4	11.43



**Figure 1. Student Knowledge Test Results in Field Trials**

Figure 1 shows that student learning outcomes in the Field Trial show that there are six students in the very high category with a percentage of 17.14%. In the high category, there are 15 students with a percentage of 42.86%. In the medium category, there are ten students with a percentage of 28.57%. While the low category, there are four students with a percentage of 11.43%. Thus, the tendency of student learning outcomes in the Field Trial is in the category of high learning outcomes. The results of the trial application of the Learning Model of Industrial Control Engineering based on Augmented Reality in the Field Trial showed that the learning model developed was consistently able to improve learning processes and outcomes.

### 3.5. Evaluation of Learning Model

Analysis of improving learning outcomes using n-gain score analysis was carried out to prove the effectiveness of the effectiveness of the Learning Model of Industrial Control Engineering based on Augmented Reality product is more effective than the products that have been used so far. The n-gain score analysis was based on learning outcomes in experimental class 1 and control class 1. Furthermore, the n-gain score was analyzed and interpreted into the n-gain score categorization table.

**Table 5. Analysis Results of N-Gain Score.**

Class	Mean Pretest	Mean Post Test	N-Gain
Experiment 1	63.41	83,21	0,54
Control 1	61.02	64,33	0,08

The results of the n-gain score analysis in the experimental class 1 obtained a mean pretest value of 63.41, a post-test mean value of 83.21 and an n-gain score of 0.54. Meanwhile, in the control class 1, the mean pretest score was 61.02, the post-test mean was 64.33, and the n-gain score was 0.08. Based on the acquisition of the n-gain score in experimental class 1, it can be concluded that there was an increase in learning outcomes in the medium category. While the acquisition of the n-gain score in the control class 1, there was also an increase in learning outcomes in the low category. Thus, it can be said

that the use of the Learning Model of Industrial Control Engineering based on Augmented Reality is more effective than the learning model that has been used so far.

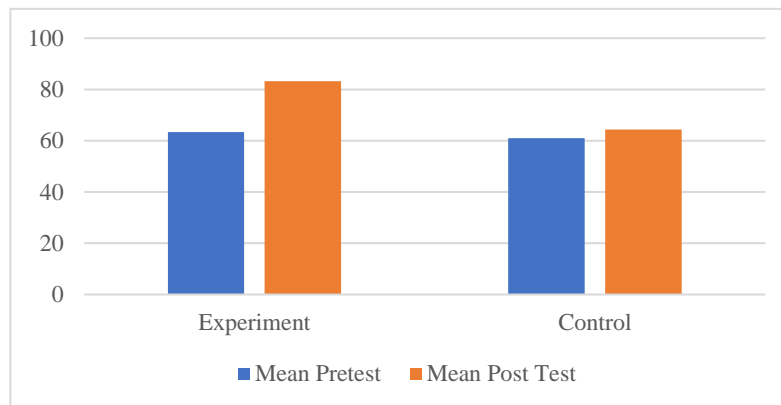


Figure 2. Comparison Graph of Learning Outcomes between Experiment Class 1 and Control Class 1

## 4. CONCLUSIONS AND SUGGESTIONS

### 4.1. Conclusion

The description of the development of this learning model is carried out in several stages, namely: (a) Needs analysis stage; to obtain a description of the graduate profile, analysis of lecture implementation, student analysis, and determine the description of the learning model needed; (b) the design stage; the scope of which includes setting CPMK, setting learning achievement indicators. As well as compiling a learning model design based on the components of the learning model which consists of compiling a learning syntax, establishing a social system, establishing a reaction principle, establishing a support system, and determining the impact of learning; (c) Development stage; its scope includes compiling learning tools consisting of learning modules, preparing semester learning plans, preparing student assignment plans, compiling assessment rubrics. At this stage, the learning tools that have been developed are further validated by two experts (d) The model trial stage; The trial of the learning model includes the stages, namely field trials; (e) the Evaluation stage; which is done to obtain the learning model developed can improve student learning outcomes. The Learning Model of Industrial Control Engineering based on Augmented Reality is stated to be able to improve student learning outcomes. The value of the n-gain score in the experimental class 1 is 0.54, which means that there has been an increase in learning outcomes in the medium category.

### 4.2. Suggestions

Based on the things that have been stated, further suggestions can be put forward as follows: (1) Development of a Learning Model of Industrial Control Engineering based on Augmented Reality is better to use different digital-based learning and development methods so that new research results are obtained as a compliment; (2) The polytechnic board of directors may suggest to lecturers to use Learning Model of Industrial Control Engineering based on Augmented Reality as an alternative learning model in Industrial Control Engineering Courses to improve student learning outcomes; and (3) Lecturers of Industrial Control Engineering courses in the teaching and learning process are expected to use learning models, one of which is the Learning Model of Industrial Control Engineering based on Augmented Reality.

### 4.3. Implication

Based on the things that have been stated before, the following implications can be proposed: (1) Research using the Learning Model of Industrial Control Engineering based on Augmented Reality in the learning process to improve student learning outcomes Industrial Control Engineering Course is expected to be used as input for other researchers to carry out similar research, in other subjects, or even on other methods for further research; (2) The application of Learning Model of Industrial Control Engineering based on Augmented Reality in the teaching and learning process is very beneficial for lecturers and students, so it is hoped that its continuous application as an alternative learning model in Industrial Control Engineering Courses and other subjects.

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